Aspects of physical and cognitive development in the infant orang-utan (Pongo pyqmaeus) during the first fifteen months of life

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ASPECTS OF PHYSICAL AND COGNITIVE DEVELOPMENT IN THE INFANT ORANG-UTAN (*Pongo pygmaeus*) DURING THE FIRST FIFTEEN MONTHS OF LIFE.

A thesis presented in candidature for the degree of Doctor of Philosophy

by

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Philosophy have I digested,
The whole of Law and Medicine,
From each its secrets I have wrested,
Theology, alas, thrown in.

Poor fool, with all this sweated lore,
I stand no wiser than before.

Goethe (Faust/Part 1)

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ABSTRACT

Several aspects of Orang-utan development were followed from 7 - 63 weeks. Housing care and feeding are described. Deciduous dentition and weight data are recorded, and compared with human and chimpanzee data. Physical development was in advance of Homo sapiens.

Motor development was studied by (i) intercoordination of discrete limb/body movements. Ever-more complex behaviour stemmed from accretion or intercoordination of previously seen behaviour, or arose *de novo*. (ii) General motor development showed a gradual mastery of more complex actions. (iii) Gessel testing of motor development and comparison with other Hominoidea revealed this Orang-utan to be in advance of the human infant. Development was more similar to Gorilla than Chimpanzee, yet was in many respects more extended than the chimp. This is explained by the small Gorilla and Orang subject number, and variability within Primate species.

Piagetian cognitive development was tested using a battery of sensorimotor tests. The Orang-utan was in advance of the human infant, except in the Stage VI Stick test, which was never achieved. An alternative to Piaget's explanation of certain sensorimotor behaviour is advanced. There was, generally, a shorter (though complete) sensorimotor period in the Orang. Contrary to human data, there was no synchronicity in achievement of the same stage over different tests. This is explained by the species' different ecological/evolutionary histories. A phylogenetic scale of Piagetian accomplishment is suggested.

Visually directed grasping was achieved at 3½ months, before H.sapiens, and after the chimpanzee. Several new grasping behaviours are described, many of Piaget's observations are confirmed, and several are not. Development of hand to mouth, visual following and visual-auditory coordination are charted.

Tuition using operant conditioning techniques resulted in the learning of 4 sounds in 3 months. These were used with greater than 70% consistency for four goods/services. Error sounds are analysed. Later sounds were learnt faster. Comparison is made with human language, and Pongid artificial language, development. Its relevance to language evolution is discussed.

PREAMBLE.

It is passing strange that, although the most endangered of the Great Apes, the Orang-utan, Pongo pygmaeus, has until now been the victim of an almost criminal amount of neglect, not least in the field of psychological development. Most students of the creature in the wild believe that not more than 5000 free living Orang-utans survive in the forest fastnesses of Borneo and Sumatra (e.g. Fisher, Simon and Vincent, 1969). The population decreases yearly as more and more of its habitat is destroyed. The species is listed in the Red Data Sheets of the International Union for the Conservation of Nature and Natural Resources as endangered, and it is likely to become extinct in the wild. If the Orang-utan is not studied soon it will never be studied at all.

Such a study is necessary, and not only for the reason mentioned above. There seems to be no comprehensive account in the literature of the development of an infant Otang-utan, ie., a wide spectrum of topics has never been looked at longitudinally in a single member of the genus Pongo. It seems that current opinion inclines to the view that the study of the African Great Apes is sufficient to delineate the capabilities or otherwise of other members of the Pongidae. Manifestly, this is false. The Orang-utan is separated from the Chimpanzee and the Gorilla by millions of years of separate evolutionary development, and by thousands of miles. No one claims that we can make definitive statements on the intelligence of the Wolf in the U.S.A. by studying Cape Hunting Dogs in Africa.

A further reason has to do with the increasing influence of the theories of the Swiss psychologist, Jean Piaget. His theories have been studied on a longitudinal basis in the human infant by numerous co-workers, but have yet to be attempted with species other than Man. One aim of the research was to test the hypothesis that similar methods could be usefully applied to other species, in this case the Orang-utan. This proved to be the case.

The work attempts the elucidation of an infant Orang-utan's development in a broad range of areas, a number of which, as far as is known, have never before been studied in this species. Chapter 1 (Care, feeding and physical development) and Chapter 2 (Motor development) comprise brief chapters concerned with those aspects which it was possible to study while pursuing the main points of the research, Chapters 3, 4 and 5. These latter chart Cognitive, Grasping and Linguistic development respectively. With an "n" of 1, the findings of the following pages cannot be considered as other than tentative. However, given the species' survival status, to await the chance to study even 10 Orang-utan infants is to wait forever. Further, and as discussed at more length later, the precision and detail of a developmental study decreases rapidly with increasing subject number.

To a varying degree then, Chapters 2 - 5 are pioneering studies, and it is hoped that they will be received as such. The reader should bear this in mind when viewing the undoubted inadequacies in specific areas of study. Overall, however, one trusts that a fairly lucid picture of the infant's development has been achieved. It is to be hoped that such a scanning of the Orang-utan's abilities during the first 15 months of life will stimulate further research on this, the most neglected of the Great Apes.

CHAPTER ONE

EXPERIMENTAL SUBJECT, REARING CONDITIONS AND PHYSICAL DEVELOPMENT

EXPERIMENTAL SUBJECT

PEDIGREE

The subject was a male Orang-utan or Maias (Pongo pygmaeus, Hoppius, 1760), named "Cody". The infant was the result of a match between "Adam", a male of the Sumatran sub-species (P. pygmaeus abelii, Lesson, 1827) and "Mandy", a Bornean sub-species female (P. pygmaeus pygmaeus, Hoppius, 1760). Both parents had been imported at the age of approximately two years (D. Cooke, pers commn.).

DETAILS OF BIRTH *

The infant was born at approximately 12 noon, July 28th, 1973, after a gestation period of 263 days (approximately the same as that given by Asano (1967) for an Orang-utan at Taina Zoo, Tokyo. Parturition was rapid, with the neonate being delivered within an hour of the first signs of labour. The speed of delivery corresponds with the Taina birth (Asano, 1967). There are no data on the fate of the placenta.

Although showing considerable interest in the infant, Mandy seemed completely ignorant of the infant's need to suckle, placing him in diverse positions about her person, but not holding him to the breast. When the infant fortuitously found the nipple, the mother would pull him from it. Fears for the infant's safety increased, and after 15 hours, with the mother showing no signs of initiating or allowing breast feeding, the female was anaesthetised and the baby removed to be hand-reared.

* The details concerning the first 6 weeks of life are as reported by the curator of Flamingo Park Zoo, Mr John Laing, or by the keeper in charge of the Great Apes at that time, Mrs Ethel Andrew. The latter kept copious notes of the events from which much of this section (and the early feeding and weight data (up to the 6th week)) are taken.

CARE AND FEEDING

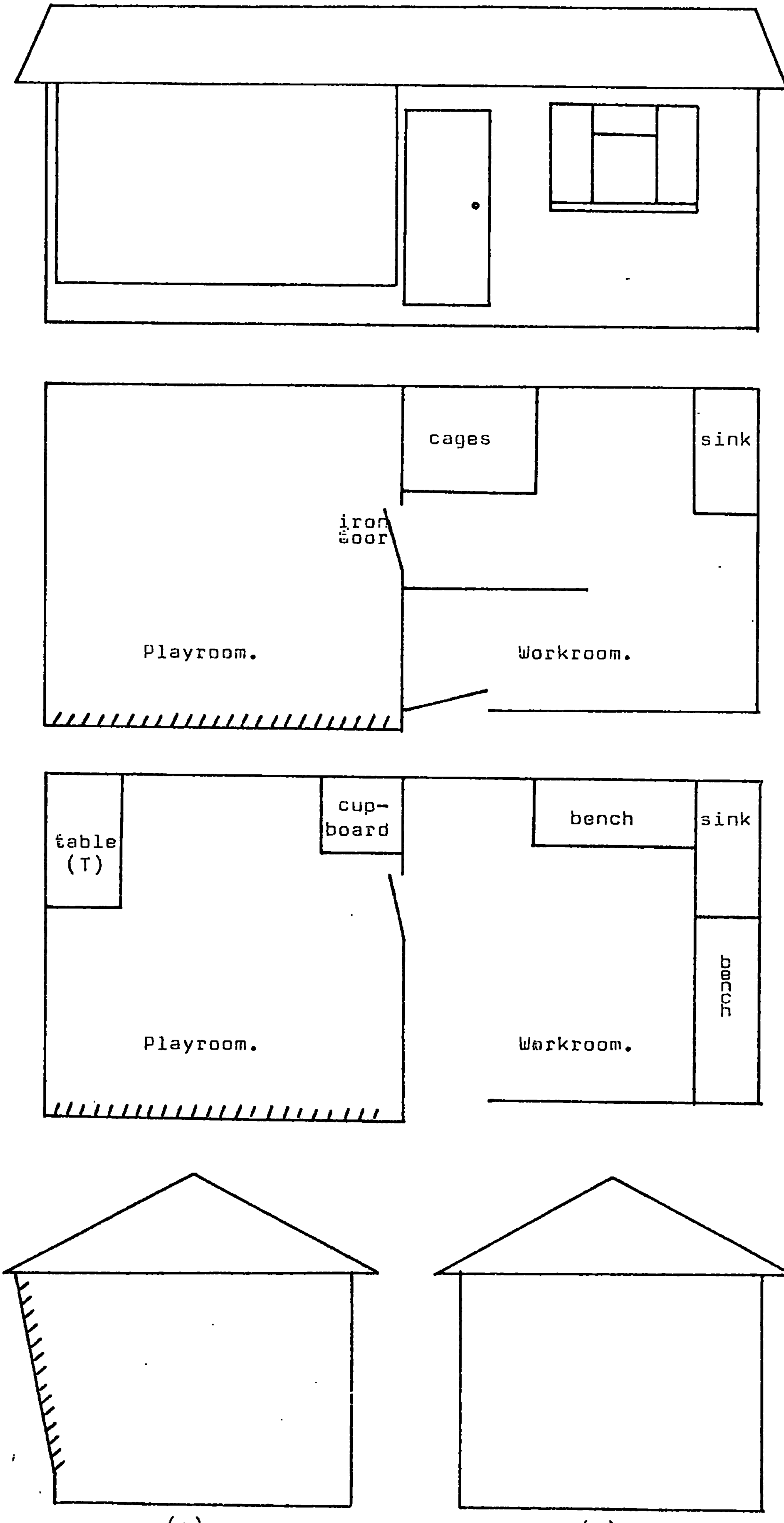
HOUSING

The infant was transferred to a small, single-storied, two-roomed bungalow, entry being effected by a single door (see layout diagrams, fig.1.1 for all main dimensions). One room (hereinafter called the "playroom") was fronted by an armour plate glass window which extended from the roof to 14 inches above the floor. This room was separated from the second room (hereinafter called the "workroom") by a door, constructed of $^1/_8$-inch diameter mild steel rods in a 2-inch meshwork, and with a double bolt system for security. The workroom's interior was, for the first ten weeks of the infant's life, as shown in fig.1.1(ii), containing four small chimpanzee cages, a wooden partition and a small sink. After this time the room was refurbished; the chimp cages and the partition were removed, and long benches installed, as detailed in fig.1.1(iii). At the same time, a cupboard and table were added to the playroom and the floor tiled.

Heating of the building was by two 2-kilowatt blow-heaters, one heater to each room. The action of these devices was controlled by a thermostat which allowed a choice of constant temperature conditions. The infant was kept in a constant ambient medium of 24°C. (75°F) for the first three months of life, following which the temperature was decreased to 21°C (70°F). This temperature was maintained until the infant reached an age of 8 months when it was further decreased to 18.5°C (65°F). Following this date the infant, previously held strictly within his quarters, was allowed outside during periods of mild weather.

The neonate spent his first weeks of life in a small carry-cot (13" x 26" x 9") placed directly beneath the warm air currents of both heaters. No additional objects were available to the infant's sensory channels during this period. On my arrival (infant's age: 6 weeks 5 days) an attempt was made to transform this dull, monotonous habitat into one approximating that of a human infant. Toys were hung up around the infant and also occasionally placed beside him in the carry-cot. The walls were painted and, noting the findings of several workers on the beneficial effects of handling (eg. Adler and Conklin, 1963), there was much carrying and fondling of the

Fig.1.1



(i) Front View

(ii) Plan View (before conversion)

(iii) Plan View (after conversion)

(iv) Side View
(a)Playroom
(b)Workroom

infant. As the infant grew and became more adept at crawling, climbing, etc., additional toys were introduced. No comprehensive record of toys presented to the infant was kept, (this proved impossible as, to take one example, many people brought Cody "presents" during my absences). However, the following objects may be listed as his main toys, together with their approximate dates of introduction.

Toy	Date of introduction
Rattle string:	7th week
Hanging toys: key ring, small bear, 2 plastic discs, rattle, collar, diabolo	7th and 8th weeks
A-Frame, Big cot, 2 teddy bears, Chair, Peg-board, Bath	9th week
Potty, Blanket, Squeaky dog, Red plastic cubes	10th week
Rope	64th week

In addition, a radio or taped music was often kept running during the infant's waking hours. It was noted that the infant showed no obvious interest in this broadcast material, even during the latter part of the experiment.

During the last month of the research, Cody was moved from the zoo to a house in Sunderland. This move (accompanied by all his toys and furniture) was not seen to noticeably upset the infant.

CARE OF THE ANIMAL

Throughout the period of the research (6 weeks 5 days to 1 year 11 weeks 4 days) the primary interactor with the infant was the experimenter. During the first two months the infant required specialised care, involving feeding at 11.00 p.m. each night and 6.30 a.m. each morning. These feeding sessions were curtailed after this time, and, on average, a day began between 8.00 and 8.30 a.m. with the experimenter's entry into the hut. The infant was changed, fed and then played with. Cleaning up of the room, washing nappies, cleaning plates and utensils lasted until approximately 9.45 a.m. A 15-minute observation period of Cody's general abilities, primarily motor and especially grasping, was taken at this time, then testing of one of the appropriate "topics of the day" continued for one hour after this. The experimenter went to coffee at around 11.00 a.m. At 11.20 a.m. further testing began and was continued up to 12.30 a.m. After lunch (12.30 - 1.30 p.m.) the infant was once again fed and changed, a 15-minute observation period similar to that of the morning session then ensued, following which testing, or playing continued until 3.00 p.m. From 3.30 to 4.30 p.m. there was a further hour of testing. Playing with the infant for 15 minutes was followed by a final feed and nappy change, after which he was placed in the playroom and left to his own devices until the following morning. A small 60-watt "night light" was switched on just prior to the experimenter's leaving, usually around 5.45 - 6.15 p.m.

The routine was infinitely malleable; if Cody appeared more at ease playing for an extra ten minutes this was allowed, if he seemed keen to continue an experimental test session this was likewise permitted. On occasion, the infant appeared to be so upset by the experimenter's leaving that it was deemed necessary to stay with him until he slept (any time between 7.00 and 9.00 p.m.). In passing, it should be noted that the infant was never seen to take "naturally" to the wild Orang's routine of waking, feeding, siesta, feeding and sleeping (MacKinnon, 1974; Harrisson, 1962).

The only aspects of the routine which remained relatively inviolable were the feeding periods, and the 15 minutes of observation which followed, although on occasions even these were waived.

It should not be thought that the experimenter completely monopolised the attention of the infant. Rather, he played the part of "mother", with various individuals (keepers, visitors, photographers) popping in and out. During the times of experimenter absence Cody was cared for by one or other of two keepers with whom he was especially familiar.

CLOTHING

Except when taken outside his cage, Cody for the most part wore either T-shirt and diaper, or diaper only. It was only when travelling that woollens were donned to protect the infant from inclement weather.

Diapers: The infant was kept in diapers for reasons of cleanliness. In the high canopy of the Orang-utan's native habitat any faeces or urine would simply fall away from the infant's body. In the close confines of the infant's cot, however, defaecation without some method of confining the stools would result in a miasmatic calamity at each bowel movement. Coprophagy was also seen several times. Consequently, diapers were used as a "cachement area". Later, as the infant grew, he became quite adept at removing both his diapers and plastic pants.

ILLNESS

The infant suffered from only one complaint during the duration of the experiment: gastro-enteritis. Although the sole infection, several of the attacks were severe, and, in the early weeks, potentially fatal. Treatment was effected by the use of kaolin to slow bowel movements; the preparation was given in the infant's solid food (dosage: $\frac{3}{4}$ teaspoon per pan of cereal). A wide-spectrum antibiotic ("Penbritin") was also given in his food or, in severe cases, by subdermal injection. The other main threats to the infant's well-being, pulmonary infections, never materialised. This is thought due to the constant temperature environment in which he was held, and to the non-admittance into his rooms of persons suffering from colds, 'flu or similar complaints.

BATHING

The subject's hands and face were lightly bathed after each meal, or as the occasion demanded. A full bath was given approximately two times each week. Not only did the bath serve to keep the infant clean, its aftermath is thought to have helped forge a stronger infant-experimenter bond. It was found that Cody greatly enjoyed tickling, grooming and brushing. The latter was a necessity following his bath, and this occasion proved an opportune time to initiate the remaining two services. Brushing was by long strokes down belly, limbs and back, grooming by pulling aside a portion of hair with one hand and scratching at the exposed skin with the finger tips of the other hand, after the manner said to be enjoyed by chimpanzees at the Gombe Stream Reserve (.. Fisher, pers. comm.). Brushing and grooming were, on almost all occasions, accepted by the infant for as long as the experimenter would continue.

The infant was ticklish in many areas of his body, corresponding to those enjoyed both by human infants (and adults!) and in those chimpanzees who have been home-raised (Kellog and Kellogg, 1933; Hayes, 1952; Gardner and Gardner, 1971; Kohts, 1935). Thus, the lateral region of the ribs, axillae of legs and arms, belly and soles of the feet were all sensitive. A quite anomalous "ticklish" area, from a human point of view, was the infant's paroxysms of delight when tickled on the median aspect of the junction of upper and lower arm (i.e. on the inside of the elbow joint).

NUTRITION

As the obtention of milk from the female proved impossible, human infant powdered milk was fed the infant after he was removed from his mother (with the exception of the first feed, this being a glucose and water mix, of which 3/4 fl. oz. was taken). Feeding times and additions of novel food are shown in Table 1.1.

Table 1.1

Time	Food	Feeding Times
day 1 to week 8	Oster Milk (half cream)	a.m.: 6.30, 10.30, 12.00 p.m.: 4.30, 7.30, 11.00
week 8 to week 12	Oster Milk (full cream)	a.m.: 8.30 p.m.: 1.30, 5.00
week 12 to week 24	Oster Milk (full cream) Cereal – tinned (Heinz) baby food	as weeks 8 – 12
week 24 to week 40	Cow's Milk Cereal tinned baby food egg	as weeks 8 – 12
week 40 to week 63	as weeks 24 – 40 plus fresh fruit	as weeks 8 – 12

In addition to the diet described in Table 1.1, dietary supplements in the form of "ABIDEC" and "Delrosa" were given from the day of separation and two weeks following this date respectively.

The infant grew rapidly under the influence of this régime, as will be seen from the weight data, (pg.14 ff.). Cody accepted new foods readily, the sole difficulty being the infant's tendency to produce much looser stools at each change-over period, as the alimentary canal adjusted to this new foodstuff.

Feeding was in the usual human fashion, i.e. feeding bottle and teat for administering milk, spoon and plate for the solid food. Cody adapted easily to both means of revictualling as soon as they were offered, and later learned to use a mug as a container for his liquid sustenance.

The average energy intake per day per month is shown in column 2 of Table 1.2, with a break-down of consumption by food type, columns 3 - 8. For this table, the average energy intake per day (taken from the final 7 days of each month and allowing 10% wastage for each food-item) was computed using calorific values given on the foodstuffs (for cereals and milk), in literature (sugars, eggs, fruit (Colin, 1966)) and from data given by the Heinz Research and Nutrition laboratories (Tackly, pers comm.)

Table 1.2

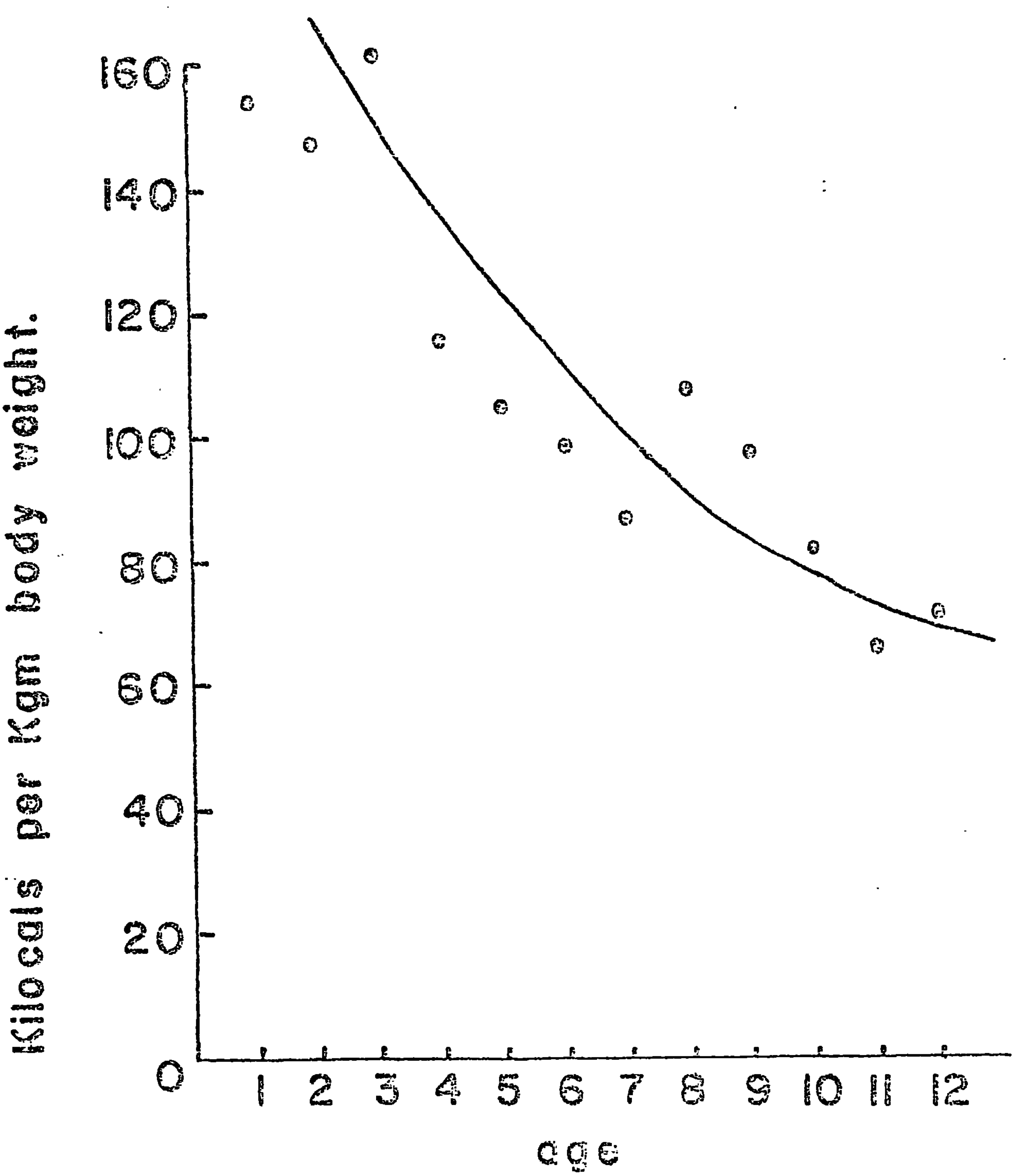
	Kcals per day							
Month	Total	Cereal	Milk	Tinned	Sugars	Egg	Fruit	Kcal/day/ Kgm body wt.
1 *	450	-	450	-	-	-	-	155
2	635	-	635	-	-	-	-	148
3	693	35	445	213	-	-	-	162
4	590	153	335	37	65	-	-	116
5	579	164	419	41	55			105
6	626	126	433	46	21			99
7	590	102	410	-	68	10		87
8	765	134	493	10	90	38		108
9	742	117	505	30	62	28		98
10	644	96	390	-	100	16	42	82
11	542	64	390	-	80	-	8	66
12	610	61	404	-	92	37	16	71

* Data from month 1 taken from notes of animal keeper in charge of Cody during this time.

N.B. All figures have been taken to the nearest Kilocalorie.

FIG. 1.2

KILOCALORIES CONSUMED PER DAY PER KILOGRAM BODY WEIGHT IN THE FIRST TWELVE MONTHS OF LIFE.



Average energy intake per day per kilogram body weight is tabulated in the final column, using information derived from the weight graph, fig.1.2,& page 14. When these data are graphed with month number as abscissa, a relatively consistent decline in Kilocals/day/Kilocals body weight is seen as time progresses. This decline would seem to indicate a gradual decrease in the amount of food taken that is utilised directly for weight increase. This result (Table 1.2 column 9 , and fig.1.3 ,

PHYSICAL DEVELOPMENT

Given the prior commitment to those aspects of psychological development detailed in the preamble, a comprehensive study of physical development was not possible. Owing to this, only those parameters which could be most conveniently measured were studied. The two presented here are the times and sequence of the deciduous dentition and the weight increase of the animal.

DENTITION

The dentition of the Pongidae is thought to have evolved from that of their presumed ancestor, members of the genus Dryopithecus.

With regard to time of eruption of the teeth in the Hominoidea, the most work has been performed on Homo sapiens (e.g. Robinow, Richards and Anderson, 1942; Adler, 1958; Hellman, 1943), some on the chimpanzee (Schultz, 1940; Rissen and Rissen, 1945; Vanderplank, 1937) and but a small amount on the gorilla and Orang-utan. Further, the majority of studies concerns the permanent dentition of these species, the deciduous dentition receiving much less attention. Schultz (1941), reviewing the information then available on this subject cites only Brandes' report (1939) wherein the times of eruption of the deciduous dentition of a single male Orang, raised in captivity, was recorded. Other data have since become available (Heinz, Georg and Klos, 1966).

Method

Eruption of the deciduous dentition in the infant Orang-utan "Cody" was monitored on a daily basis from 12th September, 1973, (age 6 weeks 5 days) until completion of deciduous tooth eruption. From commencement a schedule of morning gum inspection was instituted, and any new tooth noted. A tooth was recorded as "erupted" if any cusp of that tooth had pierced the outer integument of the gum. Inspection was daily, with the exception of those times that the experimenter was absent (on average, two days every two weeks) or ill. On only one of these occasions did a tooth erupt (the right lower canine). The ape-house keeper had, however, been requested to observe and note any tooth eruptions during the experimenter's absences, and stated that on this occasion, eruption had occurred one day before the experimenter's return. As the experimenter had been absent for only two days, and but a single cusp was piercing the gum, the accuracy of this observation was taken to be correct. With this exception, tooth eruptions are precisely dated.

Results

Cody's times of eruption of tooth-pairs are shown in column 1 of Table 1.3. As can be seen, the first tooth erupted on 7.11.73, with the infant then 103 days old. Sequence of tooth eruption in this subject was lower then upper first incisors, followed by lower then upper second incisors, though in this case the tooth at the left side erupted some time before the right-hand counterpart. The pattern with the first and second molars is not so clear-cut, with the eruptions of the left first upper and lower molars being split by the first indications of the right first upper and lower molars. The right and left lower canines follow, the left and right lower second molars being next to erupt. The penultimate tooth-group to show is the upper canines (left and right) with the final addition to the lacteal dentition being the eruption of the upper second molars, the right upper second molar being the last to emerge on 10.11.74, with the infant 471 days old.

There was very little trouble experienced with teething in the infant - unlike others (e.g. Harrisson, 1961) in which the gums were swollen, and food refused because of teething troubles, or where the gums had to be slit. The infant in this investigation showed very little signs of discomfort, the only change in behaviour being a seeming increase in the amount of biting and chewing of various objects.

Discussion

How typical is Cody's sequence of tooth eruption? Data are scarce, but some studies have listed the sequence of eruption. As far as is known, only two accounts are published on this subject (Schultz, 1941, Heinz-Georg and Kloo, 1966) together detailing total deciduous tooth eruption in three infant Orang-utans, and the partial path in three others. These, plus the information derived from the present study, are tabulated in Tables 1.4, 1.5 and 1.6.

As with all the data presented in this work, the small number of subject(s) in the sample precludes definite statements as to the situation prevailing in the species as a whole. However, certain trends can be mentioned.

Scrutiny of these data reveal a great deal of variation in both time and sequence of eruption. The position is greatly clarified when each animal is listed according to the average time of eruption of right and left homologous teeth, i.e. right and left upper first molar, right and left upper canines, etc. (Table 1.4.).

Table 1.3. - Deciduous Dentition.

Date of Eruption.	Age in Days.	Tooth Erupted.
7.11.73	103	Right first lower incisor.
7.11.73	103	Left first lower incisor.
15.12.73	141	Left first upper incisor.
15.12.73	141	Right first upper incisor.
24.12.73	150	Left second lower incisor.
8.1.74	165	Right second lower incisor.
18.2.74	206	Left second upper incisor.
22.2.74	210	Right second upper incisor.
1.4.74	247	Left first lower molar.
19.4.74	265	Right first upper molar.
22.4.74	268	Right first lower molar.
22.4.74	268	Left first upper molar.
1.5.74	277	Left lower canine.
7.5.74*	280	Right lower canine.
21.5.74	297	Left second lower molar.
2.6.74	310	Right second lower molar.
5.7.74	313	Left upper canine.
14.7.74	322	Right upper canine.
2.10.74	463	Left upper molar.
10.10.74	471	Right second upper molar.

* Said by keeper to have erupted one day previously.

Table 1.4.

Tooth Pair	Cody	Buschi	SUBJECTS Brandes	Viko	Bobby	Satu	Anak	Average range of eruption for each tooth pair
Upper I_1	(0) 141	(0) 142	(8) 136	(18) 192.5	(11) 224.5	(0) 124	(0) 208	5.3
Lower I_1	(0) 103	(0) 129	(10) 124	(7) 178.5	(6) 154	(0) 124	(0) 202	3.3
Upper I_2	(4) 208	(0) 200	(3) 201.5	(14) 301	(0) 390	-	-	4.2
Lower I_2	(15) 157.5	(0) 200	(7) 181.5	(7) 262.5	(7) 240.5	* 188	(8) 239	7.3
Upper C	(7) 317.5	0 (341)	(3) 316.5	(0) 357	-	-	-	2.5
Lower C	(6) 280	0 (341)	(21) 322.5		-	-	-	9.0
Upper M_1	(3) 266.5	(0) 166	(7) 156.5	(21) 227.5	(0) 215	-	-	6.2
Lower M_1	(21) 257.5	(0) 161	(2) 149	(21) 199.5	(0) 202	* 188	-	8.8
Upper M_2	(8) 467	(0) 281	(4) 278	(0) 364	-	-	-	3.0
Lower M_2	(13) 303.5	(0) 281	(4) 260 -	(10) 282	-	-	-	6.75
Average range tooth pair eruption	7.2	0	6.9	11.1	3.9	0	2.7	-

Figures in parentheses give the range of eruption in days for that specific tooth-pair/animal. The average range for all tooth pairs combined was less than one week (5.6 days, range: 0 - 21). As can be seen, the lower canines contribute the greatest spread in terms of individual range in eruption times, the upper second molars the least. The average value for onset of the deciduous dentition is 144.8 days, for completion 371.8 days (n = 4, Bobby, Satu and Inak omitted). However, time of onset of eruption is subject to great variability (103 and 202 days, a range of 99 days) completion of deciduous dentition being even more markedly variable (322.5 to 467 days). The duration of eruption in any one animal also varies markedly, ranging from minimum of 124 - 322.5 (equals 197.5 days) for Brandes' Orang subject, to 103 to 467 (equals 364 days) in the case of Cody. The average for this parameter is 258 days (n = 3). Note that Cody both began eruption earlier and completed it later than the other Orangs detailed. The reasons for this are not known; it may be that, having access to many objects which he could bite (as opposed to an infant on the mother Orang) may have speeded the onset of teething,yet it would be thought that just such an advantage would have brought about an early end to this condition. However, the data show that just the opposite is true with regard to this latter condition. In the absence of more definite knowledge, the most likely explanation for the variable times of eruption is thought to be the individual genetic constitutions of the individuals concerned.

Tables 1.5 and 1.6 are of help in determining the probable sequence of tooth pair eruption. In table 1.5, each pair to erupt is ordered vertically from first to last. Where two tooth pairs are said to have pierced the gums simultaneously both pairs are displayed athwart the two boxes. Scanning across the horizontal columns of Table and counting the number of times each tooth pair appears in that row allows the construction of columns 2 - 4 in Table 1.6. The most probable eruptive sequence can then be arrived at by calculating which tooth pair is present in the highest proportion in any horizontal row. In this way we find the sequence to be that described in the final column of Table 1.6, viz: I_1, M_1, I_2, M_2, C. This sequence does not correspond to that given in Harrison (1962), perhaps because the subject number is so low in the latter account. In addition, there is a definite possibility that the lower tooth of any upper and lower tooth-type will erupt before its upper tooth

Table 1.5

Cody	Buschi	Brandes	Viko	Bobby	Satu	Anak
LoI_1	LoI_1	LoI_1	LoI_1	LoI_1	$U\&LoI_1$	LoI_1
UI_1	UI_1	UI_1	UI_1	LoM_1		UI_1
LoI_2	LoM_1	LoM_1	LoM_1	UM_1	LoI_2& UM_1 *	LoI_2
UI_2	UM_1	UM_1	UM_1	UI_1		-
LoM_1	$U\&LoI_2$	LoI_2	LoI_2	LoI_2	-	-
UM_1		UI_2	LoM_2	UI_2	-	-
LoC	$U\&LoM_s$	LoM_2	UI_2	-	-	-
LoM_2		UM_2	UC	-	-	-
UC	U&LoC	UC	UM_2	-	-	-
UM_2		LC	LC**	-	-	-

* only one tooth from each tooth pair showing

** not given, but only teeth left to erupt

Table 1.6

Position	Tooth Pair	Sequence most probable	Specimen Number (n)
1st	I_1 - 7	I_1	7
2nd	I_1 - 6 M_1 - 1	I_1	7
3rd	M_1 - 4 I_2 - 2	M_1	6
4th	M_1 -3½ I_2 -1½ I_1 - 1	M_1	6
5th	I_2 - 4 M_1 - 1	I_2	5
6th	I_2 - 3 M_1 - 1 M_2 - 1	I_2	5
7th	M_2 - 2 C - 1 I_2 - 1	M_2	4
8th	M_2 - 3 C - 1	M_2	4
9th	C - 3 M_2 - 1	C	4
10th	C - 3 M_2 - 1	C	4

counterpart. Figures for all teeth in all the animals considered show that on 38 occasions the lower teeth appeared before the upper; on only two occasions was the reverse true, with simultaneous eruption occuring eight times.

When compared to the most probable sequence of eruption, Cody's sequence is seen to be atypical in two respects: (i) the inverted sequence of eruption for M_1 and I_2, and (ii) the arrangement of alternate eruption of M_2 and C (C then M_2, C then M_2). With regard to (i), and given that the figures for the time interval between the first I_1 eruption and the first M_1 eruption are 32, 25 and 31 days (for the three Orang-utans for which we have most data - Buschi, Brandes' and Viko) then Cody's figure of 154.5 days seems to indicate a late eruption for M_1. In addition, the time (54.5 days) from the eruption of the first I_1 to the eruption of the first I_2 is shorter than for the remaining three subjects mentioned. pointing to a slightly early eruption of the I_2 teeth.

Table 1.7

	*Human	Orang	≠ Chimp	Cody
1	I_1	I_1	I_1	I_1
2	I_2	M_1	I_2	I_2
3	M_1	I_2	M_1	M_1
4	C	M_2	M_2	C/M_2
5	M_2	C	C	C/M_2

* Robinow, Richards and Anderson (1942).
≠ Nissen and Riesen (1945).

It is evident from Table 1.7 above that, on average, all the species listed initiate deciduous dentition with eruption of I_1. I_2, then M_1 follow, except in the Orang-utan, the M_1 <u>then</u> the I_2 erupting in this case. Following this, the human infant appears to erupt anomonously (when compared to the other two species) having a C, M_2 sequence. By contrast, both Chimpanzee and Orang-utan erupt M_2, C. Thus, it would appear that all members of the Hominoidea studied so far show an initial similarity at the beginning of deciduous dentition eruption, but thereafter diverge considerably. This finding, however, is simply a generalisation, and as the " Cody " data indicate, there is considerable individual variation within the species.

With regard to date of onset of the deciduous dentition, the information of Nissen and Riesen (1945) places the chimpanzee at 70 days average (n = 16) well in advance of the Orang-utan (145 days, n = 7) with the human eruptive sequence occurring last, on average at 219 days, (n equals 64, Robinow, Richards and Anderson, 1942). The end point of the deciduous dentition changes the relative positions of the species somewhat; (Orang-utan 376 days; chimpanzee, 376 days; man 852 days - sources as for onset). Thus, the Orang completes its deciduous dentition, on average, at the same time as the chimp, with the human infant once again last. As the chimp starts earlier, the Orang-utan's eruptive span is much shorter, being 306 for the former, 229 for the latter. The human once more possesses the greatest span of the three hominoids, with an average figure of 633 days.

WEIGHT

The weight at birth and its subsequent increase with time are important parameters in comparative development, but for which there are no concrete data when wild-living Orang-utan are considered. The position with regard to zoo-born animals raised on the natural mother is somewhat similar - rarely can the female be induced to part with her offspring so that weighing may be undertaken. As far as is known, data from this source are similarly absent. With zoo-born hand reared infants there is more information; several animals have been weighed while rearing took place. However, difficulties arise in that the infant is both reared under unnatural conditions and fed with artificial nutrients, any of which may affect growth and body weight abnormally. This applies equally to the female before and especially during pregnancy. Consequently, the comparability of such birth weights and their increase with that of the wild Orang-infant is open to question. It is only by amassing a large number of reports on such animals that it may be possible to reach some approximation of the position in the wild. The following 3 pages are concerned with the birth and subsequent increase in weight of the Orang-utan "Cody" during the first twelve months of life.

Method

The infant's weight was monitored at least once a week. Usually, a weight datum was obtained more often that this, primarily to check upon the infant's health (as when daily weight measurements were taken during an early bout of gastro-enteritis) but also to allow a more complete picture of weight increase than is usually presented. Weighings were obtained on an "Avery" commercial weighing machine (No.1215 BFL/S - 625817). Accuracy checks on the machine were instituted every two weeks. At first the infant would lie quietly on the pan of the apparatus while weighing was in progress. Later (approximately 3½ months) the infant became increasingly active, owing to attempts by him to achieve contact with the experimenter. Accuracy in these cases was seriously impaired. Fortunately, it was found that in these cases the placing of a rolled blanket on the infant's stomach (which he immediately grasped) greatly decreased such disruptive behaviour and allowed the obtention of accurate results.

Results

The increase in weight (in Kilogrammes) with time is graphed in fig.1.3 and tabulated in Table 1.8.

The infant's weight can be seen to increase with time. Birth weight is doubled in less than four months, and tripled in eight months. Quadrupelling of the birth weight was not achieved by the end of the twelfth month, decreases of more than 0.1? Kgm are three in number, occurring around 28.8.73, 3.1.74 and 15.4.74.

Discussion

Considering first the decreases referred to above, perusal of the diaries reveals that, on each of the three dates, the infant was subject to severe attacks of gastro-enteritis. The fall off in weight can therefore be attributed to this infection, causing as it does diarrhoea, with dehydration and loss of appetite. Other than this, weight change was steadily upward, with the most rapid increase being in the first quarter and the slowest in the last. Other small decreases correlate with two or more days of observer absence, times at which the keeper in charge reported refusal of food (especially solid food) by the infant.

Seitz (1969) gives the average birth weights for male and female Orang-utan as 1,740 gm. (n = 7) and 1,694 gm. (n = 5) respectively. The minimum weight is given as 1,420 gm, and maximum as 2,040 gm. Both subjects were female. Cody's weight at birth (2,380 gm) exceeds all infants so far recorded (and other male infants by at least 365 gm.), but falls within the maximum limit given by Portman (1956)

TABLE 1.8

Change in Weight with Time

DATE	KGM.	DATE	KGM.	DATE	KGM.
29. 7.73	2.384	21.11.73	4.854	19. 6.74	8.204
1. 8.73	2.469	24.11.73	4.925	22. 6.74	8.204
4. 8.73	2.668	29.11.73	5.053	26. 6.74	8.2465
6. 8.73	2.753	2.12.73	5.124	3. 7.74	8.261
14. 8.73	2.966	5.12.73	5.166	10. 7.74	8.346
17. 8.73	2.853	8.12.73	5.209	17. 7.74	8.360
19. 8.73	2.839	12.12.73	5.273	24. 7.74	8.474
20. 8.73	2.697	16.12.73	5.394	8. 8.74	8.801
21. 8.73	2.612	21.12.73	5.549		
22. 8.73	2.612	26.12.73	5.641		
23. 8.73	2.597	3. 1.74	5.450		
24. 8.73	2.626	7. 1.74	5.734		
25. 8.73	2.697	10. 1.74	5.890		
26. 8.73	2.782	15. 1.74	5.905		
27. 8.73	2.810	19. 1.74	6.004		
28. 8.73	2.867	26. 1.74	6.117		
29. 8.73	2.895	31. 1.74	6.358		
30. 8.73	2.895	5. 2.74	6.344		
2. 9.73	2.910	8. 2.74	6.387		
5. 9.73	2.966	11. 2.74	6.501		
11. 9.73	3.236	16. 2.74	6.529		
12. 9.73	OBSERVATION	20. 2.74	6.579		
	BEGINS	23. 2.74	6.621		
13. 9.73	3.237	26. 2.74	6.699		
15. 9.73	3.378	2. 3.74	6.799		
17. 9.73	3.314	6. 3.74	6.777		
19. 9.73	3.335	15. 3.74	6.926		
22. 9.73	3.392	19. 3.74	7.040		
25. 9.73	3.435	23. 3.74	7.068		
27. 9.73	3.492	28. 3.74	7.026		
30. 9.73	3.605	31. 3.74	7.097		
3.10.73	3.634	5. 4.74	7.239		
6.10.73	3.761	7. 4.74	7.437		
10.10.73	3.804	10. 4.74	7.395		
13.10.73	3.932	13. 4.74	7.338		
16.10.73	4.045	16. 4.74	7.267		
19.10.73	4.102	22. 4.74	7.423		
22.10.73	4.073	24. 4.74	7.494		
24.10.73	4.201	2. 5.74	7.650		
27.10.73	4.173	10. 5.74	7.707		
31.10.73	4.272	13. 5.74	7.792		
4.11.73	4.457	20. 5.74	7.764		
7.11.73	4.457	25. 5.74	7.991		
10.11.73	4.627	28. 5.74	7.906		
14.11.73	4.534	4. 6.74	7.920		
17.11.73	4.797	12. 6.74	8.232		

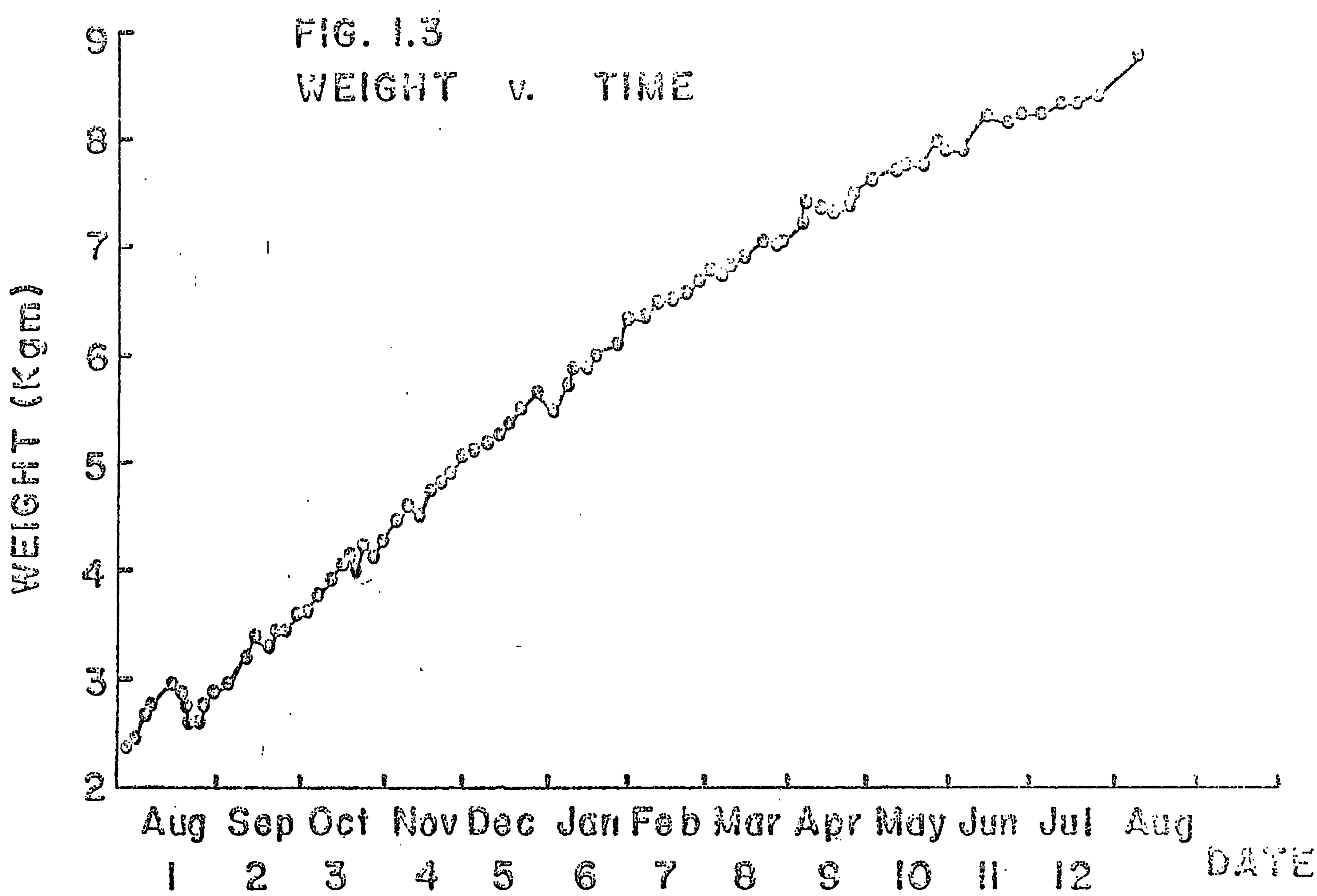


FIG. 1.3
WEIGHT v. TIME
WEIGHT (Kgm)
9
8
7
6
5
4
3
2
Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug
1 2 3 4 5 6 7 8 9 10 11 12
DATE

and Brandes (1939) as 2,500 gm. Indeed, Cody's body weight becomes less anomalous at three months of age, and by the sixth month is almost equalled by one male, "Samu". At nine months Cody's weight is surpassed by this latter and equalled by another male, "Viko", while at twelve months both these infants are heavier than Cody. Brandes (1931, 1939) states that the infant "Buschi" was estimated to double his weight by the age of six months. By contrast, Cody achieved this target in less than four months (see fig.1.3). A perusal of Table 1.8 also reveals an earlier doubling of the birth weight than that described by Brandes in Marndi, Toni, Sigli, Viko and Noell (in each case the birth weight was doubled in three months). This result, and the discrepancy between average birth weights of Brandes (1939) - 1,500 gm. and Seitz (1969) - 1717 gm., may be best explained by a single factor. The improvement in dietary status of captive Orang-utans since Brandes' report with better nutrition and dietary supplements, could easily have produced the difference in birth weights reported and the increased rate of growth (see Wackernagel, 1962).

The infant's birth weight - as is true for all Orang neonates - is small when compared to the human infant's (2,380 gm compared to approximately 4,000 gm. (Boyd, 1935). However, when considering rates of increase in weight, this Orang-utan subject outstrips the human child quite quickly. Whereas the infant human is only approaching a three-fold increase in birth weight by the end of the first year of life (Sinclair, 1973) Cody had already achieved this level by the ninth month. Indeed, although being half the weight of a human infant at birth, this Orang-utan was, by the end of the twelfth month of an absolute weight equal to that of the average human child (approximately 9 Kgm. (Boyd, 1935)). This finding is explained by the Orang-utan's earlier onset of maturity (Schultz,1969).

CHAPTER TWO

MOTOR DEVELOPMENT

GENERAL MOTOR DEVELOPMENT

The development of gross motor behaviour in the captive Orang-utan, although not difficult to observe, does not appear to have been documented at the time of writing. This is not the case for the remaining members of the Pongidae. Chimpanzee data are available in a rather diffuse form from a number of studies wherein this species was home-raised (Kellog & Kellog, 1933; Hayes and Hayes, 1951; Gardner and Gardner, 1971), and from other rather more specific, detailed work (Rissen and Kinder,1952; Jakobsen, Jakobsen and Yoshioka, 1932-34; and Budd, Smith & Shelley, 1943). Data on the Gorilla, apart from the home-raised reports (Hoyt, 1941; Benchley, 1942) are more sparse; Knoblock and Pasamanick (1959) have reported on the motor and adaptive behaviour of a gorilla, using the Gessel method of testing, and naturalistic notes on the development of two gorilla infants have also been published, (Kirchshofer, Weisse, Bereny, Klose & Klose, 1968). Other workers, (e.g. Harlow, 1961; Zimmerman, 1967) refer only peripherally to motor abilities in infra-human primates in the course of research directed towards other study aims. With regard to the Pongidae, it appears from the data so far accumulated, that the gorilla's adaptive responses to various test problems plateau out at around the 44-week level (Knoblock and Pasamanick, 1959) whereas the chimpanzee produces responses comparable to the human up to the 3-year level. It is thus of great interest to determine the Orang-utan's position within this ability league.

The ontogenesis of walking, crawling, standing and a host of other motor behaviours has been studied in great detail in the human infant. Such minutiae as finger-to-thumb-apposition, and rapid alternating supination and pronation of the forearms and hands have recently come under study (Grant, Boelsche, and Zin, 1973) as has the motor development of infants blind from birth, (Adelson and Fraiberg, 1972, 1974; Fraiberg, 1968). Of great importance in studies of this type, however, are the normative tests which chart the sequence, and usual times of emergence of various motor behaviours in a sample. Shirley (1933), Bayley (1935) and Gessel and Armatruda (1947) have given the most detailed accounts of human infant develop-

-ment in this regard, data that can be used not only for screening tests designed to discover behavioural abnormalities, but also as the basis for comparative studies between species.

However, the accumulation of normative information on human (and animal) subjects is but one side of the developmental coin. Times of achievement of standing, walking, etc., are of interest, but the process by which the animal comes from very simple behavioural sequences to those involved in climbing, etc. is of equal importance. It is also, as the section "Intercoordination of Motor Patterns" shows, far more complex. The results are divided into three parts, a rough outline of each being given below.

In Part One (Intercoordination of Motor Patterns) the development of behaviour at the level of individual limb and trunk movements is charted, and it was planned initially to follow such actions through from the beginning to the termination of the study. In this the study was similar to a developmental "ethogram", (Eibels-Eibesfeldt, 1970), of the Orang-utan, with the difference that new behaviour patterns would be added as they appeared. Unfortunately, it became obvious, early in the research, that the elucidation of the minutiae of motor development and their interrelation was complex in the extreme, and that to attempt such an analysis would require a full-time effort, to the exclusion of all other aspects of behavioural development. As the work is intended as a pioneer study of the Orang-utan, it was reluctantly decided to curtail this interesting aspect of the research, and to be content with simply charting the development of the main motor landmarks of the infant's activities. This individual description of the infant's activities, (idiosyncratic in as far as the infant's behaviour was modified by the available objects in his envirionment) forms the topic of the second part of the results (General Motor Development). So as to make the infant's development more strictly comparable with other species of pongids, and with man, Part 3 describes the results of presentation to the infant of the motor development part of the Gessel test (Gessel and Armatruda, 1947).

METHOD

Naturalistic Observation

This began on the sixth day of the sixth week, recordings being made on record sheets. In the beginning behaviour patterns were simple, and it was enough merely to observe the new behaviours and their intercoordinations as they occurred. Later, as motor and cognitive behaviour became more complex, formal observation was performed on a routine basis of two 15-minute periods/day, as described in Chapter 1 , page 4 . During these periods the animal's motor behaviour was described down to the level of limb, head and trunk movements, by means of a series of words, abbreviations and symbols, these latter being devised whenever it was found necessary in the interest of speed and accuracy. An example of the cypher follows:

PRONE

C u o L a + l, d, ls xtend,
Cody up on left arm and leg, down, legs extend, he goes

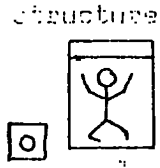
u o es, H up, Vs me, R h scr L a ,
up on elbows, head up, looks to me, right hand scratches left arm,

L h ϕ_v $\rightarrow$ rattle
left hand in vertical hooking movement at rattle.

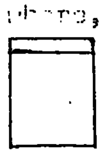
In addition to formal observation, informal and incidental observations were taken whenever a new development was seen to occur outside formal observation periods. In many instances these proved invaluable additions to the records, and emphasise the desirability of an in-depth, concentrated study of development as opposed to the more usual cross-sectional research. As an example, if the creature turned from prone to supine, outside the formal observation period, this was recorded.

Lacking video-recording for so long a period as I was present with the animal, and in order to increase understanding of the animal's motor and cognitive development, two visual and one auditory aids were employed.

a/ Plan drawing. Here the observer drew a small diagrammatic plan of the immediate environs of the animal, plus his relation to these structures. In the beginning the plan was very simple, e.g.



where,



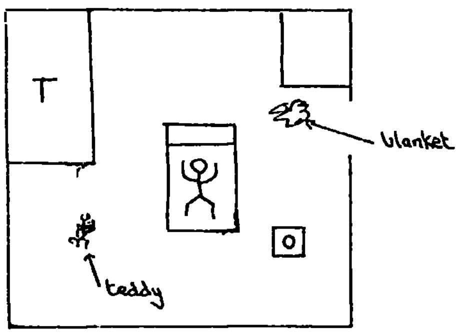
indicates the small cot in which the infant was housed,

designates the infant, and his position vis-a-vis the cot and observer,

and

indicates the observer, seated on a wooden chair.

Later, as the infant's agility increased, the plan encompassed the whole room, thus



Only those toys upon which the infant concentrated his attentions were marked on the plan, several other playthings being usually scattered around the floor at any given time.

b/ Sketching. Small vignettes of the infant were made whenever possible so as to clarify certain postures, movements, etc. In addition, photographic evidence was taken, as shown in plates 1-12.

c/ Tape-timer. So as to obviate the need to refer to a clock or watch during observation a tape cassette was pre-recorded, giving the passage of time verbally at 2-second intervals. An individual ear-piece was used so that the sound was available only to the observer.

In sum, these four techniques, code, plan, sketching and tape, allowed quite a comprehensive picture of motor development to be followed clearly.

Gessel Testing:

Presentation of the Gessel test was made on the table T (see fig. 1.1(iii)pg.2a) at one week intervals. Every trouble was taken to conform to the sequence and method of presentation described in "Developmental Diagnosis" (Gessel and Armatruda, 1947), with the exception that the subject was seated on the experimenter's lap to avoid emotional disturbance. The behaviour was recorded on duplicated record sheets.

RESULTS AND DISCUSSION

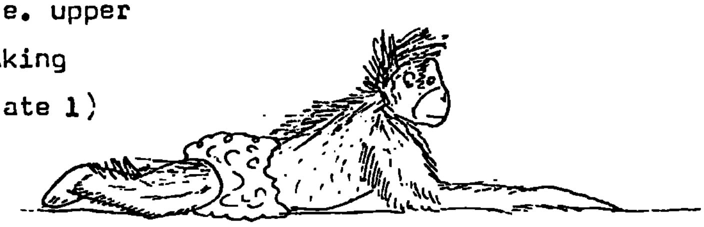
Intercoordination of Motor Patterns

Table 2.1 charts the infant's progress in the prone position over the first eight days of observation. On each day, the infant's novel behaviour (i.e. not previously seen) has been added to the table, and the relationships with prior behaviour detailed by connecting lines. I have defined three major modes by which such development can progress: There is an almost infinite number of intercoordinations between the various movements, and between the motor sequences in a battery of motor patterns. There are also accretions, tiny advances on, or finer control of, a previously stereotyped behaviour pattern. Finally, there are those behaviours which seem to arise de novo, i.e. without any previously recognisable antecedents. Whether their cause be due to physiological maturation or simply due to gaps in observational technique is a matter for conjecture and further experimentation. Each action has been classified as one of these three modes in Table 2.1; i = intercoordination; a = accretion; and dn = de novo.

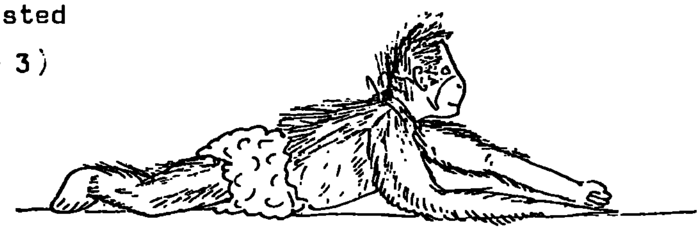
Certain abbreviations have been used so as to conserve space.

1. n.p.: Normal position, ie., the infant lying flat on the cot floor, arms and legs bent at 90° at elbows and knees, head on floor, in midline or turned to left or right.

2. Up on elbows (u o es) i.e. upper body slightly raised, taking weight on fore arms. (plate 1)



3. Up on 1 elbow, 1 arm fisted and straightened (plate 3)



4. GBMs - Gross bodily movements, where all limbs and the trunk engaged in short, undirected movements, e.g. squirming.

All other behaviour terms are self-explanatory, with the exception of ɸ movements (hooking actions with the hand, see page 112), and the abbreviations R, L, and ast, designating Right side, Left side and "at the same time" respectively.

Behaviours seen following initial data collection (first horizontal column) number some 65 movements. As, during the first fortnight, very little in the way of experimentation was possible, copious notes concerning the infant's motor behaviour were kept. Table 2.1 can therefore be considered a fairly complete list of this infant's actions during the first eight days of observation.

Although a relatively complete description, this is not to say that the designations (accretion, intercoordination, de novo) are invariably correct. In this regard the table must be considered provisional. For example, the last two behaviours of the series "legs meet briefly in midline" —> "feet clasp incompletely in midline" —> "feet engage in midline, toes clasping" can legitimately be viewed as accretions (i.e. small advances in greater control of a movement). However, the behaviour "leg up and grasping" (marked as an accretion to the "leg Up" behaviour is not so clear-cut. In a third behaviour series, a similar action, "hand up and grasping cot" is considered an intercoordination of "hand up", and "grasping blanket". Thus "leg up and grasping" may be (and very probably is) an intercoordination of "leg up" and a "foot grasping" behaviour, which would perhaps have been noted prior to the "leg up and grasping behaviour" had observation been conducted earlier. Indeed, observation from birth is mandatory if the unravelling of an ordered sequence of behaviour is to be attempted. It is to be expected that such progress will follow a "Piagetian" series, with increasingly more complex behaviour supplanting, or assimilating, earlier, less complex movements. A suggestion of this is given in Table 2.1, where the actions of later days do seem, for the most part, to comprise more complex actions. However, until further work, (taken from the birth of the infant until some arbitrary end-point) is performed, the question must remain speculative.

General Motor Development

Table 2.2 details what might be termed the idiosyncratic development of this infant's motor skills (idiosyncratic in that not every infant would possess e.g. an A-frame above the cot, or an iron mesh door to climb on - its behaviour would therefore differ en route to identical behaviours, the ability to crawl, climb, stand, etc. - see also page 185). This individuality means that comparisons of behaviour are difficult, except with regard to the times of appearance of crawling, etc. These latter are considered in more detail in the "Gessel" chapter.

Table 2.2

Week	Date	BEHAVIOUR
7		Up on elbows in prone
8		Up on all fours, head down
9		Stands supporting most of weight, when held Up on all fours and looks around
10		Rolls prone to supine. Trying to sit in supine
11		Grasping object when supine, and, by pulling, moving the body
13		Pulls himself almost completely to sitting, in supine. Right hand grasps cot side, up on legs and other hand (prone) Pulls to sitting when allowed to hold experimenter's hand Moves from prone facing top of cot, to supine facing bottom of cot Moves from prone facing top of cot, to prone, facing bottom of cot Moves so both hands over one side of cot and pushes himself off
14		Turns supine to prone
15		Pivots (90^{o}, 180^{o}, 270^{o}) using hand on other side of direction of pivot
16		SITTING, by his own actions (supine) STANDING, holding support (from prone Moves in standing
17		Pulls himself up so high legs off ground
18		Both legs on side of cot, holding A-frame
19		Both legs over side of cot, not touching floor, holding A-frame
20		Uses rails of large cot to pull himself up so both feet off ground
21		Uses large cot to climb A-frame to $^{2}/_{3}$ its height
22		Standing OUT OF COT, can't get back inside
24		Climbs back in cot CRAWLS
26		Legs touch A-frame in climbing Crawling when out of cot (to Iron door) BALANCING while standing
27		Legs grasp A-frame in climbing Crawls, from cot to middle of workroom where experimenter standing Stands away from cot, holding A-frame, grasps large cot and door Out of cot, CRAWLS BENEATH observation chair
28		Crawls under large cot

CONTINUED .....

Table 2.2 – conntinued

Week	Date	BEHAVIOUR
29		CLIMBS iron door, cannot climb down for 3 days Grasps top of table Pulls himself up on A-frame and swings legs Pulls himself up on A-frame and touches its tip with head
31		Crawls from cot almost to workroom sink
32		Uses A-frame as a "walker"
35		Uses A-frame to climb to get objects on table
36		Crawls to furthest point in workroom
39		Climbs off chair unaided
40		Touches top of cupboard
41		Crawls to window and, standing, looks out at people
42		Pushes A-frame to door, climbs, using both
49		Climbs onto window ledge
53		Climbs into large cot
54		Climbs onto table
56		Climbs into sink

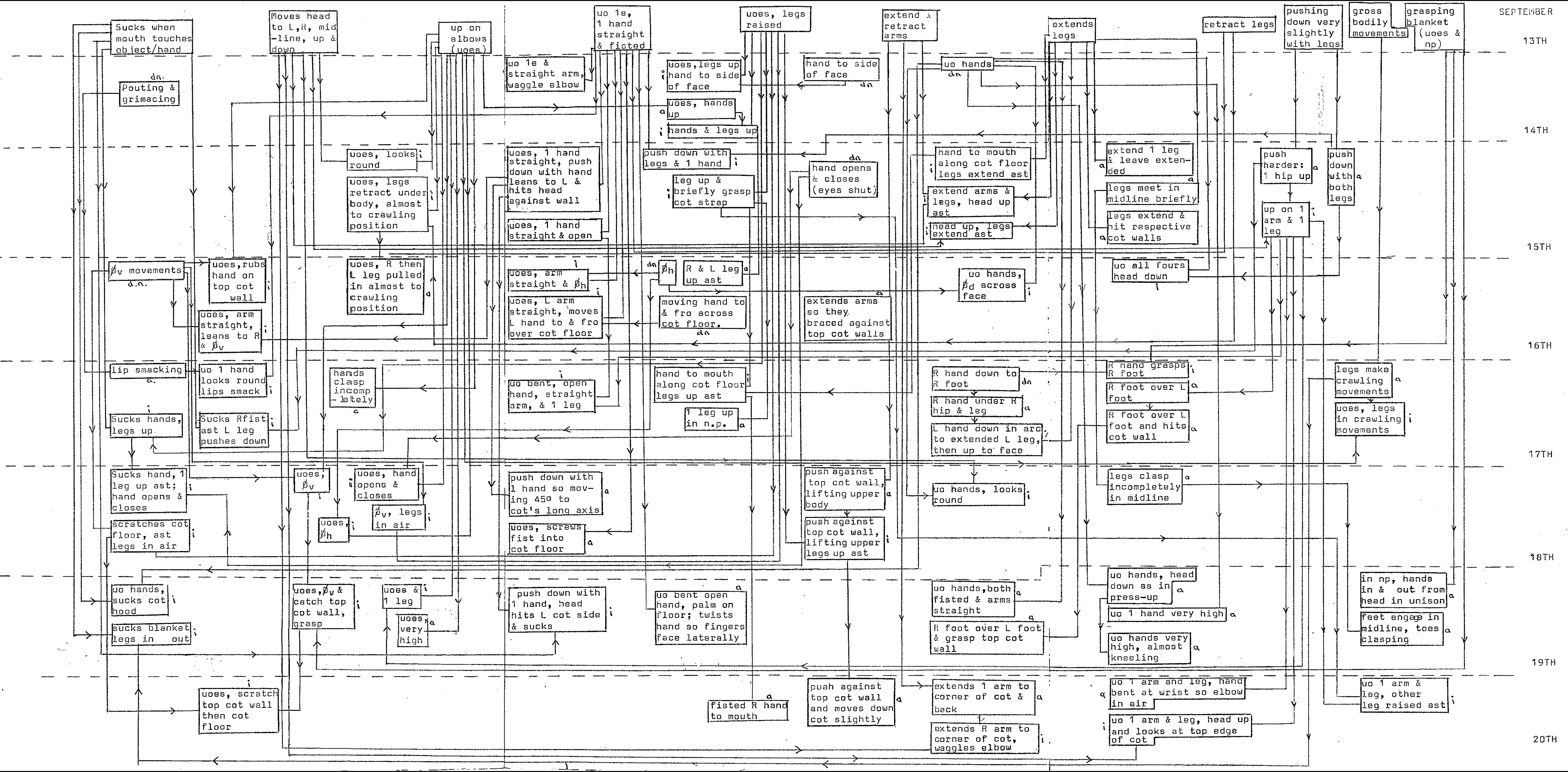

SEPTEMBER
13TH
14TH
15TH
16TH
17TH
18TH
19TH
20TH
Sucks when mouth touches object/hand
Moves head to L, R, mid-line, up & down
up on elbows (uoes)
uo 1e, 1 hand straight & fisted
uoes, legs raised
extend & retract arms
extends legs
retract legs
pushing down very slightly with legs
gross bodily movements
grasping blanket (uoes & np)
Pouting & grimacing
uo 1e & straight arm, waggle elbow
uoes, legs up hand to side of face
hand to side of face
uo hands
uoes, hands up
hands & legs up
uoes, looks round
uoes, 1 hand straight, push down with hand leans to L & hits head against wall
push down with legs & 1 hand
hand opens & closes (eyes shut)
hand to mouth along cot floor legs extend ast
extend 1 leg & leave extended
push harder: 1 hip up
push down with both legs
uoes, legs retract under body, almost to crawling position
leg up & briefly grasp cot strap
extend arms & legs, head up ast
legs meet in midline briefly
up on 1 arm & 1 leg
uoes, 1 hand straight & open
head up, legs extend ast
legs extend & hit respective cot walls
$\emptyset_v$ movements
uoes, rubs hand on top cot wall
uoes, R then L leg pulled in almost to crawling position
uoes, arm straight & $\emptyset_h$
$\emptyset_h$
R & L leg up ast
uo hands, $\emptyset_d$ across face
uo all fours head down
uoes, arm straight, leans to R & $\emptyset_v$
uoes, L arm straight, moves L hand to & fro over cot floor
moving hand to & fro across cot floor.
extends arms so they braced against top cot walls
lip smacking
uo 1 hand looks round lips smack
hands clasp incompletely
uo bent, open hand, straight arm, & 1 leg
hand to mouth along cot floor legs up ast
R hand down to R foot
R hand grasps R foot
R foot over L foot
legs make crawling movements
R hand under R hip & leg
uoes, legs in crawling movements
Sucks hands, legs up
Sucks Rfist ast L leg pushes down
1 leg up in n.p.
L hand down in arc to extended L leg, then up to face
R foot over L foot and hits cot wall
Sucks hand, 1 leg up ast; hand opens & closes
uoes, $\emptyset_v$
uoes, hand opens & closes
push down with 1 hand so moving 45° to cot's long axis
push against top cot wall, lifting upper body
uo hands, looks round
legs clasp incompletely in midline
$\emptyset_v$, legs in air
uoes, $\emptyset_h$
scratches cot floor, ast legs in air
uoes, screws fist into cot floor
push against top cot wall, lifting upper legs up ast
uo hands, sucks cot hood
uoes, $\emptyset_v$ & catch top cot wall, grasp
uoes & 1 leg
uoes very high
push down with 1 hand, head hits L cot side & sucks
uo bent open hand, palm on floor; twists hand so fingers face laterally
uo hands, both fisted & arms straight
uo hands, head down as in press-up
in np, hands in & out from head in unison
sucks blanket legs in out
uo 1 hand very high
R foot over L foot & grasp top cot wall
uo hands very high, almost kneeling
feet engage in midline, toes clasping
uoes, scratch top cot wall then cot floor
fisted R hand to mouth
puah against top cot wall and moves down cot slightly
extends 1 arm to corner of cot & back
uo 1 arm and leg, hand bent at wrist so elbow in air
uo 1 arm & leg, other leg raised ast
extends R arm to corner of cot, waggles elbow
uo 1 arm & leg, head up and looks at top edge of cot
dn
a
i

PLATE 1

PLATE 2

PLATE 3

PLATE 4

PLATE 5

PLATE 6

PLATE 7

PLATE 8

PLATE 9

PLATE
10

PLATE
11

PLATE
12

It is therefore proposed to consider simply the infant's progress towards full mobility as they occurred.

At the beginning of Observation (week 7) the infant was capable of only slight movement, notably of the head, but also of the limbs, although these did not function to in any way move the body, which remained immobile. His usual position, when not sleeping or sucking the blanket, is shown in Plate 1. Movement of the body did not come about until the 8th week, when the up on all fours with Head down movement began (Plate 5), accreting to up on all fours with looking round during the following week. "Up on all 4s" should not be thought of as appearing <u>de novo</u> as, in the days preceding this movement, many components of the total action were performed, e.g. pulling the legs far beneath the hips when in prone early in week 8; it can be seen that by straightening the legs when in this position, the hips would be raised, another behaviour seen prior to up on all fours. This action (raising hips) when combined with the up on hands movement (also seen before the completed up on all fours movement), produces a reasonable approximation to the full up on all fours action. Indeed, the latter movement was by no means always performed successfully, with leg and hand slippage being common. The twelfth week sees an intercoordination of "up on all 4s" with "hand over side of cot" when, while in prone , the infant achieved a greater degree of mobility by going up on his legs and one hand, with the other hand pushing from its high position on the cot wall.

Mobility in prone increased primarily by the use of the hands in grasping structures, and, by pulling, so moving the body. The pre-eminence of the hands is shown in week 13, where movement from prone to supine (or prone to prone) at the same time moving the head from the top to bottom of the cot, were both effected by hand-pulling and pushing at the cot. The hands and arms were also used in seizing cot wall and pushing away from it (Plate 8 , and diagrams fig.4.11 Chapter 4 , grasping development).

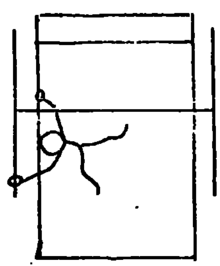
The primacy of the upper limbs seems to be one of coordination rather than strength <u>per se</u>; this is shown in the infant's ability to stand supporting most of his weight (when his hands were held and he was placed in a standing position) from the age of nine weeks (see Standing, below).

Cody attained the supine posture from prone in the tenth week, movement from supine to prone not until the 14th) and this led immediately (10th and 11th weeks) to grasp-cot-and-pull actions, seemingly aimed at the attainment of a sitting posture. The infant progressed from an almost pull to sitting (week 13) through an ability to pull-to-sitting when the experimenter's hands were grasped, to a completely independent pull to sitting in week 16.

Standing

Standing was also achieved in the 16th week, and its attainment can similarly be seen as the culmination and utilisation of several prior behaviours. Thus, the infant had been seen to pull his legs under him almost to a crawling position (see 3rd horizontal column (8th week) in Table 2.1) and, from the 13th week, to "grasp and pull" so that both hands grasped one side of the cot (see plate 8), after which the arms were straightened, so pushing the head and upper body away from the cot wall. In the 16th week Cody combined these two movements; the A-frame at the left of the cot was grasped by the infant's left hand, the right hand grasping the left side of the cot so that the infant was as shown in fig.2.1 . The legs were then drawn in under the body. Cody then pushed his head and upper body away from the cot wall, the legs bracing slightly at the same time with the result that a vertical posture (with the legs bent) was attained. Later the same day, the legs straightened completely, though for only a brief period of time. This latter movement may be considered as a further utilisation of the "legs extended" behaviour pattern.

Fig. 2.1



Standing from supine occurred 14.11.73, i.e. at the end of the 16th week, the infant first attaining a sitting position and then, with legs pulled beneath him, and hands grasping their respective cot walls, the legs were extended and Standing achieved.

Although the infant learned quickly (from week 17) to move around his cot in Standing and later to extend his perambulations - always supporting his movements by grasping cot or A-frame with at least one hand - it was not until the 26th week of life that true bipedal standing was attempted (i.e. without support from the upper limbs). In this, the infant first stood, holding either cot or A-frame; the hands were then released and held either above or to the side of his head as he attempted to balance on his legs. Cody was never very successful at this manoeuvre, managing at most three seconds standing before collapse. However, from his smiling expression and the great number of times the action was repeated, the exercise seemed to provide him with no small amount of pleasure. In addition, it very probably aided the infant's eventual bipedal running (see below).

Climbing

Climbing, in the adult-Orang sense (MacKinnon, 1974) first appeared in the 29th week, but its antecedents extend back almost to the time of standing, indeed this latter seems to have been a prerequisite for the former activity. One week after independent standing began, the infant commenced pulling himself up (using arms only, hands grasping A-frame), to such a height that his feet no longer touched the floor of his cot (17 weeks). At the same time, forward and backward movements of one leg were observed, sometimes the right leg participating, sometimes the left. These two actions, when coordinated, allowed the first placing of one leg on the side of the cot (Plate 11), and, by the end of the 18th week, Standing with both legs on the cot wall was seen (Plate 12). Straddling the cot was observed to commence the same week.

Pulling himself up by the arms continued throughout the study, with leg swinging appearing during the 29th week. The legs, previously unused, touched the A-frame in the 26th week, and grasped it on the 27th. With the legs in increasingly frequent usage from this time, as the infant's second pair of "hands", the way was now clear for climbing proper. This was first observed during the 29th week, with the scaling of the iron-mesh door between playroom and workroom. It is interesting that for three days Cody appeared able to scale, but not to descend from, the door. On one occasion, the infant, after climbing the door as the experimenter left, was found one hour ten minutes later, still at the top of the door. The experimenter sat on the floor at the base of the door for several minutes but, although giving every indication of wishing to reach his "parent", the infant did not (and presumably could not) descend. From this time on (29th week), and with the help of crawling (see below) Cody successively mastered virtually all objects and furniture in his quarters, including a small chair (39th week), the window ledge (49th week), the large cot (53rd week) the table (54th week) and the workroom sink (56th week). These objects do seem to form a scale of difficulty in climbing in which the primary dimension is height, (increasing from the small chair through to the sink). This is true for all but the cot and the table. Both these objects were of approximately the same height. In this case the availability of hand- and foot-holds (more present on the cot) seems to have been the limiting factor in climbing success.

Crawling

Crawling was first seen during the 24th week, and was, at this time, used only as a contingency when all other means of locomotion had failed. It was first observed 8.1.74, with the infant placed on the floor of the playroom, five feet from the experimenter. Cody made no attempt to move, merely raising one hand and crying. His blanket was then placed two feet from him, and in his desire to reach this comforter he crawled forward, as shown in fig. 2.2 .

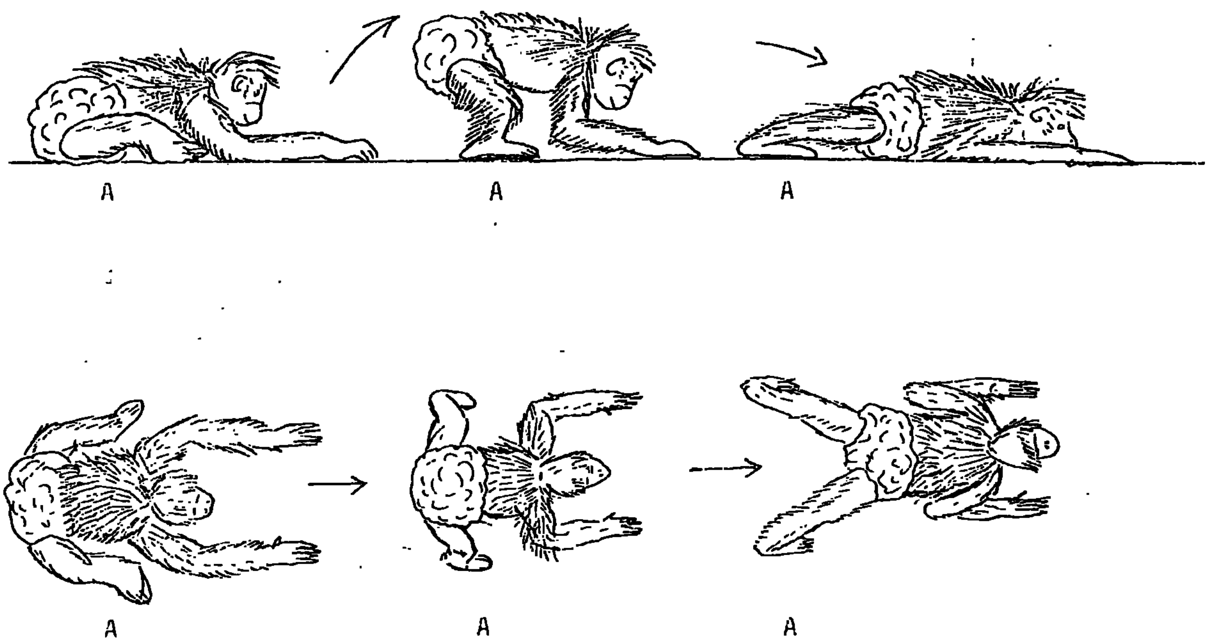


Fig. 2.2 Crawling Movements

Thus, the legs were brought forward so that the infant assumed the position shown in fig.2.2(i), the hind-quarters were then raised (ii), the feet remaining stationary, so that they passed over the legs, and attained a position forward of the feet (fig.2.2(iii)). Two cycles of "bum over legs" progression were seen as the infant made for the blanket.

Later that same day a more advanced form of crawling was seen. This consisted of the infant moving his left arm forward, his left feet drawn close to the body, while the right arm remained bent and the right foot extended (fig.2.3(i)).

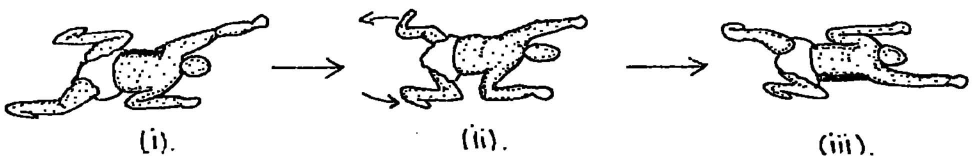


fig. 2.3

As weight was transferred to the left arm, the right leg began moving up to a position close to the body, while the left leg extended slightly at the same time (fig.2.3(ii)). Following this the left leg pushed down hard, impelling the body forward (and raising it slightly from the ground) while at the same time the right hand extended. The left hand, having remained immobile in its function as pivot for upper body, assumed a position close to the trunk, with the result that the position fig.2.3(iii) is a mirror image of fig.2.3(i). Further movement was by similar actions using the contralateral limbs to those described above.

It was not until the 26th week, however, that Cody initiated crawling movements, when having been left in his cot he was found (on one morning during this week) at the base of the play-, work-room door. Later (27th week) he began following the experimenter when he left the workroom, at one point crossing from the cot to the middle of the workroom where the experimenter was standing. That same week crawling from the cot to, and under, the experimenter's chair (next to the table) was seen. Afterwards, Cody gradually extended his out-of-cot forays, exploring under the large cot (28th week), part of the workroom (31st week), to the furthest point in the workroom (36th week) and to the window (41st week). Following this, every foot of play- and workroom space was covered by the infant's crawling peregrinations, though some areas, e.g. the S.E. corner of the work-room (where there were many electrical wires) were firm favourites. The term crawling, after the 29th week, is something of a misnomer, for Cody was, by this time, using a "crawl" which was very similar, if not identical to, the adult Orang-utan's quadrupedal "knuckle-walk"

Walking

Upright bipedal walking was not fully accomplished during the course of the experiment, Cody's greatest achievement being 3 - 4 paces of bipedal running before collapse, a behaviour which was first seen on the 91st week. Various actions of Table 2.2 can, however, be seen as precursors to this behaviour. Thus from standing inside the cot (15 weeks), grasping A-frame and raising legs (week 17), the infant went (by way of legs over cot wall in the 19th week) to standing outside the cot (week 22). Five weeks later the infant was standing away from the cot, holding the A-frame, accomplishing this by "walking" movements of his lower limbs while holding the A-frame for support. Between these two dates Cody learned to walk his way around his cot using as support for his perambulations both the A-frame and the various cot walls. The final stages of this type of behaviour saw the infant (week 27) making grasping movements towards any object within reach, this being now circumscribed by a semi-circle, centred at a leg of the A-frame and having a diameter equal to the span of his arms (fig.2.4). Attempts at bipedal standing (see above) may also be construed as an integral part of the eventual bipedal sprint which was the culmination of this particular behavioural series.

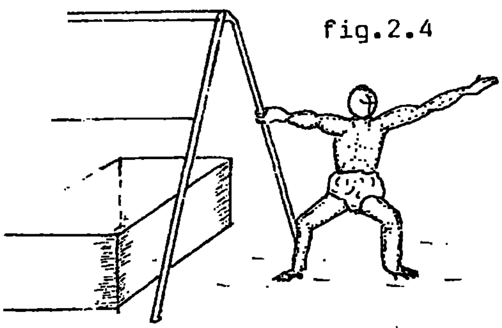
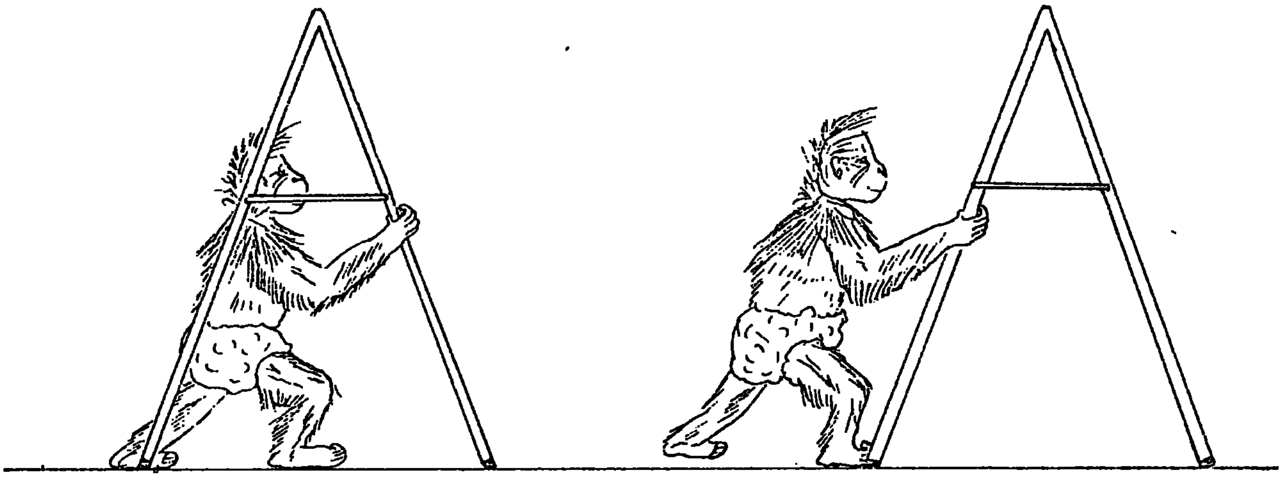


fig.2.4

Following Cody's grasping and standing behaviour (fig.2.4), the infant found that by over-reaching, it was possible to move the A-frame in the required direction, allowing an increase in "range". The behaviour later developed into the use of the A-frame as a baby-walker (week 32), with the infant standing either in the centre or at one end of the structure (fig.2.5 a and b), and pushing it towards his desired goal. The A-frame was also used to complement the iron-mesh door when climbing, although it was more often than not overturned and collapsed within minutes of reaching the latter.

fig.2.5



By the 56th week, the infant was extremely mobile, and seemed to look on each new structure he met not as an obstruction, but as a challenge. When temporarily away in a domestic setting, he immediately mastered sofa, new tables and chairs, the art of climbing onto window-sills using their curtains, and the scaling of a flight of twelve stairs. From this point on, and with the exception of bipedal walking which may conceivably have been bettered, any increase in the infant's mobility would seem to comprise more the experiencing of new objects and situations, and achieving mastery by combining previously existing behaviour patterns, than the development and maturation of new patterns of behaviour.

Gessel

The infant's responses to the behaviour items of the Gessel Developmental Schedules are given in Table 2.3. Data from the human subject (taken from Gessel & Armatruda, 1947), for Gorilla, (Knobloch and Pasamanick, 1959) and for Chimpanzee (Riesen and Kinder, 1952) are also tabulated, allowing a comparative analysis of the three pongid and the single hominid species to be made. (N.B. Riesen and Kinder's work is based on the results from an earlier version of the Gessel Schedules, (see Gessel and Thompson, 1938) and although similar, are not therefore strictly comparable).

The table shows that the motor development of the Orang-utan is much faster than that of the human subject in all but two aspects. These are behavioural item No.25, (hips high, legs flexed and crawling movements), and the "walking" items, Nos. 56 & 57. The former action is seen at 4 weeks in the human infant, (and even earlier in the

Table 2.3

BEHAVIOUR	Human	Gorilla	Chimp	Orang	
<u>Supine</u>					
1. Asymmetrical tonic neck reflex	4	6-10	(6)(5)	not seen	different
2. Midpositions & symmetrical postures predominate	16	10	11	<7	B
3. Hands engage in midline	16	2.5	<4	10	A
4. Feet engage in midline	-	14	-	14	G
5. Legs lift high in extension	24	12	-	12	G
6. Rolls to prone	24	10	11	14	A
7. Lifts head	28	2.5	4	<7	?
<u>Pull-to-Sitting</u>					
8. Complete head lag	4	0	0	0	* G+C
9. No head lag	20	10	<4	<7	C
10. Lifts head, assist.	24	10	14	9	G
<u>Sitting</u>					
11. Head predominantly sag	4	0	-	0	* G
12. Head predominantly bobbing	8	0	4	no data	-
13. Head set forward, bobs	12	6-10	-	8	G
14. Head steady, set forward	16	10	9	14	A
15. Head steady, erect	20	12	<4	17	A
16. Trunk erect in supportive chair	24	10	-	15	A
17. Sits leaning forward on hands.	28	16	24	24	A
18. Sits erect momentarily	28	-	24	26	A
19. Sits 1 minute erect, unsteady	32	18	25	26	C
20. Sits 10 minutes, steady	36	20	28	27	C
21. Leans forward, re-erects	36	20	23	-	-
22. Sits indefinitely steady	40	20-22	30	28	M
23. Goes to prone	40	20	20	28	A
24. Pivots in sitting	48	20-24	26	not seen	different

CONTINUED.....

Table 2.3 - continued

BEHAVIOUR	Human	Gorilla	Chimp	Orang	Appears in Orang
<u>Prone</u>					
25. Hips high, legs flexed, crawling movements	4	2.5	-	8	A
26. Lifts head to Zone I momentarily	4	0	0	0	G+C
27. Head drops in ventral suspension	4	0	-	not seen	* -
28. Head rotates on placement	4	2.5	-	<7	?
29. Head lifts to Zone II, recurrently	8	2.5	<4	3	*G
30. Head compensates in ventral suspension	8	2.5	<4	<7	?
31. Head in midposition on placement	8	4	-	<7	?
32. Hips low, legs flexed	12	4	-	<7	?
33. On forearms	12	4	<4	<7	?
34. Lifts head to Zone II sustainedly	12	4	<4	<7	?
35. Lifts head to Zone III sustainedly	16	6	<4	<7	?
36. Legs extended	16	10	-	<7	Ch?
37. Arms extended	20	14	11	<7	B
38. Pivots	32	10	12	15	A
39. Crawls, pushing with feet	[36]	10	14	24	A
40. Creeps	40	20	20	28	A
41 Creeps upstairs	15m	40	-	-	-
<u>Standing or Walking</u>					
42. Supports small fraction of weight briefly	12	10	<4	<7	Ch?
3. Lifts one foot momentarily	12	10	<4	<8	Ch? M?
4. Supports large fraction of weight	28	14	20	9	B
5. Bounces	28	18	-	not seen	-
6. Maintains standing with hands held	32	14	22	13	B
7. Holds rail, supports full weight	36	14	20	16	M
8. Pulls to feet at rail	40	14	20	16	M
9. Lifts and replaces foot at rail	44	18	25	17	G

CONTINUED .....

Table 2.3 - continued

BEHAVIOUR	Human	Gorilla	Chimp	Orang	
<u>Standing or Walking - cont'd</u>					
50. Cruises at rail	48	18	24	17	G
51. Cruises, using arms only	-	18	-	17	G
52. Cruises easily, using arms only	-	30	-	20	B
53. Walks with two hands held	48	28	⟨26⟩	28	G
54. Walks with one hand held	52	36	⟨26⟩	not seen	not seen
55. Stands momentarily alone	58	36	39	26	B
56. Walks few steps, stops and starts	15m	48	-	91	A
57. Falls by collapse	15m	48	-	91	A
58. Walks, seldom falling	18m	15m	-	not seen	
59. Runs stiffly	18m	12m	-	not seen	A(G)
60. Walks upstairs, one hand held	18m	40	-	14m	
61. Climbs into adult chair	18m	15m	-	39	B
62. Runs well, no falling	24m	18m	-	not seen	
63. Jumps, lifting both feet	30m	18m	-	not seen	

<u>KEY</u>

* = Data derived from keepers' information.

A = Develops <u>after</u> the date for the same behaviour in chimp and gorilla.

B = Develops <u>before</u> the date for the same behaviour in chimp and gorilla.

M = Develops between the date for the same behaviour in chimp and gorilla.

Ch = Develops at same time as chimp.

G = Develops at same time as gorilla.

Gorilla - 2.5 weeks) but does not apparently appear in this Orang-utan subject until the 8th week. It was at first thought that, as only one test session (week 7) preceded the 8th week test, the behaviour may not have shown during the 7th week, and, although being present from an earlier date, may for this reason have seemed to appear in week 8. However, study of the diary notes also indicates an absence of this movement during spontaneous movement observation. It is therefore concluded that the action was indeed missing from the infant's behavioural repertoire until observed in the eighth week. Items 56 & 57 were not seen during the 15 month duration of the experiment, but were observed during the regular monthly visits that continued after this time. On all other behavioural items Cody is in advance of the human norm.

Although developing faster than the human subject, the infant's progress is quite definitely cephalo-caudal (as is the case for man); control of the head appears first (e.g. head lifted to Zone I momentarily from birth), then the arms (pulls to feet at rail, week 16), the trunk (sits erect momentarily week 26) and finally the legs (walks a few steps, stops (and collapse) week 91). The section on the infant's general motor development also confirms a cephalo-caudal advance in motor development.

Knobloch and Pasamanick (1959) point to two outstanding differences that their research revealed between gorilla and human subject; firstly, the appearance in the Gorilla of prone progression (No.39) in advance of the use of the lower extremities in standing (No.44), and secondly, the ability of the gorilla to use its lower extremities in erect progression (No.50) before stable sitting (No.22) is achieved.

When the data pertaining to the Orang-utan is assessed, it is seen that, with regard to the first of the gorilla/human differences, this Orang-utan's development is more comparable with the human than with the gorilla infant. Thus, Cody was observed to stand supporting a large fraction of his weight at 9 weeks, thirteen weeks before crawling occurred (week 24). However, for the second of Knobloch and Pasamanick's discrepancies, Cody's behaviour parallels that of the gorilla, with cruising at the rail being seen at 17 weeks, whilst stable sitting did not appear until week 28.

The "see-saw" effect seen above with Cody in one case being similar to the gorilla and in the second case reversing this trend, is also apparent when his times of onset for the behaviour items are compared with both gorilla and chimpanzee. While the infant's progress seems to approximate much more closely the time-scale of the pongids, as opposed to man, the Orang-utan's advances seem to both differ from and be similar to each of the other pongid species tabulated depending on which behaviour items are looked at. This can be shown if any given behaviour item of the Orang is taken to occur at the same time as that of other pongid species when it falls on the same week + or - 1 week. Unfortunately, and owing to the fact that observation began in the seventh week, the times of onset of thirteen items are not known with precision, (Nos. 2, 7, 9, 28, 30 - 37, 42). However, in the majority of these cases it appears that Cody's times at least approximate those of its pongid relatives, (Nos. 7, 23, 30 - 35). It is not known, however, whether the Orang would occupy "before", "middle", or "after" positions with regard to the chimp and gorilla. Of the remaining five "less than seven weeks" items three can definitely be placed as occurring before the chimp and gorilla, (Nos. 2, 36 & 37) whilst the remaining two (Nos. 28 & 42) can be considered either as intermediate between the two other pongid species, (as their occurrence was definitely before the data for gorilla) or at approximately the same time as the chimp.

With the remaining behaviours, (apart from 12, 21, 41 where no details available) more definite statements can be made. Behaviour items which arose in the Orang <u>before</u> being seen in the gorilla and chimp subjects studied are Nos. 44, 46, 52, 55, 61. Those appearing <u>after</u> mastery by both other pongid species number fourteen (3, 6, 14 - 18, 23, 25, 38, 39, 40, 56 & 57). Behaviour items falling on the same week (plus or minus one week) as the chimp are Nos. 9, 19 & 20, whereas those corresponding to the gorilla time-scale are 4, 5, 10, 11, 13, 29, 49, 50, 51 and 53. Items appearing between the dates given for chimp and gorilla are four in number (Nos. 22, 43, 47, 48) whilst only two (Nos. 8 & 26) behaviours are seen at the same time in all three pongid species. Certain actions were never seen in the Orang-utan (Nos. 1, 27, 45 & 54). These may indicate definite differences in the species' development compared to Man. Behaviour items 58 & 59, 62 & 63, were also not seen, but as they are "late arrivals" in all species it is possible that, had the experiment continued, they would have been observed. Behaviour No.60, although seen cannot be taken as time of onset as the infant had not been exposed to stairs or stair-like structures up to the 14 months.

The finding that, overall, Cody's behaviour shows more points of correspondence with the gorilla (10) than with the chimpanzee (3), presents problems of interpretation. Knobloch and Pasamanick (1959) considered the gorilla's motor development to be accomplished in a shorter period of time than the chimpanzee's, and hypothesised that this extended development of the chimpanzee was in some way correlated with its greater intelligence. However, in the Orang-utan we seem to find a greater similarity with the gorilla than with the chimp (i.e. Cody achieves these ten behaviours faster than the chimpanzee (plus 5 items which appeared before both species)), yet there are many items (14) in which this Orang-utan's development is even more extended than that of the chimpanzee.

This lack of pattern may well speak for a different maturational pattern for each species. However, there is a second explanation for the above confusion, and one which seems more plausible.

As has been stated on several occasions, the primates are a notoriously variable group, both physically (e.g. Schultz, 1930, 1956, 1969) and behaviourally (McGrew, 1972). It should further be noted that, whereas the Gessel Test human norms are based on an "n" of 40 subjects (Gessel & Armatruda, 1947) and Riesen and Kinder's (1952) study on 16 subjects, the gorilla and Orang-utan's results refer to a single subject only. Reference to a second, more general account of the development of two gorilla infants, Alice and Ellen (Kirchshofer <u>et al</u>, 1968) serves to emphasise this point. Not only did the two infants develop at a different rate one from the other (for example, up on elbows in the prone position was attained in the third week with Ellen, the fifth week with Alice; supine to prone was consistently attained in the seventh week for Ellen, the eighth for Alice), but aspects of their development differ to an even greater extent from that of Knobloch and Pasamanick's "Colo". For example, behaviour comparable to Gessel behaviour item No. 25 was seen in Alice and Ellen during the sixth week, whereas Colo showed similar behaviour at 2.5 weeks, a difference of 3.5 weeks.

Hence, the lack of interspecific pattern in motor development may be explained by the small number of subjects studied, both for *Gorilla* and *Pongo*. When normative data for each species *are* known (including the chimpanzee's responses to the later Gesell test - see above), a pattern may be found which accommodates all pongid species. Alternatively, each species (and especially the more phylogenetically-removed Orang-utan) may posses its own ontogenetic sequence. At present it appears that the gorilla accomplishes most behaviour patterns before the chimpanzee, with the Orang-utan's actions occurring over a longer period of time than either. However, it is possible that further work, especially on the gorilla and Orang-utan, may completely disrupt this pattern.

CHAPTER THREE

PIAGETIAN COGNITIVE DEVELOPMENT

4.2. OBJECT CONCEPT DEVELOPMENT

4.2.1. COVER EXPERIMENT

Introduction

The human infant in the first few days of life is thought of as existing in a universe which is qualitatively different from that recognised by an adult; the neonate's world is comprised of pictures that may be recognisable to the infant, but which, as yet, have no permanence or spatial organisation. Piaget attempts to analyse the means by which the awareness of the object as a separate entity, existing independently of the beholder in both space and time, comes about.

Attainment of Object Notion, at around 18 - 20 months, is divided into six stages (the sequence, and not the time of occurence, being the important question) these stages corresponding to those described in the preceding section for general development, (Piaget 1955.). These stages can be elucidated by reference to the infant's response when an object which the subject wishes to possess is hidden behind a screen of some description (usually a cloth cover). During Stages I & II (0 - 4½ mo) the infant either stares at the last seen position of the object or looks away at some other point of interest, when the object is thus hidden, or even half-hidden. Searching for a half-hidden, but not a completely hidden object is indicative of Stage III (4½ - 8 mo), while a successful search for a completely hidden object is a Stage IV behaviour pattern. However, at Stage IV (8 - 12 mo) if, after several trials the object is moved from its first hiding place (designated A) to a second position (B), all within sight of the subject, the infant will search at point A, and not think to attempt B. Stage V (12 - 18 mo) is characterised by the infant searching in the last-seen position of the object, but being limited only to what he sees. The infant is unable to cope with an invisible displacement, e.g., if an object hidden in the experimenter's hand is then placed beneath a cover, the object being (silently) released, and the now-empty closed hand offered to the subject, the infant will search the hand, but not under the cloth cover. Stage VI is reached when this final limitation is overcome.

Much work has been done in replicating parts of Piaget's comprehensive study, Décarie (1965), Uzgiri and Hunt (1966), and Casati and Lezine (1968), have designed sensorimotor series to test for Piaget's 'stages'. Several investigations of the relevance of these stages have been undertaken, e.g. Uzgiri and Hunt,1972; Corman and Escalona, 1969; Miller, Cohen and Hill, 1970. Paraskevspopoulas and Hunt (1971) have shown the environment to play an important part in rapidity of attainment of this concept, whilst Mattsay (1975) has found evidence for a biological foundation to the emergence and elaboration of sensorimotor capabilities in monozygotic twins. Bower (1971) examined the evidence for object concept in very young children, and Bell (1970) the relation of this concept to infant-mother attachment. Recently, the Stage IV AB response has been the subject of detailed study in attempts to identify the true cause of the child's error. (Gratch, Appel, Evans, Lecompte and Wright, 1974; Landers, 1971; Gratch and Landers, 1971; Evans and Gratch, 1972; Harris, 1973). In addition, Woodward has found correlations between object concept attainment and performance of Piagetian tests in mentally subnormal subjects (Woodward, 1959).

To date there has been very little work done on the development of the object concept in infra-human organisms. Indeed, its existence in animals as closely related to Man as the non-human primates could until recently only be inferred from research directed at the elucidation of other problems. Thus, Gorter (1941) reports that Nycticebus spp. will not remove a cover which it has seen placed over a desired object. Galago senegalensis is said to succeed in a similar task, (Lowther, 1939), although it is not stated whether auditory cues (in the form of object (insect) movement) were precluded. The evidence of Tinklepaugh (1928) and others point to the conclusion that some adult primate species do possess at least a Stage IV object concept capacity. Such data have been obtained for five primate species , the Squirrel Monkey, Saimiri sciurea (Vaughter, Smotherman and Ordy, 1972), the Rhesus (Wise, Wise and Zimmerman, 1974), and the Capuchin, Woolly Monkey and Chimpanzee (Mathieu, Bouchard, Granger and Herscovitch, 1976). In all but the Woolly Monkey a Stage VI level of competence was achieved. However, in all these studies, no no animal has been followed longitudinally; it is therefore not possible to state that the path of object concept development follows that of Man. Further removed from Man, the cat is reported to be capable of a Stage IV discrimination, i.e. it looked for the desired object persistently after it had been completely hidden (Gruber, Girgus, Banuazizi, 1971). Stage V could not be tested, and it was found that a Stage VI discrimination produced no response in the experimental animal. Etienne (1973) describes her work on the domestic chick and concludes that the creature "seems not to go beyond the association between certain stimuli and certain responses to such stimuli, and such situations remain limited to a standardised situation. Birds produce certain adaptive responses, but this is not absorbed into a general cognitive structure". The only other animal tested, the dragonfly, as befits its lowly phylogenetic position, apparently shows only stereotyped responses at the disappearance of its prey, (Etienne, 1972).

These meagre data do seem to indicate a tendency for animals 'higher on the phylogenetic scale' to show a greater number of the developmental stages postulated by Piaget. Further, work on communication with the chimpanzee by Gardner and Gardner (1969, 1971), Fouts (1972) and Premack (1971) do seem to show the ability of our nearest relatives to manipulate symbolic sequences, an ability which, according to Piaget, becomes manifest at the end of the sensorimotor period.

Method

Testing with regard to the development of the Object Concept was initiated on the 15th. November, 1973 (infant's age: 15 weeks 6 days). All testing was carried out in the playroom of the infant's quarters, on a natural wood test table (36" x 24") which was secured to a second table, this latter being a permanent fixture of the room. In order to make the procedure as closely comparable as possible, the method was essentially the same as that of Piaget in the detailed study of his three children (Piaget, 1952). A single important difference concerns the relative positions of experimenter and subject. While, from a reading of Piaget's work it seems that the majority of trials were given with subject facing the experimenter, in the trials detailed here subject sat on the lap of the experimenter, facing the test table upon which all experimental manipulations were performed. Contact seeking is most pronounced in the infant Orang-utan, as indeed in most young primates, and it was found impossible to sit the infant opposite the experimenter, across a table. Likewise, restraining straps only served to produce violent screaming and non-attention to the task in hand.

Toys, brightly coloured objects, clothes and other paraphenalia that might distract the attention of the infant were removed from the playroom prior to testing. The subject was carefully observed during placement of the desired object and its subsequent disappearance beneath the cloth cover; any lapses of attention (turning or climbing away, sucking the table edge, etc.) during the final stages of placement or hiding could easily be detected. When this did occur, that particular trial was terminated and the covering procedure begun again from the "object uncovered" position. So as to obviate difficulties arising from cover novelty, only covers of well-known and familiar material were used.

In order to determine the various Piagetian stages, several variations of cover situation were used. Criterion for all tests was set arbitrarily at 75% correct response in any cover situation.

Cover Situations

1. Half Covered (HC). This was initiated before criterion was reached with CHF. The desired object was half covered as the subject reached toward it. Whenever possible, the cover edge was made to follow the line of symmetry with the object.

2. Covered/Hand Free (CHF). The object was covered as subject was in the act of reaching toward it. In this, and all subsequent object concept testing, an arbitrary time limit of 1½ minutes from time of covering was set. If no response was forthcoming during this time the trial was terminated and a new trial begun.

3. Covered/Hand Held (CHH). On reaching criterion in the CHF test, the subject's hand was held immobile while the object was covered, and immediately released as the object disappeared from view.

4. One Displacement (OD). In line with Piaget's investigatory method, the object was hidden in one place (designated A, irrespective of side). When found consecutively two or three times in this location, the subject, with hand immobilised, was obliged to watch the object being hidden beneath a second cover, B. His hand was then released and his choice of side recorded. If the incorrect side was chosen, he was allowed to correct his mistake. To prevent the development of side preferences 'true' trials were given with 'balance' trials, i.e., if A - B was from left to right, trials were given in a random order, but with never more than two consecutive trials at any one side, e.g. AB, BA, AB, AB, BA, etc. In addition, the side used as A was alternated over sessions.

5. Two Displacements (TD). Having successfully reached criterion for the OD test situation, subject's ability to cope with two successive displacements was investigated. After initial success in finding the object hidden in one location (A) two or three times, the infant watched the object hidden sequentially in A then B then C (hand held). As in the OD test, as the object disappeared beneath the third cover and the experimenter's hand withdrew, the subject's hand was released and his behaviour sequence recorded. The order of hiding was randomised, all three covers being used as the final position in the hiding sequence. Thus the object might first be hidden at B, then C, and finally at A. All covers received an approximately equal number of trials as the 'correct' position. Subject was allowed to correct his errors during all trials.

6. Invisible Displacement (ID). With the subject watching, the desired object was placed in a small blue plastic pan, and these were together placed beneath a cover. Under this screen the object was tipped out, onto a blanket to obviate any response to auditory cues. The (empty) pan was then removed

from the cover and offered to the infant. At the same time the subject's hand (previously held) was released and ensuing behaviour monitored. After reaching criterion in this test, two covers A and B were used, the pan plus object being hidden randomly, but not more than two times consecutively on any side, beneath A (ID-A) or beneath B (ID-B).

In all six cover situations a 'hand free, object uncovered' situation was presented frequently throughout each session to ensure that the object remained desirable. A further safeguard was added to the ID test. Here the pan plus object was moved beneath the cover as normal, but a sham tipping movement was made, the pan plus object being then offered to the animal at the same time as his hand was released. If the infant had 'decided' that each time the object and pan went under the cover, the object was to be found beneath the cover, then he might be expected to ignore the pan plus object when it was presented, and to pull at the cover. That this occurred only once in 41 trials strongly suggests that in almost all cases the infant did first look at the pan and, having seen it empty, searched beneath the cover. Incidental observations of eye movements during the experiment tended to confirm this assumption.

It was found that the infant soon habituated to previously interesting objects and it became impossible to provide sufficient novel objects to maintain his attention. A solution to this problem was found by using a small feeding bottle filled with a variety of sweet-tasting solutions of which he was particularly fond. In this way interest was maintained without the infant receiving over-much of the liquid.

The subject was considered to have succeeded in any particular cover situation if (a) the infant first removed that cover which hid the object, and (b) if this cover was quickly released and the test object secured. The subject was run for as long as he would cooperate.

Results

The results for the various cover situations are tabulated in Table 3.2 overpage. All results have been computed as percentage correct response of the total definitive trials of that session. Figure 3.1 demonstrates more lucidly the development of the infant's responses over the period of testing.

BLE 3.2. Percentage Correct Response in the Six Cover Situations.

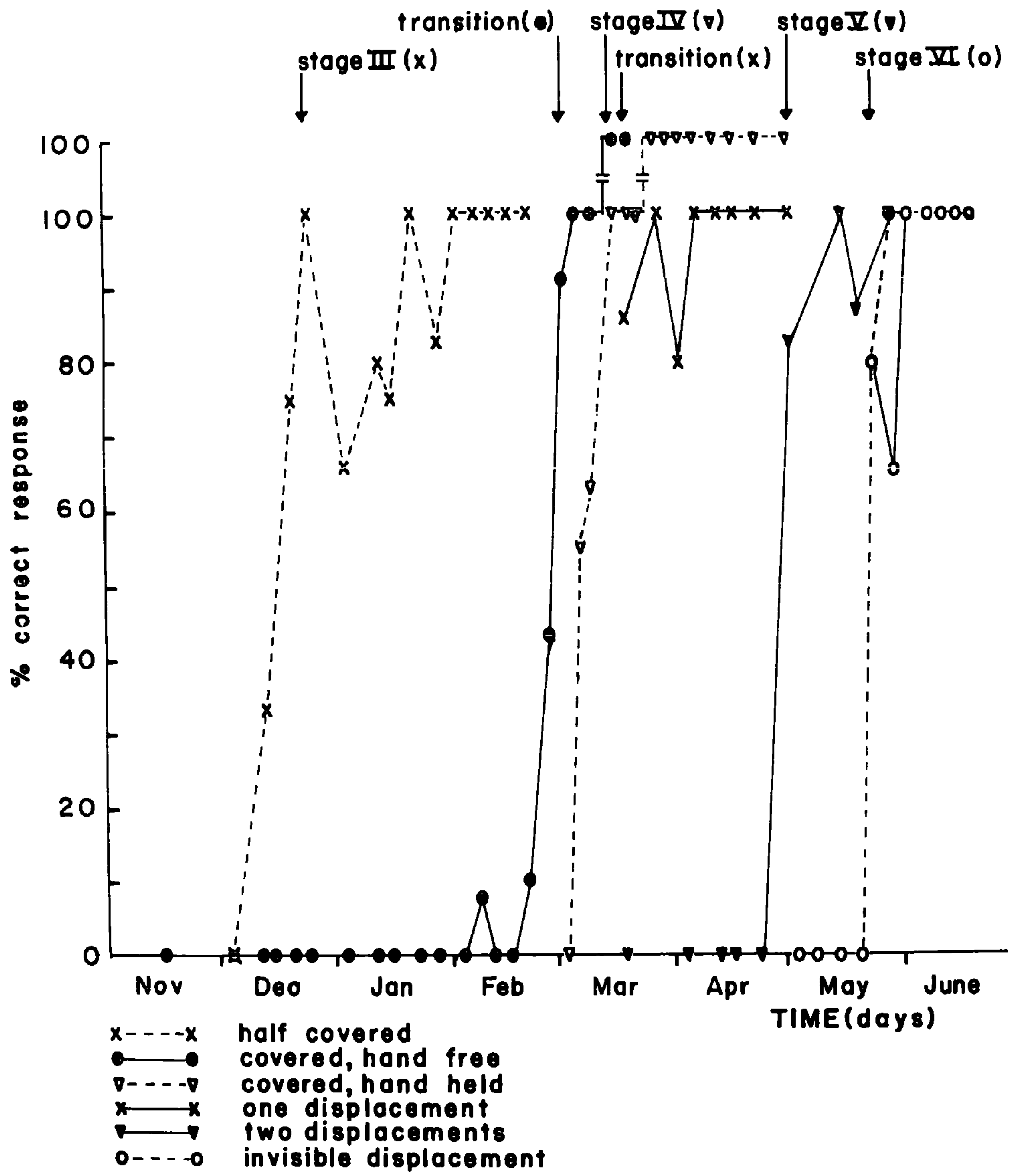
	Cover Situations							
te	H.C.	C.H.F.	C.H.H.	O.D.	T.D.	I.D.	ID-A	ID-B
.11.73	-	0 (9)						
.12.73	0 (3)	0 (5)						
.12.73	-	0 (8)						
.12.73	33 (6)	0 (6)						
.12.73	75 (4)	0 (8)						
.12.73	100 (7)	0 (6)						
.1.74	66(12)	0 (7)						
.1.74	80 (5)	0 (8)						
.1.74	75 (4)	0 (5)						
.1.74	100 (4)	0 (2)						
.1.74	83 (6)	0 (4)						
.2.74	100 (5)	0 (5)						
.2.74	100 (9)	8 (12)						
.2.74	100 (5)	0 (5)						
.2.74	100 (5)	0 (10)						
.2.74	100 (3)	10 (10)						
.2.74		43 (13)						
.3.74		93 (14)	0 (4)					
.3.74		100 (8)	56 (9)					
.3.74		100 (7)	63 (8)					
.3.74		100 (3)	100 (10)					
.3.74		100 (1)	100 (14)					
.3.74			100 (9)	86 (7)	0 (4)			
.3.74			100 (3)	100 (3)	-			
.3.74			100 (10)	-	-			
.4.74			100 (4)	80 (20)	-			
.4.74			-	-	0 (5)			
.4.74			100 (6)	100 (12)	-			

tinued overleaf

BLE 3.2 (continued)

	Cover Situations							
te	H.C.	C.H.F.	C.H.H.	O.D.	T.D.	I.D.	ID–A	ID–B
3.4.74			100 (11)	100 (5)	0 (5)			
7.4.74			100 (7)	100 (8)	0 (6)			
3.4.74			100 (6)	100 (7)	0 (5)			
2.5.74			100 (3)	100 (3)	83 (12)	0 (5)		
9.5.74					–	0 (9)		
5.5.74					100 (10)	0 (10)		
0.5.74					88 (9)	0 (10)		
4.5.74					–	80 (15)		
9.5.74					100 (3)		100 (6)	66 (9)
1.6.74							100 (6)	100 (5)
4.6.74							100 (10)	100 (9)
8.6.74							100 (7)	100 (7)
1.6.74							100 (7)	100 (7)
3.6.74							100 (7)	100 (7)

FIG.3.1
PERCENTAGE CORRECT RESPONSE TO SIX COVER SITUATIONS AS A FUNCTION OF TIME.



Discussion

With regard to the temporal order of "stage" development it can be seen from the data presented that this orang-utan subject followed an almost identical path to that postulated for the human infant. Thus, when an object was hidden from view, the animal did not search before it would search, it searched for a half-hidden object prior to seeking one completely hidden, and so on throughout the various types of cover situation presented. There is therefore a definite correlation between the stages exhibited for both orang-utan and human subjects. The only exception to this appears to be the CHH situation and the OD situation. In the latter criterion was reached in the first test session despite the fact that it was but four days after the infant was consistently successful in the CHH test. There is a possibility that the subject could pass the two tests simultaneously. However, his relative uncertainty in the first three OD sessions (86.5, 100 and 80 per cent correct response respectively) compared to his later faultless performance is reminiscent of the results of stages III and VI, and therefore speaks for these initial OD results documenting the beginning and consolidating of this particular stage. Nonetheless, it is impossible at present to state categorically that this is indeed the case.

While the stage sequence in Pongo and Homo are virtually identical, their approximate chronological age of occurrence does seem to differ, this orang-utan subject reaching the beginning of Stage VI at 10 months 1 week, and the human infant at around 18 months. Table 3 details the stages and approximate age of onset in Man (Flavell, 1963), together with that for the single orang-utan subject studied.

Table 3.3 Piagetian Sensorimotor Stage Development in Man and Orang

Piagetian Stage	Response to Various Cover Situations	Succeeds Cover Situation	Approx. Age of Occurrence (months)	
			H. sapiens	P. pygmaeus
I & II	Looks away or continues to stare at object's last-seen position	-	$0 - 4\frac{1}{2}$	$0 - 5\frac{1}{4}$
III	Searches for partly hidden object	HC	$4\frac{1}{2} - 8$	$5\frac{1}{4} - 8\frac{3}{4}$
Transition	Searches only if in act of reaching to object	CHF	Within 8th month	Within 7th month
IV	Searches under cover for object. Gives up if deeply hidden. fails: object (A) → (B)	CHH	8 - 12	$8\frac{3}{4} - 10$
Transition	Succeeds: object (A) → (B) Fails: object (A) → (B) → (C)	OD	Within 11th month	Within 9th month
V	Searches in place object last seen i.e. succeeds: (A) → (B) → (C) Fails: invisible displacement	TD	12 - 18	$10 - 10\frac{3}{4}$
VI	Succeeds: invisible displacement	ID	18 - 24	10 - ?

The great variation in speed of development within H. sapiens and indeed all primates precludes any firm conclusions with regard to individual stage-length data derived from a single member of the genus Pongo. This is especially true in the light of Paraskevspopoulas and Hunt's (1971) results on the influence of different rearing regimes on attainment on the various stages of Object Concept. However, with regard to age of attainment of the final sensorimotor stage, it does seem reasonable to conclude that the wide differential that exists between the two species (18 months for Man as compared to just over 10 months for the orang) indicates a telescoping of development in the non-human primate (or converesly, an extended sensorimotor period in Man). Cody's rearing did approximate normal human rearing, a fact which should aid comparability. Whether, as is suggested by the (admittedly limited) data, the length of each successive stage is proportionately smaller in the orang-utan when the two species as a whole are considered (e.g. ratios of H.sapiens/P.pygmaeus are 1/1 for stages I and II, but 8/1 with regard to stage V) only future work will elucidate.

On viewing figure 1 it is apparent that in all but one cover situation (the HC situation) the animal moved from a less than 10% correct response achievement - and in most cases this was 0% - to criterion within the space of a very few days, (mean: 11.6, range 0 - 23 days). Once achieved, this level of accomplishment was maintained for as long as testing was continued. The single exception to a relatively swift elucidation of a stage problem occurs during the HC tests, and this was also the problem wherein, having reached criterion, performance fell once below the 75% level. The explanation for this behaviour would seem to lie in the nature of this specific problem, in that a consistent portion of the desired object was not consistently exposed. Certain portions of any object seem to allow the infant to more easily construct the whole from the part (compare Piaget's report of his offspring's difficulty in recognising a toy stork when certain parts were hidden, 1954, pp.28 ff). It is thought likely that in such cases where performance, after having reached criterion, fell below the 75% level, this was due to the inadvertent presentation of a particularly difficult (i.e. to allow part-whole reconstructions) portion of the object. That this was the case is supported by an incidental test carried out during the HC testing - here the object was a small plastic pan. It was found that when only the handle of the pan was visible the subject produced a 100% correct response. With half the body of the pan (and no handle) visible, a 75% correct response was elicited, and with only a small arc (approximately 1/6 of the circumference) uncovered 0% correct response was shown.

With reference to Stage VI, it was thought worthwhile to examine the possibility that an $A\bar{B}$ phenomenon might exist at this developmental period. Accordingly, and as described for the ID test, the object was hidden and the infant allowed to find the object several times under one of two covers (designated A). The object was then hidden in a similar way at the second of the two covers (B). As Figure 1 and Table 2 show, there is a slight indication that the infant searched in the position it had usually been successful during this ID hiding, whereas it had previously overcome this error during the TD tests. It may be that this is a very fleeting stage in the development of object notion, although the small number of trials and the single subject prevent any firm conclusions on this matter. It would, however, be in accord with Piaget's principle of horizontal décalage, and might perhaps repay more detailed study using a greater number of subjects.

The phylogenetic scale, which the evidence of the few species studied seems to give, may in fact be more apparent than real. It is very likely that certain species in different genera will develop an object concept. Certainly, to be without the object notion would be extremely maladaptive for any predator. Consider an eagle watching a hare dart beneath a bush; if it was not aware of the creature's continued existence the vast majority of meals might easily be missed. We should perhaps seek an evolutionary scale not in the development and learning of separate concepts, but in the number of different concepts attained (e.g. spatial and temporal), and the interrelation of these into a complex cognitive matrix.

4.2.2. BOTTLE EXPERIMENT

Introduction

A passage in Piaget's "Construction of Reality in the Child" (Piaget, 1955, pp.30 - 31, 126 - 128) suggested the feeding bottle as a means of exploring the infant's Object Concept, and his awareness of spatial relations. Piaget presented the bottle to his son Laurent in a variety of ways. When within reach the infant can move the bottle from any position in such a way that the teat is placed in his mouth. There is one exception to this ability - when the bottom of the bottle is at 90^{o} to the infant's line of vision, that is, when the teat is obscured by the base. During Stage III the infant will suck the base of the bottle and will act as if the teat did not exist. It is as if the child acknowledges a part-whole relationship with regard to the bottle in the terms "base of bottle equals object bottle", but still persists in the "idea" that its own actions are in control of the object, i.e., that the act of sucking will create the teat de novo. Later, having achieved Stage IV, and the ability to find completely hidden objects, presenting the infant with the base of the bottle produces a search for the teat. The following experiment attempted to determine if such behaviour is seen in the orang-utan under study, and if so, whether time of attainment of this ability corresponded to the time found for mastery of the stage III & IV tests given during the cover tests.

Method

The act of grasping towards the teat is used to ascertain whether the teat was construed by the infant as a permanent part of the object "bottle". However, before such a test can be performed, it is necessary to determine if the infant recognises the teat as the functional end of the bottle, i.e. the end from which his "reward" is obtained. If the infant is without such a concept, then failure to search for a hidden teat (or sucking at the base of the bottle) cannot be taken as evidence as lack of a Stage IV object concept. It is simply that the infant does not recognise the teat as the area from which milk can be obtained.

Accordingly, the bottle experiment was divided into two separate test situations.

(i) Functional End Recognition

(ii) Teat-obscured Reaction

(i) Functional End Recognition

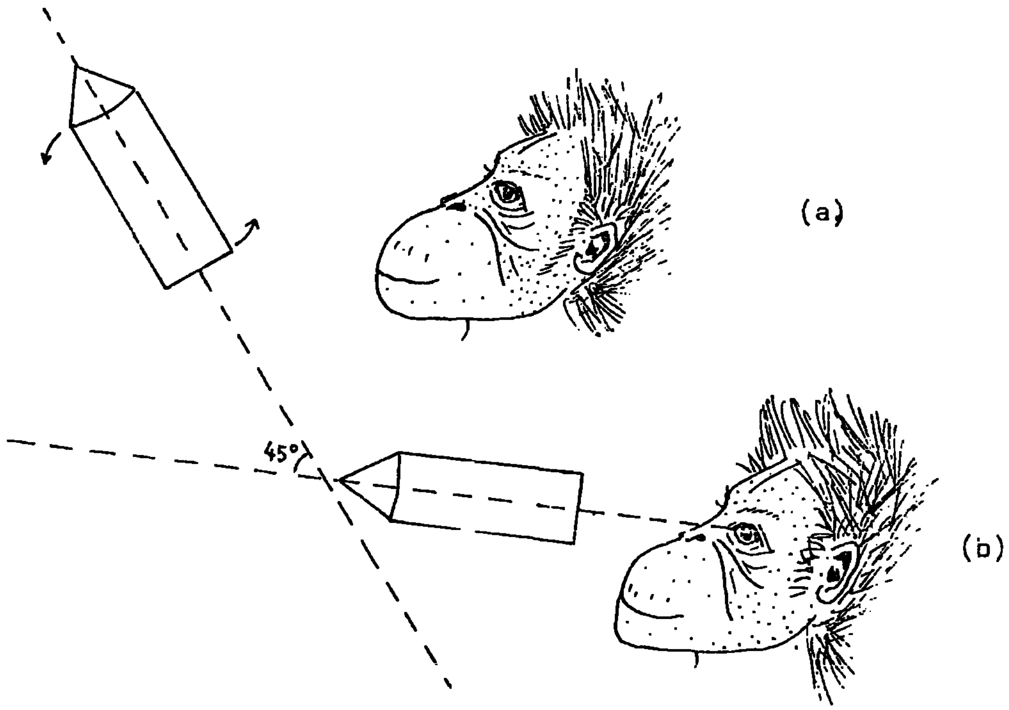
All experiments were conducted at feeding time, after cereal feeding to ensure moderately high motivation, found by Birch (1945) to be most conducive to problem solving. Following a preliminary session on 7.11.73 (in which the infant, presented with the bottle in an upside down position, just sucked close to the nipple (fortuitously) and then proceeded to move tactically upward toward the base of the bottle (4 trials), all trials were conducted in a standardised manner. Here, as in experiment (ii), the infant was seated on the teacher's lap, so as to obviate fussing and non-attention during presentation.

The feeding bottle was presented to the infant in one of two manners, horizontal with the teat to the right, or horizontal with the teat to the left. On each trial the movement of the bottle to left or right (from the vertical) was performed out of sight of the infant, i.e. the bottle's position was each time presented as a fait accompli. Each placement was random, but such that the bottle was never presented more than two times on any one side. The infant's responses to the bottle were noted, and marked as either positive (infant grasping at teat end) or negative (infant grasping/sucking at base of bottle).

(ii) Teat-Obscured Reaction

At each test session, (except sessions 1 & 2, where the bottle was presented as in fig.2 b, and in a vertical position) the infant was first presented with the bottle as in fig. 2 a. The bottle was then turned through an angle of 45° the teat being moved away from, and the base toward, the infant. Such a movement placed the bottle as in fig. 2 b, with the base of the bottle effectively obscuring the infant's view. The infant's behaviour before, during and immediately after this event was noted. On one occasion (26.12.74) the movement of the bottle was reversed (i.e. b to a, fig.3.2) and response observed. The two movements were lumped for purposes of analysis.

Fig. 3.2: Presentation method
for Teat-Obscured Test



Results

(i) Functional End Recognition.

The infant's success or failure at reaching for the correct end of the bottle are tabulated for each session in table 3.4 and shown graphically, fig. 3.3.

(ii) Teat-Obscured Reaction

The infant's responses per session are compiled in table 3.5 and marked according to whether he did (+) or did not (-) perform the action detailed at the top of the column. The results are detailed in fig. 3.4.

Table 3.4

Functional End Recognition						
Date	Left		Right		Total	
	(+)	(-)	(+)	(-)	(+)	(-)
15.12.73	0	2	0	2	0	4
20.12.73	0	4	0	4	0	8
24.12.73	2	3	3	0	5	3
	3	0	3	0	6	0
25.12.73	2	0	3	0	5	0
29.1.74	4	0	4	0	8	0
5.2.74	1	0	2	0	3	0
10.2.74	2	0	1	0	3	0
20.2.74	3	0	3	0	6	0

Table 3.5

Teat Obscured Reaction

Date	Teat in View (vertical) searched		Teat in view (45^o) searched.		Teat out of view. searched.	
	+	−	+	−	+	−
15.12.73	0	6			0	6
20.12.73	0	6			0	6
26.12.73			6	0	0	11
22. 1.74			3	0	0	4
29. 1.74			4	0	0	4
5. 2.74			6	0	0	6
10. 2.74			6	0	0	6
20.2.74			6	0	3	3
1.3.74			5	0	5	0
6.3.74			6	0	6	0
23.4.74			3	0	3	0

FIG.3.3
FUNCTIONAL END RECOGNITION TESTS.

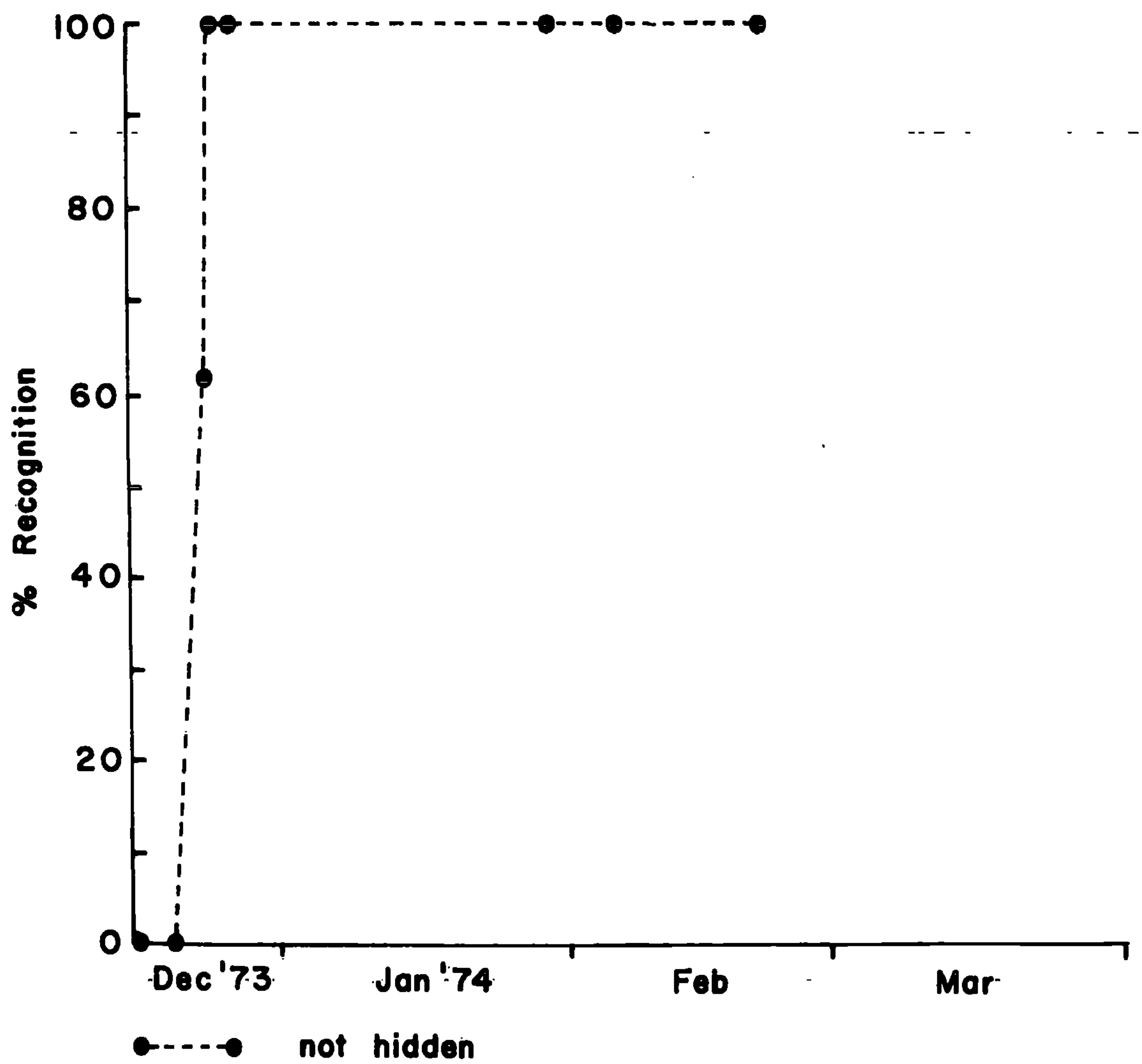
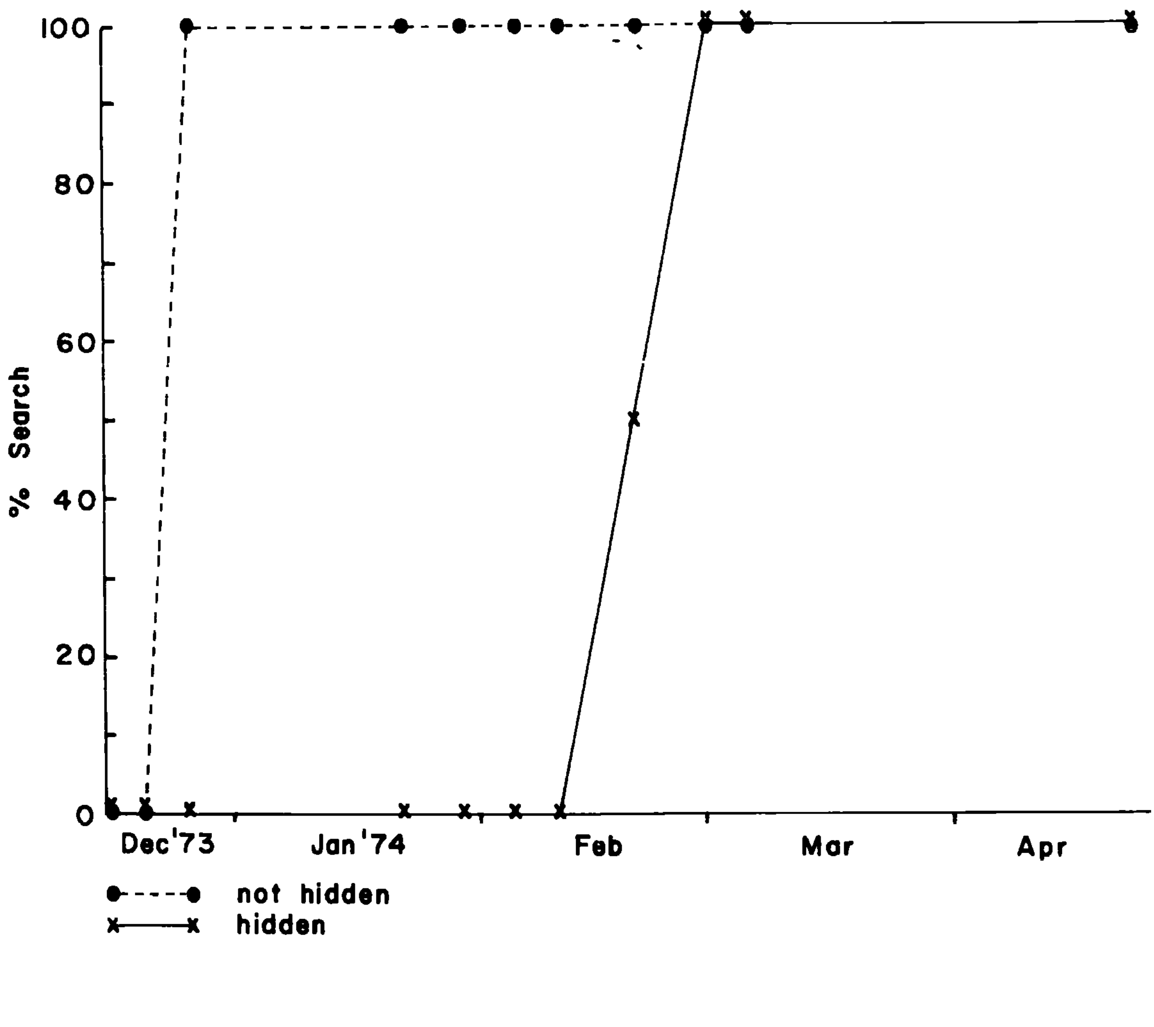


FIG. 3.4
TEAT OBSCURED REACTION TESTS.



Discussion

Functional recognition of the teat begins December 24th, a date confirmed by the "not hidden" portion of the Teat Obscured test, where the infant's systematic searching for (i.e. grasping towards) the unobscured bottle began on 26.12.73, although it was not present during the test session six days previously. There is a lag of 56 days between the attainment of this awareness and the ability to search for the teat when it is hidden by the bottle's base (attainment arbitrarily set at 80% correct response). In each case achievement is rapid, being five days for functional end recognition, and 20 days with regard to the Obscured Teat reaction. This latter result may have been substantially reduced had time allowed testing within a few days of 10.2.74. Nevertheless, times to attainment fall within and echo those seen for the object concept cover test (0 – 23 days) to which they are related (see page 42).

It is profitable to discuss in more detail the infant's behavioural responses at the times of attainment of the two abilities, and for the tests immediately preceding and following these times.

In the case of the Functional End experiment, close observation revealed what appeared to be an early $\bar{A}B$ or position preference phenomenon. Session 2, on 20.12.73, resulted in the infant grasping at the centre of the bottle (no recognition of functional end). However, during the first session of the 24.12.73, after having correctly grasped the teat end on the right side during Trial 1, the infant, on Trials 2 & 3 grasped the wrong end when the teat was presented on the left (i.e. the infant grasped at the previously correct (Trial 1) side). Trial 4, with the teat at the right, was responded to appropriately, but Trial 5, (teat on the left) once again produced an incorrect response. At each incorrect response the infant appeared "stuck", seemingly unable to release his grip on the incorrect end (holding it for up to 20 secs.) even though his eyes were observed to dart to the correct end from one to three times during each trial. Piaget reports similar behaviour with one child during cover testing; with the object in sight (in a new position), the child looked at the object while at the same time raising the cover under which the object had previously been found (Piaget, 1955, Obsn.39)

Later, on a second session of that day, the infant produced 100% correct response (see fig.3.3) but on each of the three occasions when the position of the bottle was changed his hand was observed to make towards the base end of the bottle (to the side previously correct, but now - because of the change in position - incorrect). However, the infant's arm stopped before grasping occurred, moved to the correct end, and prehended the teat. One day later, 100% correct response was again forthcoming. No arm movement towards the incorrect end was seen on the 4 occasions that the bottle's position was changed, but eye movements did continue this action, i.e. Cody looked first to the incorrect (previously correct) side, before appropriate arm movement was initiated. Thus, there seems to be a definite $\overline{A}B$ phenomenon (or a position preference) in which the infant appears to believe that his own actions are important. An alternative explanation is that the infant uses the behaviour pattern which, in his limited repertoire, is most likely to succeed. Such an explanation seems plausible when viewed in the light of other data. As previously mentioned, before searching for the hidden teat is seen, the infant sucks at the presented base of the bottle. The classic Piagetian explanation is as described on page 46, the infant attempting to create the nipple by his own action (sucking). However, during the early bottle experiment, Cody was presented on more than 10 occasions with objects of varying types, e.g. a small transistor radio. He also sucked at these objects as avidly as he did at the bottle's base. Such responses can be explained by the infant "knowing" that it is bottle-time by reference to the many contextual cues that precede and accompany feeding. He was therefore primed to respond to the presentation of any object with the behaviour that was appropriate on past occasions (i.e. sucking). A similar explanation can apply to the sucking of the bottle's base. The tendency seems to be progressively internalised, i.e. the movement is fixed in session 1, 24.12.73, to some degree malleable on the second session, and reduced to eye movements during 25.12.73. It would be most interesting to determine if such a progression is seen in human infants at this stage in the object concept, and, knowing the predisposition of anthropoids to position preference strategies in delayed response tests (Kluver, 1933,), whether such eye actions persist in the adult Great Apes.

Cody mastered the Teat-Obscured test within three test sessions. The responses observed point to the interpretation that the infant begins to cognize the permanence of specific parts of an object - that they are not destroyed by their disappearance. Thus, at 10.2.74, the infant, for the first time, moves his head slightly to one side and looks along the side of the bottle when it is presented to him base-first. However, the head was not moved sufficiently far, the infant failed to descry the teat, and no solution to the problem was found during this day. On the following session this head to side behaviour was not seen, but on 3 of the 6 trials, grasping up and past the base of the bottle (for 4 - 5 secs.) was noted. Once again, the infant failed to make contact with the teat, and this behaviour ceased. However, during the first trial of the 1.3.74 session, the infant revived the response seen two sessions earlier, and, after an extremely brief suck at the base of the bottle, moved his head to the left, saw the teat, prehended it, and pulled it to his mouth. This behaviour is very similar to that observed by Piaget with his son, Laurent (Piaget, 1953 Obsn. 92, 0:9(21) p.164). During the following four trials of this session the infant dispensed with the head movement, simply raising his hand until manual contact with the teat was made, upon which occurrence prehension ensued. Following sessions repeated this latter behaviour.

One of the most telling points with regard to these results concerns the correlation of times of attainment of these two abilities with those of the mastery of the tests in the related Cover Experiment. Mastery of the Stage III cover test (Object Half Hidden) corresponds exactly (24.12.73) with that of the Functional End Recognition test, whilst achievement of Stage III - IV transition (Object Covered, Hand Free) comes within one day of success at the Teat-Obscured Test.

The classification of the Teat-Obscured Test is debatable without recourse to the Cover Tests. Unlike these latter, it can be rationally considered as either (i) corresponding to an "Object Completely Hidden" Cover Test, with the base of the bottle obscuring the teat and acting as the cover, or (ii) comparable to an "Object Half-Hidden" Cover Test, where the infant must make a part-whole reconstruction by viewing only the base of the bottle. Given that the correspondences with regard to the times of mastery are indicative of a correlation between the degree of difficulty of the tests (i.e. Stage III Cover Test equals Functional End Recognition, Stage III - IV transition equals Teat Obscured Test) it seems that the infant views the Teat Obscured Test as an Object Completely Covered Test. Stage III Cover Test shows that Cody is able to reconstruct the part from the whole, but he cannot do this with the bottle as object until he sees part of the nipple. This shows the limitation of part-whole reconstruction at this stage; if the infant can construct an object when it is half covered by a cloth, why should he not be able to do the same for the base of the bottle? The most likely explanation is that the bottle-base is not sufficiently familiar or distinctive to the infant. When the bottle is presented during normal feeding the infant sees only the sides and top of the bottle, very rarely, if ever, is the base seen. It is therefore extremely improbable that part-whole reconstruction could occur from so unfamiliar an aspect. Piaget reports similar findings with his children: objects were reconstructed more successfully when certain areas of the toys were left exposed. It would be interesting to present a Teat-Obscured vertical bottle to the infant at this point in time. Reconstruction might be expected to conform to a normal Stage III timetable.

Although part-whole reconstruction on the basis of the base of the bottle is not possible, Stage III cover attainment is the time when Cody begins to understand the functional end of the bottle, i.e. at the same time as he begins to be able to make part-whole relationships with familiar objects. It may be that up to this point there is no interest in the shape of an object, other than to identify the object (in fact, objects are simply grasped and placed in the mouth at this time). What is being suggested is that there is, at this stage, no visual awareness of which aspect/side of the object is the most interesting orally, and therefore no knowledge of the "functional end". The juxtaposition of the bottle and cover results in this analysis may therefore point to the Stage III object concept marking not only the possession of some inchoate idea that a part of an object equals the whole object, but also a burgeoning cognizance of the correlation which each area of the object's shape possesses with regard to its (oral?) function.

4.3. SENSORIMOTOR PROBLEMS

4.3.1. INTRODUCTION

Piaget has noted several problems which the infant is able to cope with at specific stages of the sensorimotor period. Solving of such tests is said to further correlate with the stages given by the object concept problem (e.g. the cover test). The problems, and their presumed stages, are given below (Table 6).

Table 3.6

Sensorimotor Problems

Stage	Problem	Method
IV	Screens	Screen placed between object and child as child makes to grasp object.
V	Support	Desired object out of reach on a graspable support (cloth section).
V	String	Desired object out of reach with a graspable string attached.
* VI	Long Toy	Long toy placed horizontally on opposite side of vertical bars.
* VI	Stick	Desired object out of reach near to a stick within reach and long enough to touch object easily.

* Flavell (1963) cites long toy and stick problems as Stage V achievements.

Very little work has been done on these problems. Woodward's research (from which the above table was adapted) on the applicability of Piagetian stages to the behaviour of idiots (Woodward, 1959) is outstanding, in that not only were tests given, but correspondence between each test Object Concept, and manipulative ability was also attempted. Marked correlation was found (with emotionally stable subjects) between sensorimotor activity level of any one child (problem-solving or manipulative stage) and the object concept stage reached. It was suggested that the development of pathological mental defectives followed the same stages as those postulated by Piaget for the normal child, but that the stages were very much slower to develop, or were effectively arrested at any one stage.

The five problems above (Table 6) were given to the Orang-utan subject under examination over a 30-week period. There were two reasons for this procedure: to determine whether the infant was capable of solving such problems during this segment of his developmental span, and secondly, to ascertain if, as seems to be the case in normal children (Piaget, 1953, 1955) and mental retardates (Woodward op.cit.) solution/failure corresponded to the level indicated by the object concept experiments.

4.3.2. STAGE IV PROBLEM : SCREEN TEST

Introduction

Woodward's screen test requires a simple solution of the problem "screen completely obscuring the object". This may be achieved by pulling, pushing or striking the obstruction (using a familiar schema) so that it no longer hides the object and then grasping the object. What is important during this stage is the infant's ability to serialise two familiar behaviour patterns to achieve some desired goal. The capacity of the infant Orang-utan under investigation to deal with such a problem is described below. An investigation of the applicability of the screen test in determining times of attainment of other stages (transition Stage IV - V ,eg) were also carried out.

Method

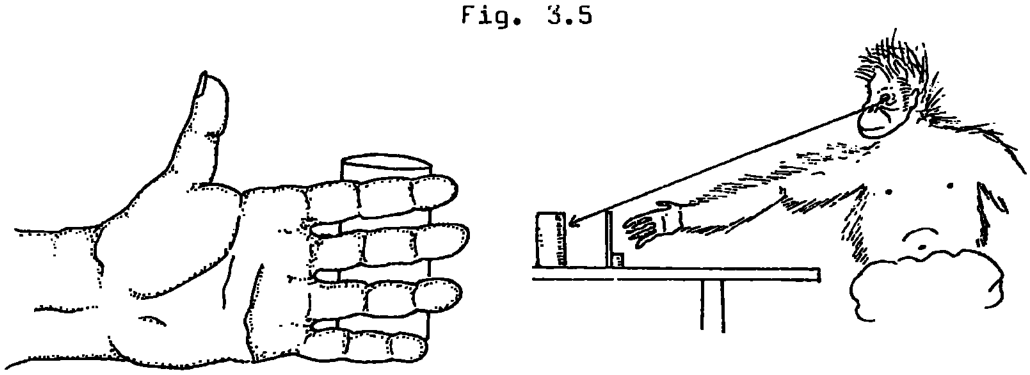
The test situation was, with one exception, identical to that described for the object concept "Cover" experiment. However, instead of a cover, or covers, obscuring the object, a variety of screens were used.

Pre-stage IV

Prior to Stage IV the infant should, if Piaget's analysis is correct, be capable at grasping at a half-screened object, or one where more than 50% of the object is in view (certain aspects are, however, as previously described, more effective).

For this period two screen types were utilised: (i) the experimenter's hand, presented thumb-up, and with fingers splayed, (fig.3.5(a).

Fig. 3.5



(a) (b)

(ii) Object-screen-subject placed in such a way that approximately half of the object was visible to the infant, but was still effectively barred from grasping by the screen (fig.3.5(b) above). In practice such an arrangement proved extremely difficult to achieve, primarily because the extreme length of the infant's arms in comparison to his sitting height made it almost impossible to arrange such a set-up. This particular test-situation was satisfactorily arranged on only one occasion during the period of testing. The remainder of the pre-stage IV tests being performed with the "splayed-fingers" screen.

Stage IV

For Stage IV ability, one further screen was used, (iii) A hardboard rectangle (size 5½" x 4") held vertically by the use of two red cubes glued to its base.

Stage IV - V Transition

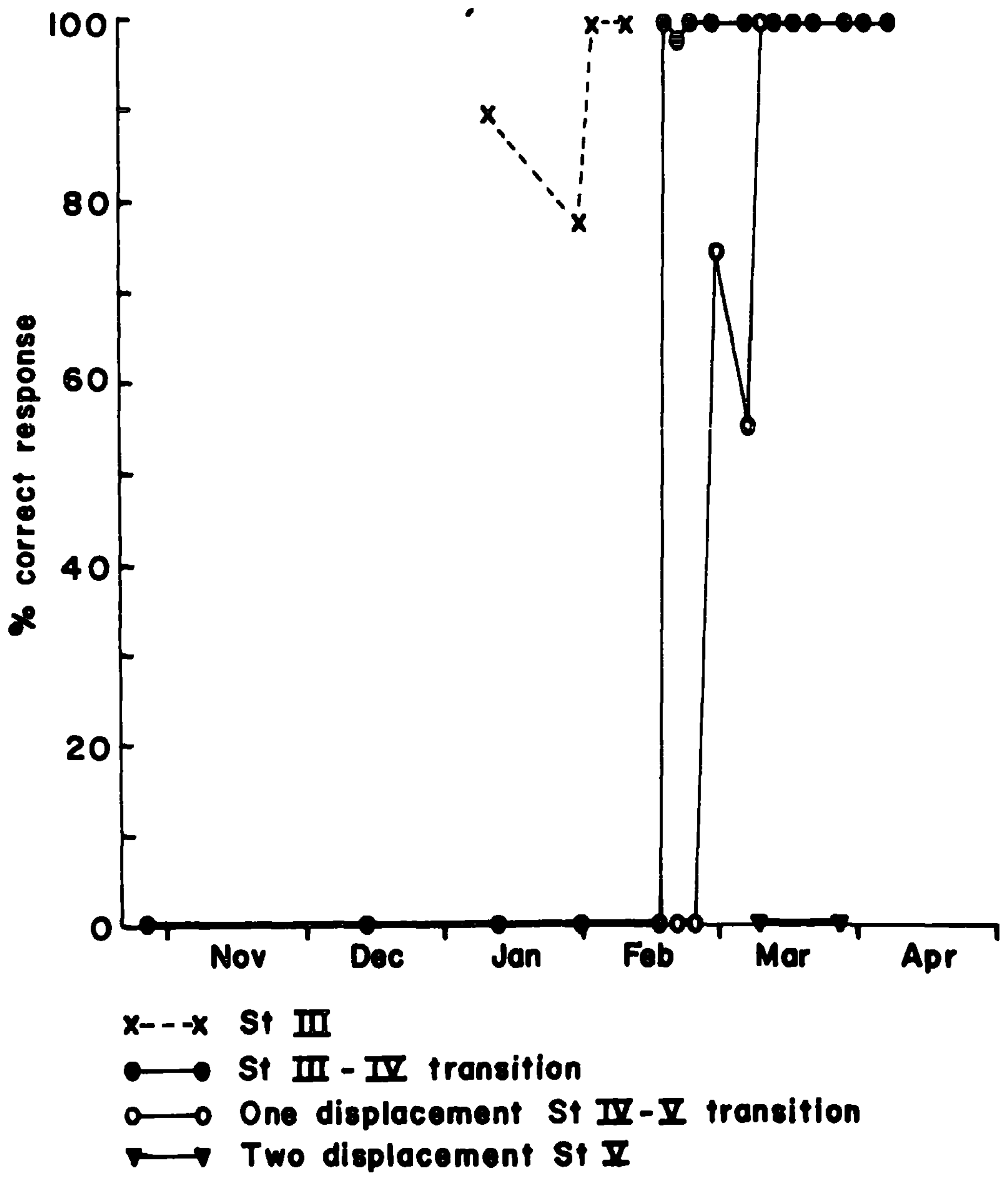
Two screens of type (iii) were utilised for this phase of the developmental spectrum.

In addition to undertaking identical precautions to those implemented in the Cover Test Situations (see page 37), the infant was, for several days before testing, allowed to manipulate, bite, and in other ways play with the screens to be used in the test situation. Play-until-satiated was also encouraged immediately prior to testing. These precautions greatly lessened the probability that the infant would grasp

Table 3.7

DATE	St III		St IV St.III-IV T^n	St IV - V Transit^n	St V
	splayed fingers	Obj. ½ visible	Obj.compl. hidden	One dis- placement	Two dis- placement
27.10.73			0 (5)		
13.12.73			0 (5)		
10.1.74	80 (15)	100 (5)	0 (3)		
29.1.74	78.6(14)	-	0 (10)		
1.2.74	100 (5)	-			
8.2.74	100 (5)	-			
15.2.74			0 (4)		
16.2.74			100 (5)		
19.2.74			98.9 (9)	0 (5)	
22.2.74			100 (7)	0 (3)	
27.2.74			100 (6)	75 (16)	
6.3.74			100 (4)	55.55(11)	
9.3.74			-	100 (9)	0 (2)
10.3.74			-		
12.3.74			100 (3)		
18.3.74			100 (2)		
20.3.74			100 (3)		
27.3.74			100 (5)		0 (4)
31.3.74			100 (7)		
5.4.74			100 (6)		

FIG. 3.6
SCREEN TESTS.



the screens as play objects <u>per se</u> during the period of experimentation.

Several variations of screen test were initiated and, as for object concept cover testing, criterion was set arbitrarily at 75% appropriate response.

Screen Situations

1/ Object Half Visible (OHV) Stage III. For this, the infant was allowed to initiate grasping movements towards the object on the test table, upon which either screen-type (i) or (ii) was brought between object and subject, partly obscuring the former. The infant's responses were noted following imposition of the screen.

2/ Object Completely Hidden (OCH) Stage IV. As the infant made to grab at the desired object, the screen (type (iii) was slid into position so as to completely obscure the object from the infant. Response to this occurrence was again noted by the experimenter.

3/ Screen One Displacement (SOD) Stage IV - V Transition. When successful accomplishment of screen situation 2/ was achieved, a one displacement situation, similar in essence to the one displacement cover method, was attempted. When the infant had found the object consecutively two or three times behind one of the two screens on the test table (designated A) the object was then placed (infant's hand held) first behind screen A and then behind the second screen (B). As the object disappeared behind B, the infant's hand was released and his ensuing behaviour monitored. Precautions to obviate the development of side preferences were as in the cover test (page 38).

Results

Table 3.7 gives details of the infant's abilities over the 12-week period during which the screen test was in operation, while fig. 3.6 illustrates the same results graphically.

Discussion

As is evident, the stage ordering is in agreement with that postulated by Piaget, and with that found in the object concept cover experiment. Thus the infant is able to achieve a successful solution to a Stage III-classified problem prior to a Stage IV problem (Screen Situation 2/ is, more strictly, a Stage III - IV transition as the infant's hand was not held during the hiding of the object) and to respond appropriately to this latter before he could master the Stage IV - V Transition situation.

In addition, the (extremely unsystematic) two displacement testing (2 sessions only) does seem to indicate mastery of Stage IV - V Transition before Stage V. With regard to the time of mastery as compared to the date of stage-attainment inferred from analysis of the cover experiment results, the dates of the screen experiment do not marry with the former, but there does seem to be a regular discrepancy between the results.
Table 3.8 details the times of attainment of comparable stages.

Test	Stage III - IV T^n	Stage IV - V T^n
Cover	3.3.74	19.3.74
Screen	16.2.74	9.3.74

Table 3.8

The screen tests thus seem to be in advance of the cover tests by a value of from 10 - 14 days. More equivocal evidence from the Stage III tests also reinforces this statement : the infant did not achieve Stage III in the cover test problem until 24.12.73, whereas the infant was capable of solving the Stage III screen test by at least 10.1.73 (first time tested), i.e. 14 days in advance of the cover tests. The reasons for such a seemingly regular discrepancy are unclear. It is not known whether such events are usual in either the human or orang infant, and on the basis of a single subject no firm conclusions can be made. It does seem, however, that for this orang subject, the screen test is in some way easier to solve than the cover. It may be that this is related to his mode of upbringing, in that, in the cage in which he was raised, most objects were solid, vertical laminates, e.g. walls of cot, of room, doors, cupboards, boxes, etc. which were grasped. It is possible that the infant's early experience with such shapes (as against the single blanket which was the only soft, material object) may have aided mastery of the screen tests in advance of the cover experiments. For example, on 10.1.77 the infant was observed to drop his teddy-bear over the edge of the carry-cot in which he was playing. The teddy was obscured from his vision, yet he nevertheless raised himself up and peered over the side of the cot as if expecting to see the teddy, which he then prehended. This act occurred before the mastery of a similar problem in the test situation and points to the difficulties inherent in such research. An object may possess permanence to the infant, not only when hidden, half hidden, etc., but also within a specific context with which the infant is familiar. This is very similar to what has been said above concerning the tardiness of cover to screen solutions; just as within the context of his familiar carry-cot, the infant seemed to expect permanence from an object before he expected it in the screen situation, then (being more experienced with screens) he expected permanence behind a screen before permanence under a cloth.

Certain behaviour observed during Stage III and Stage IV - V transition testing are illuminating in the light of the AB phenomenon referred to above, and also because of certain other behaviours to be referred to later.

During Stage III testing, using the splayed finger screen, the infant's method of removing this screen was to grasp the vertical thumb (see fig. 5(a)) and to use this to pull the whole hand to one side. This behaviour was almost certainly taken from a similar behaviour pattern in which the infant would grasp the experimenter's thumb in order to suck it (pg 152). On several occasions the experimenter lowered the thumb while keeping the hand in the original position as screen. On each occasion, the infant made a grasping action at the position where the thumb had been, pulling his hand back as if removing the barrier. This movement was sometimes repeated twice before the infant grasped the forefinger and used this appendage to remove the barrier. It should be noted also that 10.1.73, the infant's 'passing' of the "object half visible" Stage III test involved only the infant pushing his hand at the half-seen object, but no pulling away of the screen, as was seen in the splayed fingers test. Thus the infant might be said to be at Stage III with regard to his ability to reconstruct an object and with his ability to remove a hardboard screen, but as far as 'serialisation of two familiar schemata' is concerned he is at transition Stage III - IV during splayed fingers trials. Thus it seems that, once again, past experience is the prime requirement for attainment of stages. The experimenter's hand was already associated with a behaviour pattern (grasp thumb and suck) which could be pressed into service for the removal of the hand-screen. Perusal of the diaries shows no such well-used schema with regard to the screens (they had only been introduced three - four days before). Therefore, Stage III behaviour is seen with hardboard screens, Stage III - IV transition with hand-screen. It thus appears that Piaget's stages, though valid generalisations, can, on a smaller time scale, be broken down to the gradual mastery of specifics, dependent upon the amount of experience which the infant has had with the object/situation.

The Stage IV - V transition situation also shows interesting anomalies. Here, the object was first placed behind the screen A, then behind B, the infant's hand being released at the same time. During the first session of this situation, Cody gave every impression of discovering that the object could be found behind the second screen. On each of five occasions, after knocking down the first screen and pausing briefly, the infant then prehended the fallen screen and began to bite/suck at it. After several seconds the first screen was discarded and the second grasped at and overturned. With the object exposed the infant gave, by means of his expression and body tone (forehead skin tightening, eyes opening, and cessation of activity) every impression that he was surprised to see the object there. Everything occurred as if, having "lost" the object, the infant plays first with one screen and then decides to play with the second, only to discover the "lost" object fortuitously by this second act of prehension.

Again, after this session on incorrect attempts, the infant would often knock down the incorrect cover, make a grasping action at the empty space behind it, and then knock down the correct cover and grasp the object (e.g. T (Trial)$_6$, 7, 10, 27.2.74, T_8, 6.3.74). The reason for such behaviour is not at all clear.

it might be place-holding.

On occasions the infant's eyes were seen to "lock onto" the first screen as the object disappeared behind it, and to ignore the movement of the object to the second screen. However, this does not explain all the inappropriate responses, for on more than one occasion (e.g. 27.2.74) Cody did watch the movement of the object to the second screen, only to move his eyes back to the first (incorrect) screen before making an inappropriate response. And further, even on the former occasions, watching the first screen persistently cannot explain why, after knocking down the incorrect screen, he should go through the actions of grasping at a non-existent object. Even more strange, though seen fewer times, was the infant's knocking down of the correct screen, and, with the object plainly visible (at least to the experimenter), knocking down the incorrect screen, grasping at a non-existent object and only then prehending the object in position B.

Such behaviour can, it appears, be explained in one of two ways. In a classically Piagetian sense, the infant believes that the object is under the control of his actions and can be brought to the point where his action is performed. A second explanation, and one to which the present author inclines, is that the infant's actions at this stage are very "concrete", i.e. not at all plastic. The infant produces an inappropriate response because, in the small sum of his experience, it was the action which worked on previous occasions, and he has no better action within his behavioural repertoire. Put differently, the action the infant produces had (to him) the greatest probability of success as it "worked" in previous test situations whereas other actions did not. This is somewhat different from giving an infant (of any species) a "belief" in anything. The actions are definitely performed as if the infant believed that he could control the object, but to the author, a more plausible explanation is as follows.

The infant is presented with a situation which it has not met before, e.g. two screens rather than one. All that the infant knows concerning screens and objects is (i) the action of pulling down a screen results in a situation where a grasping action can secure the desired object; (ii) screens are good playthings in themselves and in the absence of anything better can be prehended, chewed, etc.

If presented with two screens, A and B, and an object which is no longer visible, and if allowed to find the object behind A and nowhere else on two or three occasions immediately prior to further testing (i.e. a Stage V situation) then <u>the infant will perform the action which, in its limited experience, has been found to be the most rewarding on former trials in a similar context</u>. That is, it will pull down and grasp at A.

The observation of page 62 (where Cody seems surprised to find the object behind the second screen) may go some way towards revealing how the infant overcomes such stereotypy. Having performed action (i), and with no more stimulating object in view, action (ii) is very likely to be performed on the second screen (B), after the first (A) has been utilised. This action then leads to the (altogether novel) experience of the object behind the second screen. When sufficient exposure to this experience has occurred, it is very probable that the infant will begin to utilise this experience, <u>which is now more rewarding than the first</u>, (i.e. there are more occasions when the object is found behind the second screen after a certain sensory experience, (watching the object moved from A to B) than behind the first.

It might be postulated that there will come a time prior to this, when the "returns" from the first and second experience-groups are equal. At this juncture conflict should arise. This is, in fact, what does seem to occur e.g. when the infant pulls down the correct screen, and then, without prehending the object, pulls down the incorrect screen, makes a grasping movement at empty air, and finally turns his attention to the wholly visible object, which he grasps, (page 63). There does not seem to be a belief that the object can be constructed by the action, it appears to be more the case that the action seen is the "best bet" in an unexperienced (or very novel) situation. The action seems to be run off somewhat in the manner of a "fixed action pattern" (Eibel-Eibesfeldt,(1970), ie. an all or none reaction). Hence, not only "pull down A" but "pull down A and grasp behind it" is the behaviour seen.

4.3.3. STAGE V PROBLEMS: SUPPORT AND STRING TESTS

Introduction

These problems are, in essence, a question of the understanding of spatial relationships. One object (desired) is either placed upon a second object, one edge of which is within reach, or it is attached to a string, the end of which is likewise easily graspable by the infant. The solution is to grasp the second object/string and to pull it in, so drawing the desired object within reach. To do this requires an understanding that specific movements must be directed, not at the desired object but at the second object, be it string or support.

Most adult primates can solve the simple single-string problem easily (Guilliame & Meyerson, 1931; Harlow and Settlage, 1934; Warden, Koch and Fjeld, 1940; Finch, 1941, Kluver, 1953), though few, if any, primates have been tested with the support problem.

Adult anthropoid apes are especially adept at the string problem (Finch, 1941; Reisen et al, 1953; Birch, 1945) the problem on these occasions being to discover what degree of complexity the string web must have attained before the subject fails. Kluver (1953) does, however, report difficulty with the string problem in a ring-tailed lemur (female) who tried for a score of minutes to grasp her out-of-reach goal, only discovering the solution fortuitously. A subsequent trial saw grasping attempted for 31 minutes, although on later trials the subject did eventually learn to pull in the string to obtain the desired reward.

With regard to developmental aspects of primate string-pulling capacity, Zimmerman and Torrey's,1965) review of Mason & Harlow's work on patterned string problems (Mason & Harlow, 1961) states that infant rhesus need to have attained a certain age before the correct solution is forthcoming, and that solution is not aided by early training. In the gorilla, a single infant male, (estimated age 10 months) was said to have cognized the relation between string and object immediately upon presentation of the test, (Riesen, Greenberg, Granston and Fantz, 1953). Variation in solution of this problem in Man was found during the first year of life by Richardson (1932). Achievement of this same problem is said by Lezine, Stambak and Casati,(1969) to occur in the human infant at around the end of the first year, or, more specifically, upon the attainment of Stage V of the object Concept (Piaget, 1955), i.e. at the time the infant learns to cope with two or more seen displacements of an object. Woodward (1959) found that the correlation between solution of string and support problems and Stage V manipulations held for 10 of her 14 mentally retarded subjects.

For the pulling-in behaviour to be classified as Stage V in the Piagetian system, the action must show clearly that the infant understands the relationship "object on support". This can be achieved by placing two supports, one under, and one next to the object. If the infant pulls the incorrect support, stops before it is pulled completely in when object fails to move, and changes to the correct support, he can be said to possess this concept. Other means of ascertaining the same cognizance of spatial relationships are to place the object on one side of, or above, the support, and to note the infant's responses, (Piaget, 1955). Similar tests can be made with regard to string problem capacity.

Method

Many aspects of the support and string experimental methods are identical and they can be considered together.

The experimental situation was as shown in fig.3.7 below.

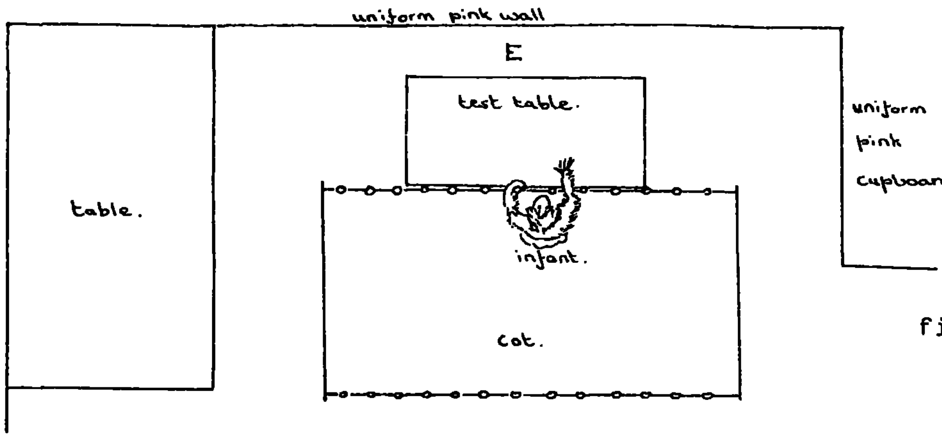


fig.3.7

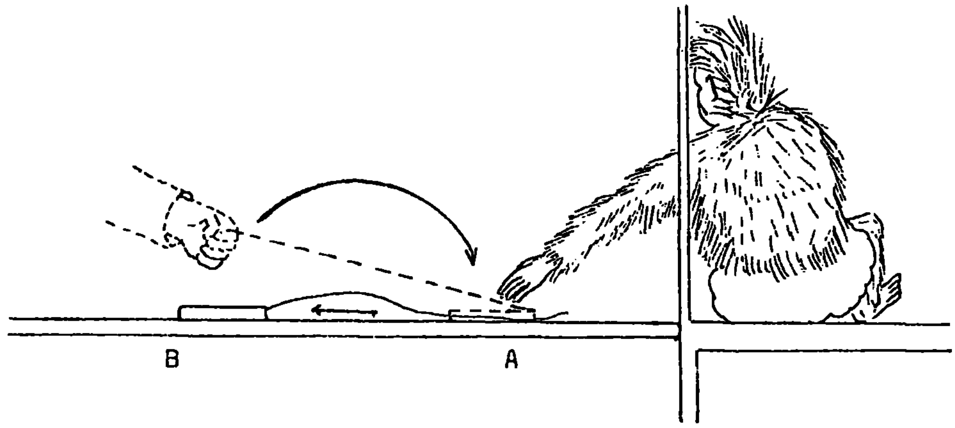
The infant was held in a normal human infant's cot, with opaque end walls and vertical bars ($\frac{1}{2}$" dowel, $3\frac{1}{2}$" wide) forming the side walls. A test table (the same as that used for the cover and screen tests) was placed against one side of the cot, at the same height as the mattress. It was on this table that the objects were presented, the presenter (E in fig.3.7) occupying a middle position, framed by a uniform pink wall. Extraneous stimuli were greatly reduced by the assumption of this position, and infant's attention to the task in hand hopefully improved. The farthermost side of the cot (from the presenter) was left open and the infant could choose to observe the outside world from this side should he so wish; it was found, however, that during experimentation, the infant sat facing E, i.e. with his back to the open side. Whenever walking about the cot or watching from the farthermost side was observed to continue for extensive periods, the session in progress was terminated. This open side, therefore, functioned as a quite sensitive indicator of the infant's decreased motivation.

The supports used consisted of two types; for single, double, and object-off-support trials, the support(s) was/were a long strip of white, blanket-type material (2'0" x $3\frac{1}{2}$"); for one-support-on-another trials a yellow duster (size: 12 inches square) was sometimes used. String was normal gardening twine, 2'6" long and approximately 2mm. diameter.

Noting Beck's finding (Beck, 1967) that Gibbons may not respond appropriately to a pulling-in test solely because their hand-anatomy makes it difficult for them to grasp a string which is lying flush with the floor, precautions were taken to ensure that Cody was able to more easily take hold of the string(s) offered him during the course of the trials. This involved fashioning a small ball of string at the opposite end to which the desired object was attached. The infant then had a much better means of prehending the object. This procedure appears to be preferable to the use of lead pellets (Riesen et al, 1953) as the pellets themselves, being of a different material to the string, may be used as play objects at this early age. That Cody was pulling in the string for the object was in all cases easily determined by the infant's orientation to the object (especially visual) as he pulled in the string. Nevertheless, a stricter criterion was implemented: only if the string was immediately released and the object grasped after pulling in was the trial marked as a "correct response".

So as to obviate the possibility of the infant gaining clues which might aid his correct solution from observation of placement of the object on the support or attachment of strings, from the initiation of two string/support problems (dates: 18 & 19.2.74) a blanket was placed over the testing side of the cot during arrangement of the apparatus, being removed only when the objects were correctly positioned. During the initial sessions of both problems (4 sessions for string, 4 for support) the problem was presented with the infant in a position to observe the placement of all parts of the test equipment. For the support experiment this simply consisted of positioning of the single support and the placing of the object upon (or beside) the support. The procedure differed somewhat with the string test sessions. Here, the object was shown close to the subject (position A in fig.3.8) and as soon as the infant made to grasp at the object, it was pulled to B and the string thrown to a position close to the cot rails.

Fig. 3.8



On both ring and string and support tests an arbitrary two minute limit was imposed. If there was no oriented response to the object or the string at the end of this period, that trial was terminated and another begun. Whenever it appeared that the infant was satiated with the object-lure it was immediately replaced by a new object. This latter was first placed just out-of-reach of the subject. If active attempts at prehension ensued, this was taken as evidence of the suitability of that particular object to serve as a lure. The new object was then attached to the string or positioned on the support and the session recommenced. Objects used as bait varied: various toys were used, including an Ever-Ready battery, squeaky plastic dog, blue mug and peg-sticks. Food was also used as a lure, in which case the bottle or spoon was normally placed inside the blue mug, which was then either attached to the experimental string, or placed on the support.

Test Types Given (see fig. 3.9 Page 71)

Support - 1/ Su 1: Single support. In this test the object was placed on a single centrally sited support with the infant watching placement. The correct response was to cease grasping at the object, to grasp the closer end of the support and by pulling in, to secure the object.

2/ Su 2: Double support. Essentially the same as Su 1 with two exceptions: (a) Two supports were used (equidistant from the centre of the test table) and the object placed on one of them (in a random order but such that the object was never on the same side for more than two consecutive trials (this rule was violated when attempting to break the infant of apparent 'position preferences')). (b) The placement of the object was hidden from the infant by means of a screen across his 'holding cage'. The distance between the two supports was 4 – 5 inches on each trial.

3/ Su 3: Object to one side. Here the experimental set-up was as in Su 1 (one support) but the object was placed, not on the support but to one side of it (to the infant's left and approximately 8" from the proximal end of the support). The correct response was to ignore the support when the object was in this position.

4/ Su 4: Object above support. Test situation as in Su 3, but with the object 8" vertically above the further end of the support. Correct response as Su 3.

5/ Su 5: Two supports. Here the object was placed on one support (just-graspable by the infant) which was itself placed upon a second support within easy reach of the subject. The design was so arranged that if the nearer support was grasped and pulled it slid out from beneath the further support without moving this latter, or the object. Correct response was marked if, on noting this occurrence, the infant relinquished his grasp on the nearer support and grasped and pulled in the furthermost. Correct response was also marked if the infant ignored the nearer support and immediately grasped the just-graspable cloth.

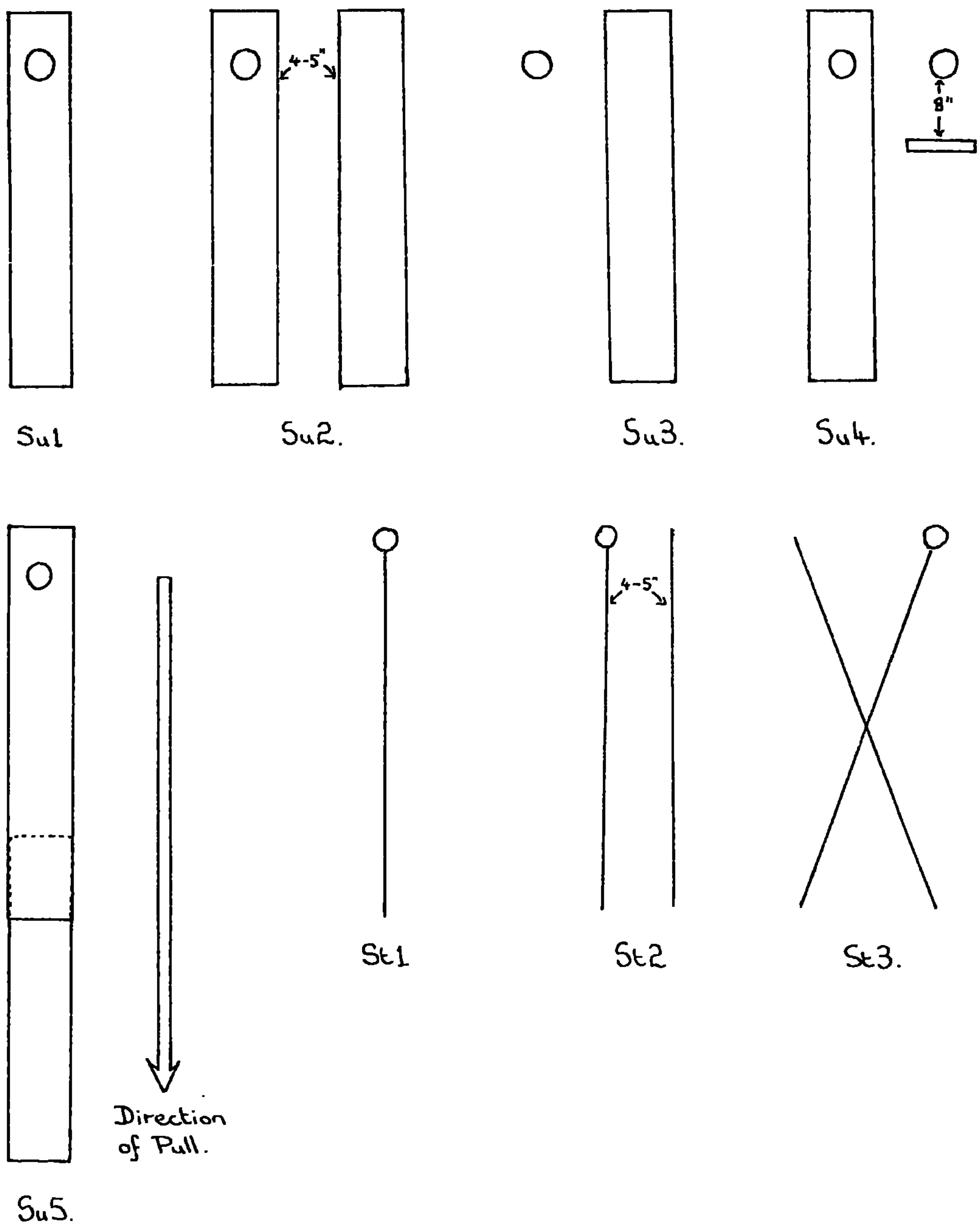
String – 6/ St 1: Single String. The object, attached to a single string, and presented in a central position on the test table. The infant was able to observe placement, and a correct response consisted of pulling in the string and securing the object.

7/ St 2: Double String (uncrossed). Two strings were used, one attached to the object, the other free. Except that strings and not supports were used, all conditions described in test-type Su 2 apply for St 2.

8/ St 3: Double String (crossed). The two strings (one attached to the object, the other free) were crossed in an X-type arrangement (see fig.3.9) such that the distance from object to end of free string was 4 - 5 inches. This test is not a true part of the Piagetian repertoire and corresponds to Harlow's test number 4 (Harlow and Settlage , 1934). It was hypothesised that, as the problem is more complex than any so far mentioned, success would come some time after St 2. accomplishment.

Fig. 3.9

Test-Type Given (seen from subject's position)



Results

Graphs depicting support test results are shown in fig.3.10, string test results, fig.3.11, the same results being tabulated in tables 3.9 and 3.10 respectively. In addition as position preference is a not unusual strategy of Primates in string tests of this type (e.g. Birch, 1945; Finch, 1941) and as the subject under investigation seemed to revert to a similar position/habit, it was thought profitable to examine the tests Su 2, St 2 and St 3 for signs of position preference. The correct responses of the infant for each side were computed separately as a percentage of the total number of trials given on that side. Histograms were drawn, (Left and Right columns for each date tested) and these used for comparison (fig.3.12 and table 3.11). One criterion was arbitrarily constructed for analysis of the position preference histograms: Position preference was said to be the dominant strategy of any date where there was a greater than 75% correct response on one side, while the second side was 66% or less of the first side's figure. Thus, if Left (L) equalled 50% Right (R) equalled 25% there was said to be no poisition preference; if L equalled 80%, R 38% a position preference was counted; if L equalled 80%, R equalled 60%, no position preference. An analysis of total side preference figures for each side and test-type is given in table 3.12.

Table 3.10

Date	Single String (St1)		2 Strings Uncrossed (St2)				2 Strings Crossed (St3)				Stops response when incorrect	
			L		R		L		R			
	+	−	+	−	+	−	+	−	+	−	½ way	½ way
18.1.74	0	100(10)										
21.1.74	10	90(10)										
30.1.74	100	0 (5)										
6.2.74	100	0 (7)										
18.2.74	100	0 (4)	71	29(7)	10	90(10)					0	100(11)
26.2.74	100	0 (2)	33	67(3)	20	80 (5)					83	17 (6)
3.3.74	100	0 (5)	100	0(2)	100	0 (5)						
8.3.74	100	0 (3)					100	0 (1)	67	33 (3)	100	0 (1)
11.3.74			22	78(14)	100	0 (3)					46	64(11)
17.3.74			70	30(10)	100	0 (5)					50	50 (2)
21.3.74			88	12 (8)	78	22 (9)					67	33 (3)
27.3.74			100	0 (5)	100	0 (5)	0	100 (5)	100	0 (4)		
31.3.74			100	0 (2)	100	0 (3)	36	64(14)	84	16 (6)		
8.4.74			100	0 (8)	100	0(11)						
14.4.74			91	9(11)	100	0 (9)	84	16 (6)	15	85 (7)		
18.4.74			86	14 (7)	100	0 (9)	80	20 (5)	100	0 (3)		
23.4.74			100	0 (2)	100	0 (4)	0	100 (4)	75	25 (4)		
2.5.74			80	20 (5)	100	0 (5)	25	75 (4)	0	100 (4)		
9.5.74			100	0 (5)	86	14 (7)	80	20 (5)	33	67 (6)		
15.5.74			83	17 (6)	100	0 (4)						
16.5.74							43	57 (7)	20	80 (5)		
22.5.74							75	25 (4)	75	25 (4)		
25.5.74							70	30(10)	38	63 (8)		
29.5.74							57	43 (7)	75	25 (8)		
5.6.74							91	9(11)	29	71 (7)		
12.6.74							71	29 (7)	89	11 (9)		
19.6.74							44	56 (9)	13	87 (8)		
26.6.74							56	44 (7)	44	56 (9)		
3.7.74							55	45(11)	22	88 (9)		
10.7.74							67	33 (6)	11	89(11)		
18.7.74							67	33 (9)	71	29 (7)		
24.7.74							44	56 (7)	67	33 (9)		
7.8.74							88	12 (8)	67	33 (6)		

Table 3.9

Date	Single Support(Su1)		2 Supports (Su2)				Object to 1 side/above (Su 3&4)		2 Supports (Su5)		Stops response when incorrect	
			L		R							
	+	−	+	−	+	−	+	−	+	−	+	−
9.1.74	20	80 (5)										
30.1.74	0	100 (4)										
6.2.74	100	0 (7)					0	100 (6)			0	100 (6)
10.2.74	100	0 (6)					73	27 (7)			67	33 (3)
19.2.74	100	0 (3)	100	0 (2)	33	67 (6)					50	50 (4)
25.2.74	100	0(10)	100	0 (5)	43	57(14)	100	0 (3)			50	50 (8)
1.3.74	100	0 (4)	100	0 (4)	93	7 (7)	0	100 (4)			50	50 (4)
7.3.74	100	0 (5)	67	33 (3)	100	0 (2)	50	50 (4)			33	67 (3)
10.3.74	100	0 (4)					100	0 (3)	100	0(9)		
15.3.74	100	0 (5)	60	40 (5)	100	0 (3)	75	25 (4)	100	0(5)	100	0 (2)
21.3.74											60	40 (5)
1.4.74			100	0 (4)	100	0 (4)						

Table 3.11
Position Preference
Results for 3 Test
Situations.

Su 2		St 2		St 3	
DATE	P.P.?	DATE	P.P.?	DATE	P.P.?
19.2.74	L.P.P.	18.2.74	L.P.P.		
25.2.74	L.P.P.	26.2.74	No		
1.3.74	No	3.3.74	No	8.3.74	L.P.P.
7.3.74	R.P.P.	11.3.74	R.P.P.		
15.3.74	R.P.P.	17.3.74	No		
1.4.74	No	21.3.74	No	27.3.74	R.P.P.
		31.3.74	No	31.3.74	R.P.P.
		8.4.74	No	8.4.74	-
		14.4.74	No	14.4.74	L.P.P.
		18.4.74	No	18.4.74	No
		23.4.74	No	23.4.74	R.P.P.
		2.5.74	No	2.5.74	No
		9.5.74	No	9.5.74	L.P.P.
		15.5.74	No	15.5.74	-
				16.5.74	No
				22.5.74	No
				25.5.74	No
				29.5.74	No
				5.6.74	L.P.P.
				12.6.74	No
				19.6.74	No
				26.6.74	No
				3.7.74	No
				10.7.74	L.P.P.
				18.7.74	No
				24.7.74	No
				7.8.74	No

Table 3.12: Cumulative Position Preferences for Each Test Type.

	Su 2	St 2	St 3	TOTAL
Left Position Preferred	2	1	4	7
Right Position Preferred	2	1	3	6
Total Position Preference	4	2	7	13
% of total Test Sessions	66.6%	14.29%	38.0%	32.5%

FIG.3.10
SUPPORT TESTS.

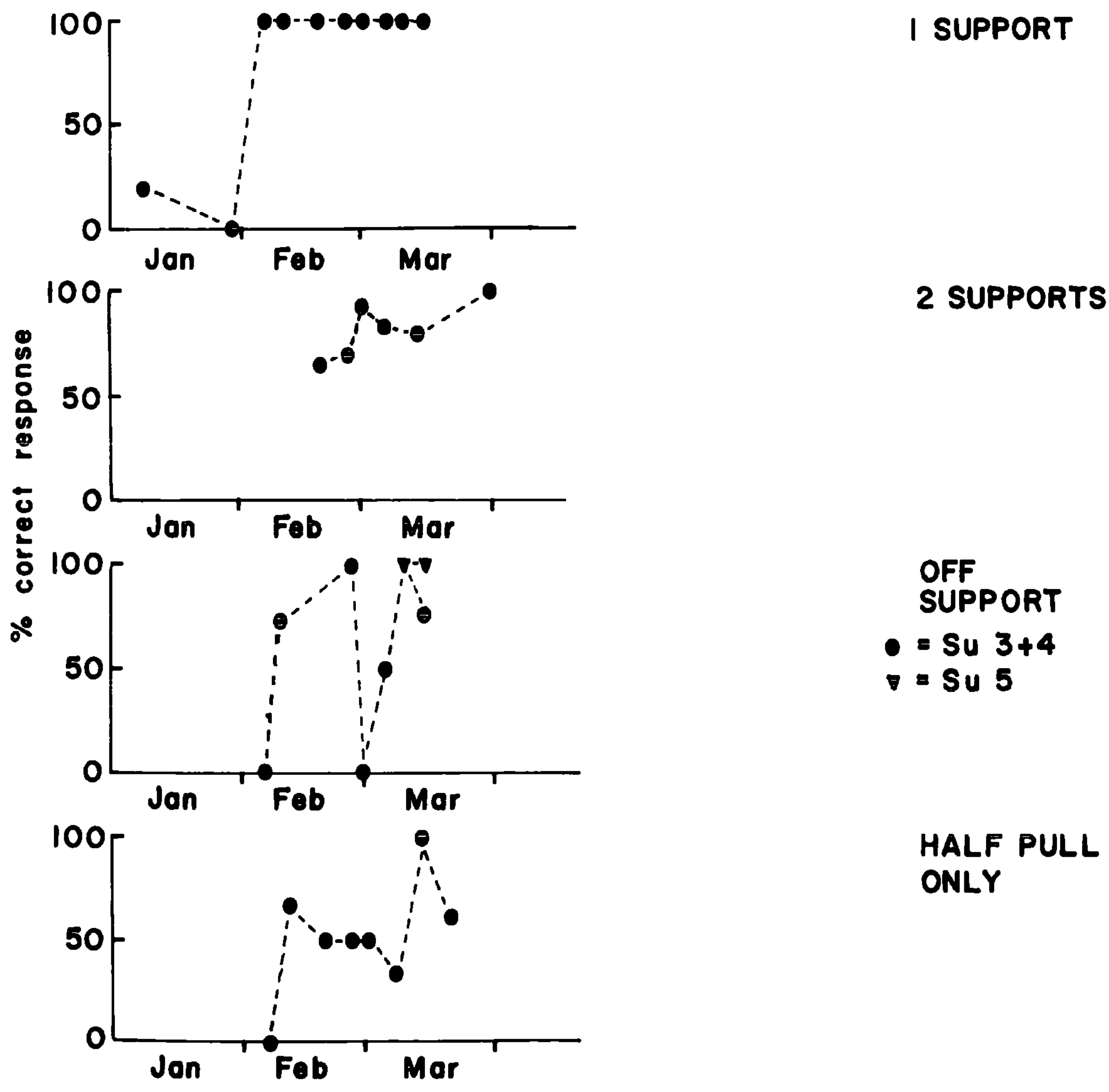
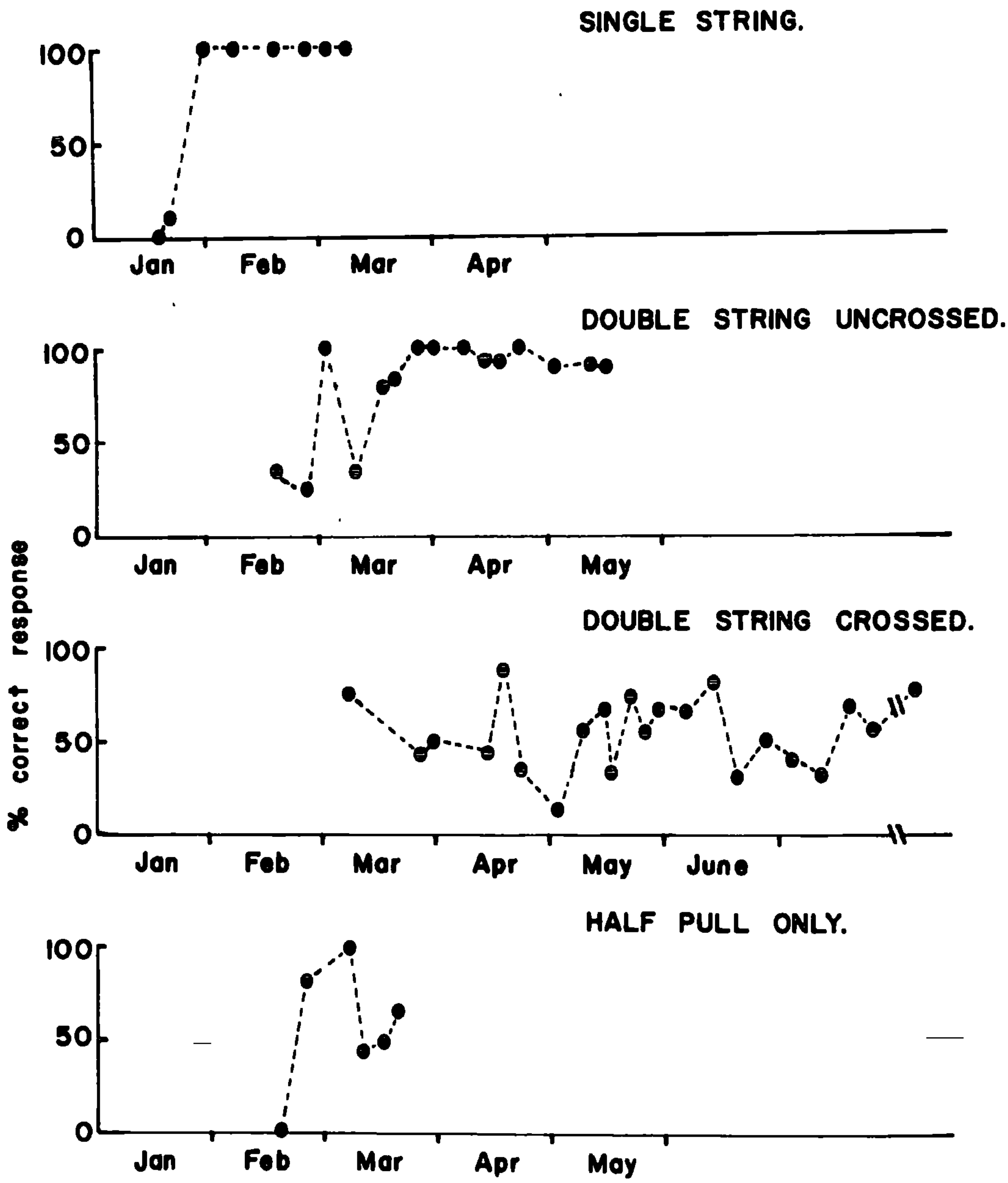


FIG. 3.11
STRING TESTS.



Discussion

A primary point of note concerns the sequence of accomplishment of the test-types. It is found that the single support/string capacity occurs before the double support/string achievement. This agrees with Piagetian theory. As predicted, the double string (crossed) test was not achieved in advance of the single and double string tests mentioned above - indeed there is no indication in the results that the infant mastered this problem before termination of the Stage V tests. Thus, one of the most important Piagetian tenets, the sequential unfolding of capacity in any one area, from simple to more complex, is seen to hold for this Orang-utan subject and agrees with the findings for human subjects (Piaget 1953).

Su 1 and St 1

Considering first the simple single tests (Su 1 and St 1), it is seen that Su 1 solution occurs at February 6th. The date for the solution of the comparable St 1 test is January 30th. The two dates are thus almost coincident, and it should be noted that the previous test of the support experiment occurred before January 30th (i.e. before the first time of criterion achievement for the string test). Thus, it may be that accomplishment of the two problems occurred simultaneously, but that the support situation was not tested for until February 6th. Be that as it may, solution of both problems falls within a seven-day time frame, a quite close degree of synchrony. As with the majority of other experiments previously recorded, time from approximately zero appropriate response to a response level above criterion is remarkably swift, being from 0 - 100% in seven days, and 10 - 100% in nine days for Su 1 and St 1 tests respectively. Once learnt, both tests show a continuation of 100% correct response to their date of termination.

However, to state that the infant can solve a simple one-string/support problem does not indicate that he understands the concept "object-on-support/string". It may simply be that he has discovered the 'answer' fortuitously, (indeed, this seemed to be the case at onset of competence - see page 79)

and simply reproduces this response because it brings results. There are several ways in which this question can be resolved. To determine the date when the infant is cognizant of <u>which</u> string/support will produce the object, the two string/support tests can be utilised (St 2 & Su 2). Another facet of the problem is knowing <u>when</u> an object can be obtained by pulling in a support/string, and when it cannot (Su 3, 4 & 5). In addition, incorrect answers in either of these above test-situations can be analysed to reveal (a) if the infant pulls in an object blindly, or, when he notices that his actions are not moving the object, (b) if he inhibits pulling and attempts to grasp the object by other means (i.e. <u>how</u> he makes the pulling-in action). The geneses of these three competencies are examined below.

Su 2 and St 2 Problems

The times of achievement of these problems are remarkebly consistent across the two tests, with dates of March 1st and March 3rd for the two support and two string tests respectively. The sudden decrease to 21.5% after a previous 100% response in the string experiment (March 11th) is unusual. A strict reappraisal of the diary notes at around this date indicates no sudden trauma or illness that could account for such a decrease. It is thought that the poor showing may reflect some general aspect of decreased motivation or, alternatively, a sudden forgetting of the means of solution of the problem.

Su 3, 4 & 5 Problems

The object-off-support tests (Su 3, 4 & 5) are much less satisfactory with regard to number of sessions given. Teleologically, it would probably have been better (it would certainly have been less confusing!) to have concentrated on one aspect of the problem, e.g. object to one side of support (Su 3 & 4) or Su 5, than to have attempted three different tests within so limited a time-scale. The infant may have achieved competence in these problems by February 25th (100% appropriate). Confidence in this result is marred by the small number of trials comprising the session (3) and by the poor showing of the two subsequent trials, (0% and 50% respectively). It is considered more accurate to regard the solution of these problems as occurring from March 10th, although the trial number is in no way sufficient for firm assessment on this topic. Test Su 5, while being of small session number (2) possesses a more respectable trial total (14), and reveals that solution was extant by at least March 10th at a 100% level of appropriate response.

The final segment of evidence, the number of times an incorrect response was inhibited before more than half of the support/string had been pulled in demonstrates a wide discrepancy between support and string times of achievement (data taken from the Su 2 and St 2 responses only). The support test reveals that inhibition of pulling in achieved criterion on March 15th, whereas the string analysis cites February 26th as the date for criterion achievement. The decrease following two criterion responses corresponds to the sudden decrease referred to above for St 2 test, and may be due to one or other of the two suggestions put forward for this latter test. However, in this case the decrease continues for a greater period of time, and such speculations become even more tenuous.

The discrepancy in the results of these two very similar problems may be due, in large part, to a difference in the infant human's and the Orang-utan's manner of tackling the pulling-in component of the test. Whereas the human infant (probably because of his relative inferiority in manual coordination at this time (Halverson ,1931), pulls in the string hesitantly and has ample opportunity to visually sample the results of his dawdling action, the infant Orang-utan's more highly developed manipulatory abilities and motor control leads it to grasp and pull in the support/string in one sweeping flourishing movement. Following achievement of a 100% response level, an incorrect response was almost invariably linked to such one-time, pulling in movements. Hence the analysis of pulling the support/string totally, or partly in, may not be so useful a method of analysis for the Orang-utan as it is for the infant human subject.

In sum then, and following solution of the single string/ support problem at around the 27th. week, (January 31st. to February 6th.), each test type (Su 2, 3 & 4, St 2 & 3) indicates that an understanding of the different facets of object-on-support examined here occurs between the ages 6 months 3 weeks and 7 months 2 weeks (February 26th - March 15th). This spread of times, and slow accretion of competence is what may be expected from an infant in the early stages of constructing his world. Many similar problems are solved at approximately the same time, but the solution of the problem-complement is not an instantaneous affair.

Where then, should one decide where object-on-support understanding begins? Any line of demarcation must to some extent be arbitrary, but the writer is inclined to suggest the achievement of the 2 support/string tests (Su 2 & St 2) as heralding the onset of such cognizance. This test group shows a great consistency in time of occurence (March 1st & 3rd respectively) and is backed by a greater corpus of data than any of the remaining experiments. In addition, the remaining experiments do tend to cluster around these dates and they are, in a loose sense, the "mean" of all the experimental results and analyses obtained on this question.

The problem of correlation of these findings with those of the rest of the major test-types is given in the overview at the end of this chapter.

Mode of Solution

Position preference seems to have been used intermittently by the infant as a solution. It is possible to determine the number of times each test situation saw position preference used, see table 3.11, giving some indication of the use of the strategy. One area in which overlap (of comparably difficult problems) does occur is during Su 2 and St 2 experiments between the dates 18.2.74 and 1.4.74. Here comparison is legitimate and it is found that position preference occurs twice as often in the Su 2 test situation as in the St 2 situation. This fact seems due to the infant's perseverance with position habit over two test-dates during Su 2 testing as against one test-date for St 2.

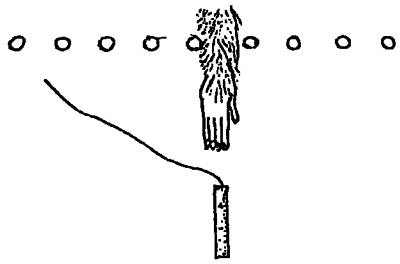
Overall, it can be seen from table 3.11 that the infant did not use position preference as a standard strategy in all test sessions. Rather, the position preference tactic seems to have been randomly "thrown in", as it were, in the course of a series of sessions in which other strategies are also used. Side preferences are equally "shared" betwen right and left (R : L equals 2 : 2, 1 : 1 and 3 : 4 for test-types Su 2, St 2 and St 3 respectively). In toto, this behaviour would seem to indicate an attempt by the infant to discover the correct solution, i.e. he is not rigidly bound to one particular response ad infinitum, but does change strategies from time to time. The conditions which precipitate the assumption of a p.p. strategy, or its rejection, cannot however be elucidated from the present data.

Clues to the infant's mode of solution of the problem can likewise not be determined accurately from the data accumulated on body movements, etc. presented here. As mentioned previously, video-tape recording seems the most promising method of solving such questions, allowing as it does an almost infinite number of re-runs in which many specific aspects of behaviour (which in toto present too great an information load for the sensory channels of the observer, but which may all be important in the elucidation of a particular behavioural event) can be recorded with precision. However, tentative conclusions may be drawn from certain observations (albeit incomplete) of the infant's eye movements and bodily positioning while attempting the problems.

Referring to the test St 1; Cody, at 21.1.74 performed the appropriate response during one of ten trials. This, however, appeared to be a completely fortuitous solution, and having occurred at Trial 3, with seven subsequent trials in which no positive response was forthcoming, it is thought unlikely to have demonstrated in any fashion, intentional behaviour of the Stage IV type. The following test session (30.1.74) sees a sudden 100% response with very little indication of trial and error. What may have occurred is a grasping of the string as an interesting object in itself, with the realisation of its connection with the object after the string had been gripped and pulled. This certainly seems to be the case in the first successful trial of this session - Cody ignored the object and string for 1 minute 13 seconds on this occasion, then seized the string and brought it to his mouth without looking at the object. He then dropped the string and grasped the object. The following trial evinced some evidence of the infant's awareness of string-object functional unity. The string was grasped immediately and pulled three times, the infant's eyes looking in the direction of the object. However, arm action was by no means efficacious for such a pulling-in function - being akin to that of a child playing "trains" - and the object moved but slightly with each movement. The lips were then used to prehend the string, and object possession achieved in this way.

The following session (6.2.74) showed trials which seemed to indicate strongly that the infant by this time understood that pulling the string led to acquisition of the object. There was also evidence that the infant could move away from the desired object to accomplish this end. The object and string had been placed as in the diagram below (fig.3.13).

fig.3.13



To quote from my protocols

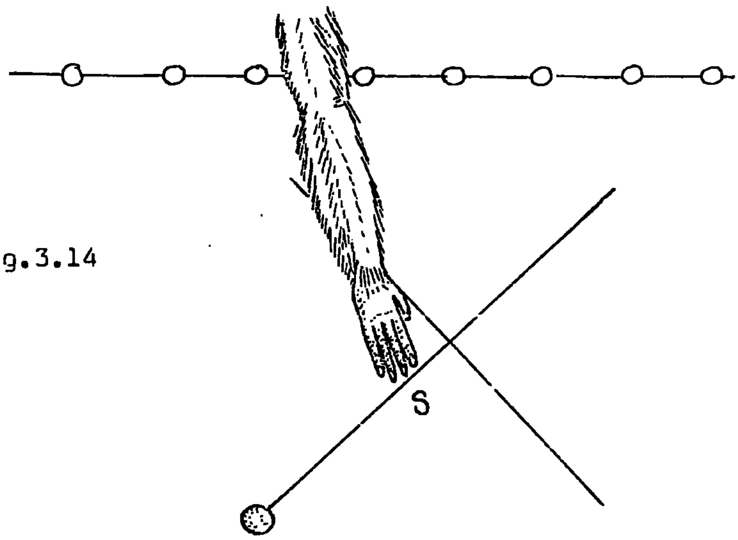
" Using felt-tip pen as object... Cody spends three Øvs in direction of object, one time Øv in direction of string near object, can't reach. As he withdraws his hand, hits closer piece of string and moves object; looks from hand to object but pulls hand inside. After a ten second pause looks to end of string, tries to grasp four times with Right hand.... can't reach it through the rails (of cot) he grasping from, moves down rail (i.e. away from object), reaches and grasps end of string, pulls in to mouth, his right hand going down and grasping string closer to object.

Object now lying at bars, Cody looks to it and head down and tries to suck. As he does this his right hand - it seems unintentionally - moves back, pulling the object closer. He immediately head up and looks to his right hand, pulls two times, object coming further in each time. Thengrasp it and to mouth. These last two sentences describe movements executed with great"tension" and speed, showing every indication of his just "realising" the connection between object, his hand and the string."

This session also reveals what may be a transitory AB-type behaviour. Following a trial with the string at 45^{o} (as in fig.3.13 above) two trials were given with the object and string reversed, i.e. (then). The infant seemed incapable of responding to this new position. This was not because of satiety with the object, as on two subsequent trials immediately following these refusals, using the same object but with positions as the original trial, he immediately succeeded. This inability was overcome in later trials.

Sighting along the strings with the eye placed close to the ground to determine the correct string to grasp was used by one of Birch's chimpanzee subjects (Birch, 1945) but was not however used by the present subject. In looking, Cody seemed to either look directly at the object and to grasp the string vertically below it (i.e. the string closest to a line 90^{o} to the rails and passing through the object) or to begin from the end of the string closest to this point and direct his gaze up towards the object, seemingly irrespective of the presence of a string or not. This method proved successful with St 1 & 2 and with Su 1 & 2; the strategy may also go some way to explaining the infant's below-criterion responses for most of the St 3 tests: such a strategy would invariably fail in such a test as the answer is to grasp the oppositely placed string. Cody very infrequently looked from the object along the string to the end nearest him, at this point in development, a finding which agrees with that of Finch (1941) with regard to chimp capacity in patterned string tests. The infant was also on one occasion seen to devise his own solution to the crossed-string problem. On this occasion the crossed-strings were inadvertently placed closer to the animal than was usual. Cody immediately began grasping towards the area of string marked 'S' on the figure below. It seemed that he was "solving" the problem by the simple expedient of ignoring the crossed-string area, so turning this more complex problem into one that he could solve - one string at 45°.

fig.3.14



With regard to pulling-in movements and looking at the object, Cody was observed to watch the object and not the string as pulling-in occurred. As has been seen, failure to inhibit pulling-in when the object did not move can on most trials be attributed to the infant's one-pull technique, which served to obviate any feedback when an incorrect response was made. However, during early sessions of St 2 testing slow pulling-in with the object looked at was seen. It seemed that, at this early stage, the infant was incapable of inhibiting his movements and would pull the incorrect string completely before changing to or ignoring the correct string. Such behaviour may also be interpreted by reference to Piagetian theory, which posits the infant's belief in the dependence of objects on his own actions is dominant at this time (see overview).

Support - With these tests the infant's responses are very much as in the comparable problems of the string test-series. Up to 6.2.74 the infant during Su 1, showed no interest in the support as a means of obtaining the desired object, and simply grasped repeatedly at the out of reach object during each trial. And this despite the fact that on 30.1.74 the infant produced 100% appropriate response for strings, before support testing in which a 0% correct response was observed. Thus generalisation from string to support problem does not seem to have occurred within that day.

The 6.2.74 saw a sudden 100% correct response for this test, identical to the string test. In addition, the infant showed evidence of being aware when to stop pulling-in, when the object was on the support. Thus, he would not always pull the object and support completely in, but would stop pulling as soon as the object was within reach, release the support immediately and grasp the desired object. With the Su 3 tests (pulling-in with object to one side of support), the infant showed very little indication of inhibiting movement when pulling-in with no object movement, although watching the object as the action was performed was seen each time. Such inhibition occurred only partially on one occasion in six Su trials on 6.2.74, with the infant pulling the support half way in (watching the object), pausing, and (with eyes still intent on the object) pulling the support completely in. As such, this response seems to correspond to the St 2 protocol of failure to inhibit pulling-in as described above. It can thus be classified as an example of horizontal decalage (Piaget 1953) - the occurrence of similar behaviours, at different times, within a stage. A similar horizontal decalage occurred during object concept development. In Piagetian terms, the explanation of this behaviour would seem to once again centre around the infant's belief in the efficiency of his own actions as the prime mover in the permanence and position of objects. Alternatively, one may ask, what other adaptive response can the infant make? The infant knows only that the object can be prehended by (a) oral prehension, (b) manual prehension or (c) pulling-in a string/support. (a) and (b) do not "work" when the object is out of reach: the object is out of both oral and manual reach in this experimental situation; (c) has worked previously in this regard, and, with no other behaviour pattern available, in this context, "pulling in support/string" may very well be utilised as the behaviour pattern "most likely to succeed". Thus, until a more appropriate response is discovered (usually by trial and error at this stage) the infant has good reason to respond in this seemingly inappropriate fashion. On later sessions, having achieved a more adaptive response, pulling-in support when the object does not move can be attributed to the infant's one-time, agressive pulling-in method, as in the case of the string problems.

With the 2-support tests (Su 2) similar responses to those of St 2 are evident. Looking from a point directly in line with the object was seen many times (as described for St 2) resulting in a correct response. However, on several occasions the infant, having grasped the incorrect support, was observed to look up the incorrect support to its farthermost end, apparently note the absence of the object on this support, look across at the object on the second support, and yet to nevertheless pull in the incorrect support before turning his attention to the remaining support. Such behaviour once again seems explainable by reference to the infant's egocentrism and belief that objects are under the control of his own actions irrespective of any physically perceivable link, or to a run-off of a previously correct behaviour pattern while still comparatively naive with regard to the 2-support experimental situation.

4.3.4. STAGE VI PROBLEMS

Introduction

The criterion for Stage VI accomplishment is, with slight variation, usually given as the infant's capacity to discover new means to solve a problem through mental combinations (e.g. Piaget, 1953, 1955; Etienne,1973; Flavell, 1963; Woodward, 1959). This ability has also been termed "insight" or "foresight" and such a method of problem solution is not unknown in the Pongidae (Kohler, 1925 ; Birch, 1945; Hayes,1952). Despite the variation in nomenclature, all such behaviour refers to the organism's ability, when presented with a novel problem, to solve its intricacies without resort to overt activities such as trial and error, where chance-made movements which prove fruitful are, (because of visual and presumably tactile/ kinaesthetic feedback), repeated and gradually refined until an untroubled and almost faultless performance is achieved.

With most problems, mental combination or "covert experimentation" (which presumably involves internal recall and rearrangement of past experiences) requires mental rearrangement of the spatial relationships of objects (Piaget, 1955). Piaget (1953, 1955) and others (Woodward, 1959; Flavell, 1969) have noted several examples of simple problems which can be solved by such internal manipulations. These include rolling a long flacid object into a ball, so as to insert it through a small opening, detour movements around and under objects (e.g. under furniture); using a stick to bring within reach an out-of-reach object; turning a long horizontal object through 90^{0} so as to bring it through vertical bars.

Two tests were chosen to serve as indicators of Stage VI accomplishment. These were 1/ Long toy presented horizontally outside vertical bars (hereinafter referred to as "Long Toy" or "LT"), and 2/ Object out of reach, with stick within reach ("Stick Experiment" or "SE"). The choice of these two problems was deliberate; the first problem requires but one component movement (turning the toy through 90^{o}) and one projected outcome (object then able to come through bars). The stick experiment requires several "steps" to acquisition of the desired object and it was hypothesised that the infant would accomplish LT prior to the solution of SE. This is said to occur for human infants (Woodward 1959). It should be noted that solution of these problems is not restricted to a Stage VI level of functioning; especially with the first problem (LT), trial and error responses may succeed in producing a correct response with later refinement of the movement by visual/kinaesthetic/tactile feedback. Indeed, of Piaget's two children who were tested frequently with the stick problem, one at least seemed to discover the solution by visual feedback from chance-made movements (Piaget, 1953, Obs 159 - 161).

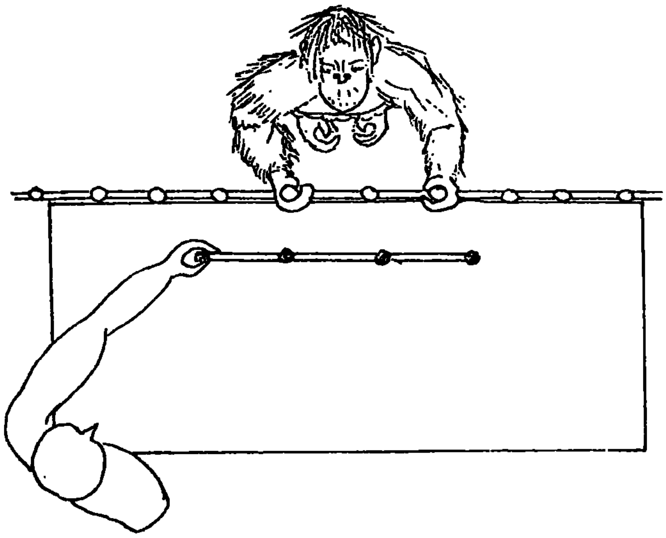
As was mentioned above, insight-ful problems are not unknown amongst the great apes (Kohler, 1925 ; Kellogg & Kellogg, 1933; Birch, 1945). The <u>development</u> of this capacity from lower forms of functioning, however, has been greatly neglected in the Pongidae, and a comparison with its development in Man would cast much light on the generality of Piagetian theory. It was therefore of interest to determine not only if the infant was capable of such problems, (and if so, at what age, and with what correspondence with different comparable problems (at least for human infants) such as Object Concept studies), but also to attempt elucidation of the manner by which the solution was arrived at.

<u>Method</u>

Test Situations

1/ Long Toy (LT). During the first nine sessions LT testing was given to the infant in an identical setting to that of Stage V testing (support and string problems), and the reader is referred to those pages for more details. For the LT situation, the long toy was placed as shown in fig. 3.15. i.e. horizontal, and close to the bars.

Fig.3.15

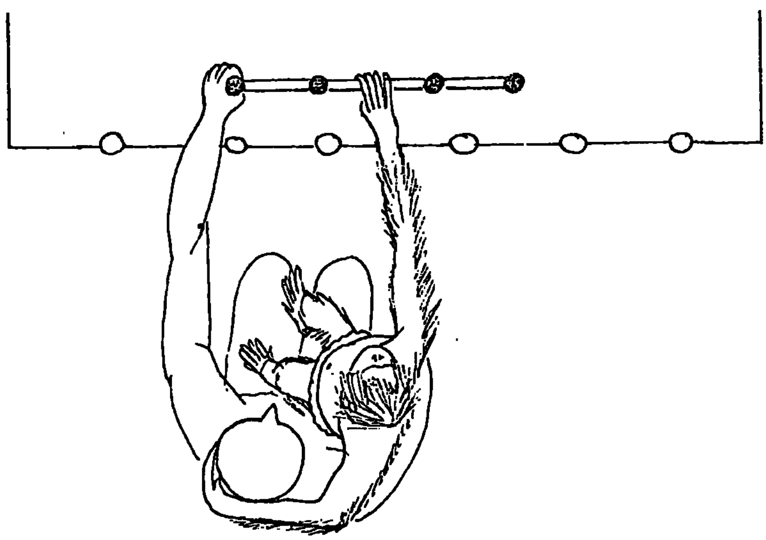


It was found necessary for the experimenter to maintain contact with one end of the long toy so as to ensure that the infant grasped the object centrally. Failing this, the infant would often make to take hold of one end of the long toy, and simply pull it in this fashion through the bar space. The long toy used primarily in this test is shown in fig.3.15, a 1 ft. 6 in. aluminium tube of $\frac{1}{2}$ in. diameter, having four plastic balls attached, one at either end and two more placed equidistantly along the rod. The design is intentional and based upon preliminary testing in which it was found that the raised spheres on the rod greatly facilitated the infant's ability to easily grasp the object from the test table. Those preliminary long toys without spheres took, on occasion, up to four grasping attempts before they were secured. The long toy utilised above was used in the majority of trials. Occasionally, because of satiety of interest in the object per se, <u>both</u> ends were dipped in a solution of honey and water of which the infant was fond. Alternatively, a second long toy (of wood dowelling, with identical dimensions to that of the metal rod of the original long toy, but without balls) was used. Here, presentation was made in the usual manner, except that the experimenter held the object approximately 1 inch above the level of the test table, so as to facilitate grasping by the infant.

Following the first nine sessions, two aspects of the test situation became unsatisfactory. Firstly, the infant took to climbing from the cot in which he was housed during the course of the experiment and this, when performed each trial, effectively terminated the session. In addition, a strategy (evolved 28.1.74) became more prevalent. This involved the infant prehending one end of the long toy with his mouth (after grasping it centrally with one hand) and then, by drawing back his head, pulling the object into the cot. So as to obviate both difficulties, the infant was, from the 20.2.74, placed as detailed in fig.3.16. The infant was sat on the experimenter's knee at a distance from the bars which prevented oral prehension of the long toy. Being on the experimenter's knee, and therefore possessed of the contact-comfort which most of the cot-climbing was designed to achieve, there was much less likelihood of the experiment being disrupted on this account, and it could thus go forward with some semblance of discipline. The long toy was presented on, or just above the mattress of the cot (which now functioned as a test table), the experimenter introducing the long toy through the rails from the left side of the cot each time, once again taking care to ensure central grasping by the infant.

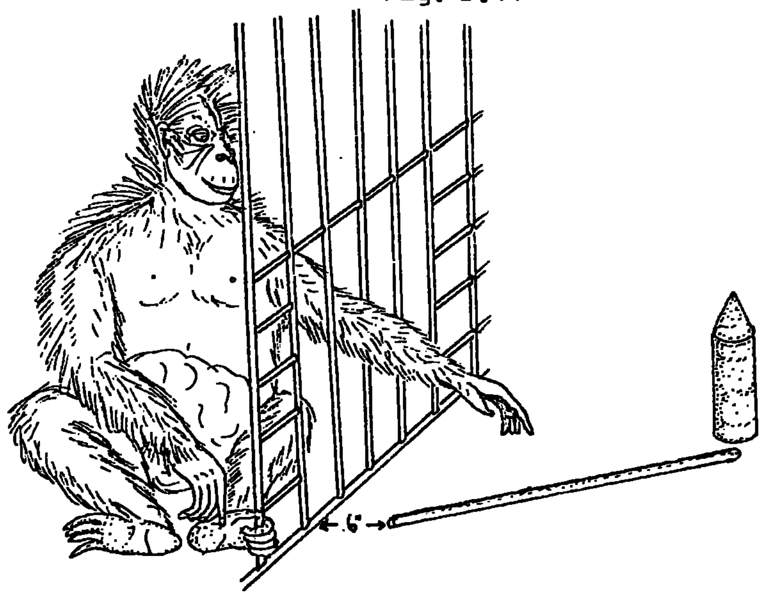
The infant's responses to the experimental set-up were noted and are described below, in both Results and Discussion sections.

Fig. 3.16.



2/ Stick Experiment (SE). Owing to the onset of increased climbing from the cot referred to above, the stick problem was transferred from its envisaged site at cot and test-table. The metal meshed door separating the play- and work-rooms was chosen as the new test position. The door was constructed of one-eighth inch diameter mild steel rods in a 2-inch square meshwork. Four of the horizontal rods, in each of four columns at the base of the door were removed, resulting in a small series of centrally placed vertical bars, 8 inch wide by 10 inch tall. the object to be obtained was placed on one side of these rails, with the infant and experimenter on the other side. A stick (usually the dowel rod which acted as the replacement long toy) was placed approximately 6 inches from the bars as in diagram, fig. 3.17.

Fig. 3.17



The object was normally the infant's milk bottle, an object for which he was at least moderately motivated on all trials. Frequent demonstrations (on average 3/session) of the method by which the object might be obtained by use of the stick were given beginning 19.6.74. The infant's responses on all sessions were recorded for as long as it seemed he was at least partially interested in the problem (4.5 - 15 minutes).

Results

The results of the LT and SE tests are detailed as % appropriate response in figs.3.18 and 3.19 respectively. In addition, the long toy results are tabulated in table 3.13.

Table 3.13

LONG TOY TEST % correct response					
DATE	+	−		+	−
9.1.74	0	100 (5)	6.3.74	100	0 (11)
18.1.74	0	100 (3)	8.3.74	100	0 (7)
19.1.74	0	100 (7)	11.3.74	100	0 (7)
21.1.74	0	100 (4)	16.3.74	100	0 (11)
28.1.74	0	100 (4)	19.3.74	100	0 (13)
5.2.74	33.3	66.6 (9)	21.3.74	100	0 (14)
9.2.74	0	100 (4)	9.4.74	100	0 (10)
10.2.74	26.7	73.3 (15)	22.4.74	100	0 (10)
15.2.74	36.4	63.6 (11)	9.5.74	100	0 (10)
20.2.74	21.5	78.5 (14)	21.5.74	100	0 (10)
25.2.74	0	100 (10)	19.6.74	100	0 (10)
28.2.74 morning	0	100 (6)	25.7.74	100	0 (10)
afternoon	70	30 (10)	22.8.74	100	0 (10)

FIG. 3.18
LONG TOY TEST.

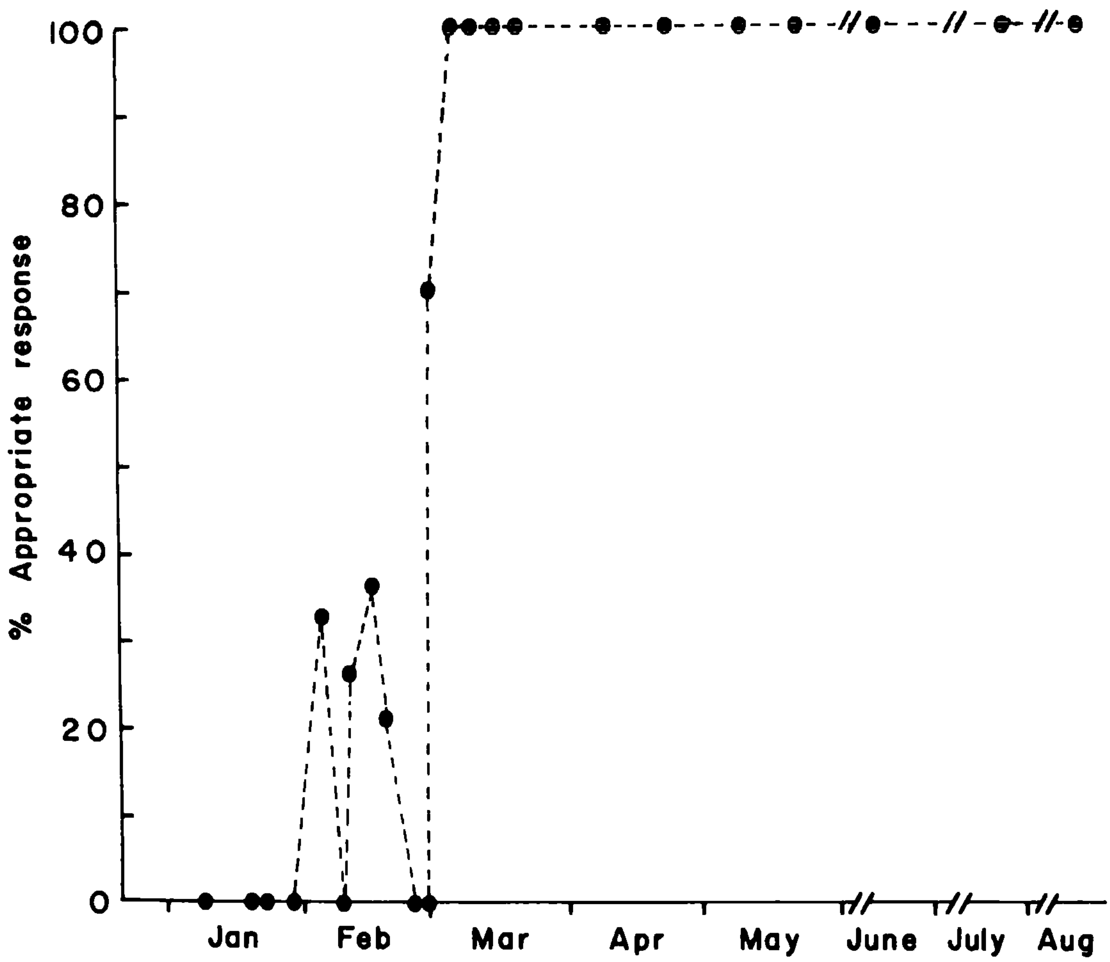
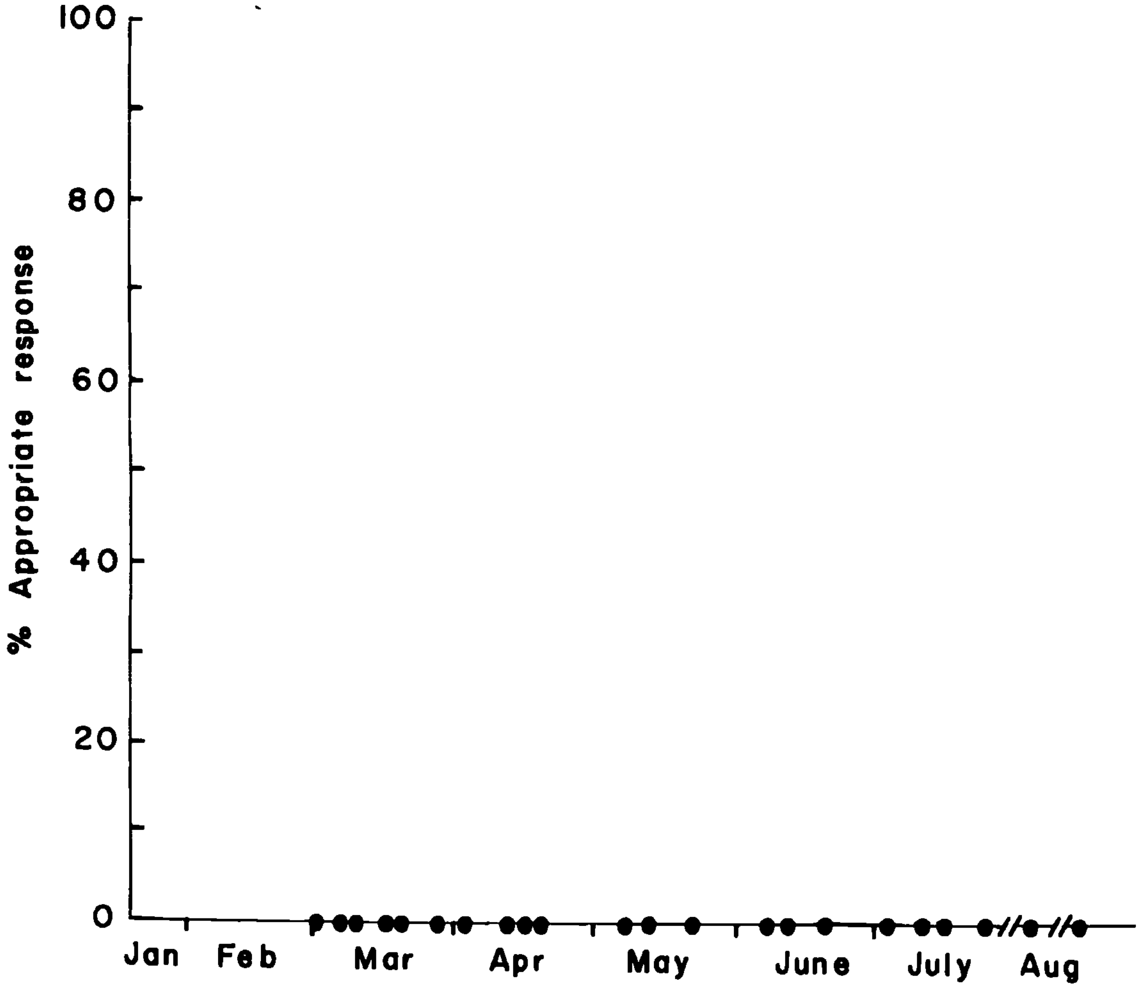


FIG. 3.19
STICK TEST



Discussion

Long Toy Test

Solution of the test above criterion (75%) occurs on March 6th, 1974. The results indicate what seems to be a three-phase progression to competence: (i) zero correct response (9.1.74 - 28.1.74); (ii) partial success at the 25 - 36% correct response level (5.2.74 - 28.2.74); (iii) rapid increase to competence (from 28.2.74).

(i) This phase consists of 5 sessions. Reference to the diary notes indicates that Cody's responses on the first three trials were simply pulling the long toy, while still horizontal, against the vertical bars of the cot, and, after one or two such actions, releasing the object and ignoring it. Only on two of the 23 trials was even slight turning of the object seen. During the final two sessions, the infant revealed two new behaviour patterns. Firstly, "solving" the problem by bringing his head to the bars and, using his highly mobile prehensile lips, prehending the object orally at one end, following which the head was pulled in and with it the long toy. Secondly, an action which was seen briefly during session 1 and which presages the true solution, pulling the object against the bars while at the same time turning the wrist so that the object's long axis was displaced to some extent from the horizontal. This behaviour was seen at almost every trial. The displacement was not, at this point, more than $35^{\circ} - 40^{\circ}$ from the horizontal.

(ii) The 5.2.74 heralds a second phase where the object was obtained through the bars by turning it 90° on several occasions. However, it seemed that success on one trial did not greatly help subsequent trials, and was of little help over sessions, (the session results showing great variation, and not a steady increase toward competence as might be expected had one session aided the solution of the next session's trials). The infant obtained the long toy "correctly" by what seemed to be an expansion of one of the more advanced actions referred to above from (i). The long toy was pulled repeatedly against the rails with wrist turning. Turning was, however, of greater amplitude than during phase (i) and when it was sufficient (i.e. between approximately 85° and 95°) the long toy came through the rails amidst much bumping and banging of its end against the rails of either side. The impression of unplanned "groping" leading to solution was emphasised by an observation during 5.2.74 where the infant, seemingly fortuitously, turned the object's long axis 90° to the horizontal immediately. However, that he expected the usual resistance of toy against rails was evident from the fact that the infant was so unprepared for the entrance of the object to the cot that, on pulling in, the object came through so fast that one end struck him a forceful blow on the head. On later sessions, visual interest in the object's movements began to show. This was most clearly visible during one trial 20.2.74, where the infant turned the long toy past 90°. He then carefully watched his hand and the object as he compensated by turning the long toy in the opposite direction (although turning it too far to the opposite side) before finally dropping it. The percentage of correct responses <u>before</u> a consistent response above criterion thus seems to be best explained by chance. By reference to Table 3.13,it is seen that, in tests with a trial number of less than 10 trials, zero correct responses are found each time. With sessions of 10 or more trials a 25 - 36% correct response may occur. However, on 25.2.74 there are 10 trials without a single appropriate response. This seems to speak for chance solutions before 28.2.74. As mentioned, solution before this date does not seem to help following sessions, whereas after 28.2.74 chance success produces reproducibility of the response (see below (iii)). Earlier "solutions" e.g. head down and pulling in of the object with the mouth, were still seen during this period (ii).

(iii) The 28.2.74 is an excellent example of the rapidity of solution with the long toy test. In the morning session the infant evinced no evidence of understanding the correct solution to the problem, each trial ending in failure. The afternoon session is far different with a correct response level of 70%.

In this latter session, solution appears to have been discovered fortuitously, but then, unlike earlier sessions, to have been immediately repeated and refined so as to enable the achievement of a reproducible correct response. The first three trials of the afternoon session were failures as in the morning session. On trial 4, after pulling the object against the bars 2 times with minimal wrist-turning, the infant looked away, and at the same time brought arm and object upwards, simultaneously twisting his wrist 90° in an anticlockwise direction. The long toy slipped through the bars, and the infant, apparently aware kinaesthetically of its position, returned his gaze to the long toy, smilingly banged it up and down against the bars three times, and then brought one end to his mouth to suck. During the next trial, the infant was observed, after grasping, to look along the length of the long toy as if to observe its horizontal position before initiating any movement. The upward and twisting movement was then repeated, as was the striking of the bars (2 times) after the object came through the bars. The long toy was then sucked until removed from the infant. In the following trial the long toy was turned only 75° and, upon "sticking" against the rails, was immediately turned the required 15° extra degrees, and removed from the cot. The remaining four trials were also successfully attempted. Following this, on each of the 13 sessions given over a 6-month period, Cody performed at a 100% level of competence.

Stick Experiment (SE)

As detailed in fig. 3.19 the stick experiment was not at any time solved by the infant during the 6-month period of testing. That the infant did desire the object was seen by his frequent attempts at grasping through the bars towards it, and his occasional screaming when the object was not forthcoming. It may well be that the infant was, on occasions, too highly motivated to allow him to come to a solution, as was the case for those chimpanzees in Birch's study who attempted problems under conditions of prolonged food deprivation, (Birch, 1945). However, although Cody may have been over- (or under-) motivated during certain sessions, this cannot be said for the greater part of testing. The great majority of sessions were given following his eating of cereal, hence his motivation is considered to have been approximately "middling" during most of the trials, the condition shown by Birch to be most conducive to efficient solution of such problems.(Birch, 1945).

Experience with sticks has been mooted as being a necessary condition for solving the stick problem (Woodward, 1959). Such may well be the case; however, both types of long toy were left around the infant's play-room at least 50% of the infant's waking hours, and he had ample opportunity to experience "what sticks were". Indeed, Cody was several times noted as manipulating the sticks for periods of several minutes outside the test situation, looking up and down their length and seemingly observing their movements in space as he varied his hand/arm positions. Further, during test sessions Cody would often grasp at the stick, apparently as "second best", when the object he desired proved to be out of reach. There was much striking of the stick against the rails, and pushing it scrapingly to and fro through the bars. However, both in free play and during test sessions, the infant seems to have learnt nothing that aided his solution of the problem. One telling omission may explain this situation: although much time seems to have been spent manipulating sticks and similar long toys, on no occasion (as far as was determined during the more than 2000 hours in which the experimenter was in the subject's company over his first 15 months of life) was Cody seen, even by chance, to use a stick to strike, and so to move, another object. This behaviour pattern may be necessary for successful solution - in at least one of Piaget's children it was utilised in framing an answer for this problem, (Piaget, 1955).

Another important aid to solution in the human infant seems to be imitation. Piaget demonstrated the use of the stick in obtaining an out of reach object to one child, who then attempted similar actions with the final result of problem solution. At no time during the first 15 months of life was imitation seen with this infant Orang-utan subject, except where it was specifically trained-for over many sessions using operant techniques (e.g. hand on head, see Chapter 5).

Likewise, the delayed imitation expected in Stage VI with the human subject, (Piaget, 1955) and seen in Washoe, the Gardners' chimpanzee (Gardner & Gardner, 1971) and Viki (Hayes,1952), was not evident in this subject.

Thus, the two main paths by which the solution of this problem seem to be achieved in the human subject seemed to have been denied this Orang-utan subject and may explain his lack of "foresight" in this regard, despite the apparently optimum motivational condition of the creature.

It may also be that, terminating as it did just after the infant's first birthday, the experiment was not continued for a sufficient length of time to allow the charting of the discovery of a solution to this problem. Thus, in this specific domain, Stage VI may be accomplished at a later date. This certainly seems to be the case, for the infant did show "foresight" sometime after termination of the stick experiment, albeit in a different context. Stick experiment was terminated as Cody then lodged in Sunderland, there being no facilities for such testing at this location. This was a self-imposed problem, seen (with contextual variations) occasionally during the course of his rearing but which was not solved "insight-fully" until September 29th. The infant desired to open the door of the bedroom in which he was housed. The handle of the door was set at too great a height to allow easy grasping and there were no nearby ledges on which the infant could climb so as to obtain his desire. However, unlike previous occasions, the infant was observed to move away from the door, across a distance of at least 6 feet, seize hold of a tubular metal A-frame which was in the bedroom, and to pull it close to the door. The infant then mounted the A-frame and seized the door handle easily. From then on, this behaviour was repeated whenever this and similar occasions arose. As such, the response duplicates in all essential features Kohler's "banana-and-boxes" test which his chimp subjects also proved themselves capable of, (Kohler,1925).

Hence, although the initial date of attainment of Stage VI insight behaviour is not known with certainty, it is established that, in this Orang-utan subject, this level was attained by at least one year two month. It is unfortunate that the development of this response does not appear to have occurred during observation periods with the infant. However, being a covert mental process, observation (except by the overt behaviour as detailed above) is impossible.

OVERVIEW

The results of each test type given illustrate several points with reference to Piagetian theory.

With test situations which allow the monitoring of various levels within that situation (Cover, Teat-Recognition and Screen Tests), this Orang-utan infant has been shown to pass through similar stages to that seen in the human infant (Piaget, 1953, 1955; Uzgiri and Hunt, 1966; Corman and Escalona, 1969 - see introduction). It is only at Stage III and Stage IV-V Transition tests in the screen and cover tests respectively, that inadequate data preclude such a statement, and even here it seems probable that Piagetian sequencing will prove true when further work is done on the Orang-utan. Although following the same stage sequence within any test, the times of attainment of the various stages are far in advance of the normal human infant. This has already been referred to in connection with the cover experiment. To recap, it appears that development is telescoped in the Orang-utan for the test situations monitored in this research.

Two objections may be raised against the methodology of this work. The first is that in the Cover, Screen and Test-recognition tests, by giving the problems of any test-situation sequentially (St.III, then St.IV, then V, etc.) the infant was forced to solve, say, the Stage III problem presented when he might easily have solved the Stage VI problem, had this been presented at the same time. The stage sequence may thus be more apparent than real.

To obviate this, as soon as criterion was reached with one test situation, the next most complex was given. While it may well have been better to give all the tests eventually presented to the infant at the same time, this would have precluded other research with the infant (Language, Grasping, etc.). As the work is intended as a pioneering study of infant Orang-utan development, it was thought better to carry out the study as described above.

It should be noted that the response to the manner of presentation was different for each test. There was no consistent response to the test situations, i.e. the infant did not always solve a problem after suitable exposure to it. On some occasions, the infant proved unable to cope over many test sessions, e.g. Stage III - IV Transition, Cover test, (or to ever solve the problem, e.g. Stage VI, stick test).

On other tests, the infant responded appropriately from the first trial session, (Stage IV - VI Transition, Cover test). Other cases fell between these two extremes. Thus, the amount of practice which the infant achieves does not appear to be critical to his success or failure. The infant achieves problems or fails them whether there is practice or not, and he does seem unable to succeed at tests of greater complexity than that which he has just achieved. In the case of the Stage III - IV Transition test, the infant had a total of 123 trials over a period of 3½ months before achieving criterion, while it took but 21 and 0 trials to master the next two tests. It should be noted that this was not a learning set sequence (Harlow, 1949);the following two tests took a total of 25 and 34 trials respectively before mastery was attained. Stage IV - V Transition and Stage V tests are most noteworthy in this respect. Both were given within one day of each other. The test classified as less complex was solved first, while the more complex (Stage V) took a further five sessions and 44 days before criterion was achieved (see also Stage III - IV Transition, and Stage III Screen test). As mentioned above, it should also be noted that Stage VI testing (Stick test) was never solved, despite 20 sessions over more than 5 months.

In addition, it should be emphasised that Piagetian tests are designed to reveal the level of cognitive structuring that has evolved during, and because of, normal experience. Thus, the rolling of a ball beneath a table affords the infant the opportunity to experience an object concept situation. The solving of a multitude of such occurrences during normal day-to-day experience leads to the infant achieving stage after stage of object concept. Hence, the test situation should be looked on as only one of many situations in which the infant "practises" his object concept notions. Seen in this light, the "practice effects" caused by testing become a minor intrusion into the infant's ongoing "experiment" with the world in which he moves, and the infant's apparent unaffectedness by the practice afforded by testing is explained. It is therefore considered that the stage sequence shown for the various tests is a correct tabulation of the infant's ordered progression in cognitive development.

One final indication that practice did not have a marked effect on time of solving a problem is furnished by study of inter-test data.

It might be expected that, between tests, the test given first would be solved at an earlier date. That this is not so is shown by Table 3.14.

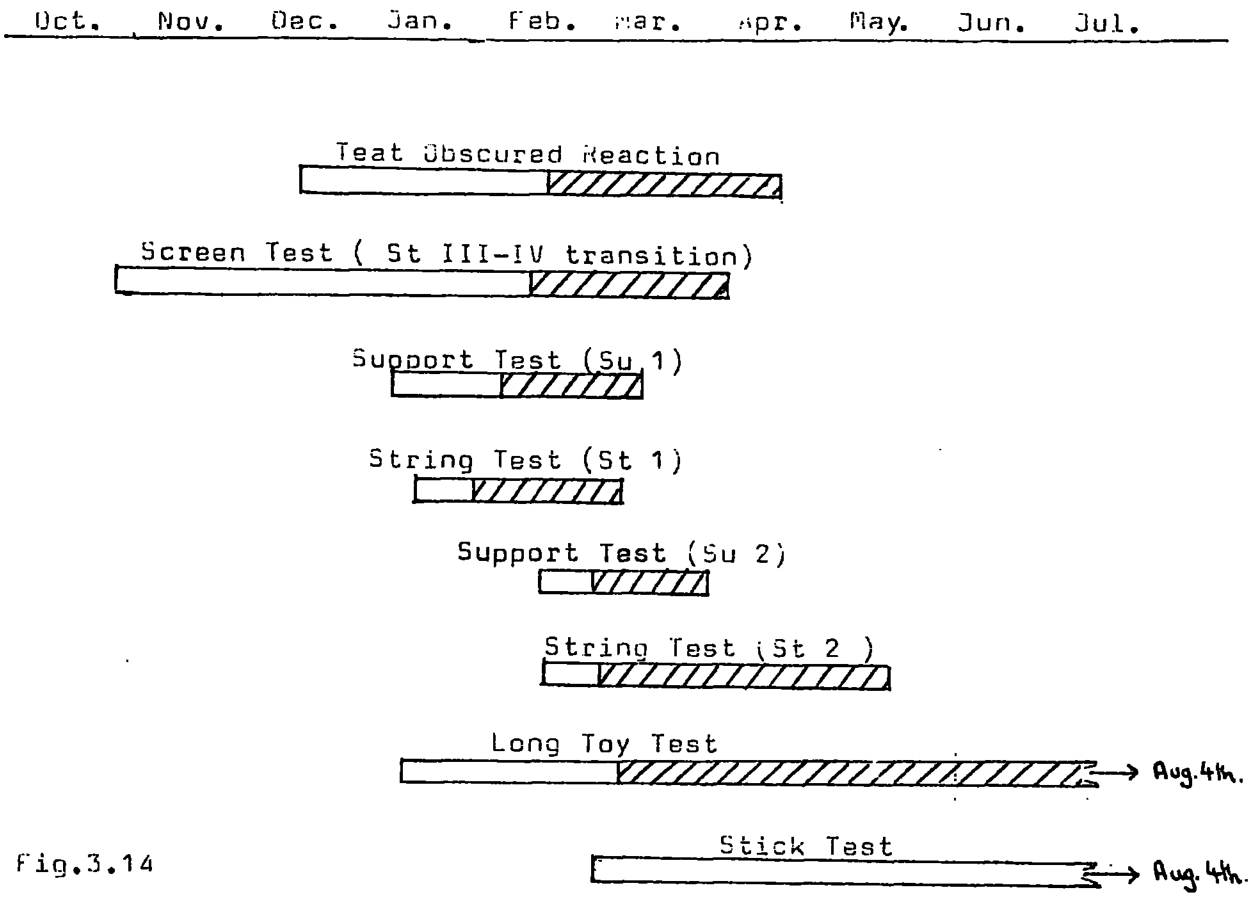


Fig.3.14

▭ = not achieved.

▨ = achieved.

Here we can see that there is a wide discrepancy between when any problem is first presented to the subject and when it is finally solved. For example, the Screen Test Stage III - IV Transition took more than three months to achieve while the 2-string test took only 14 days. Similarly, the two string test was achieved just before the long toy test, despite the fact that the infant had more than twice the time to practise the latter problem. The stick test was never achieved despite more than 5 months of constant practice.

While establishing that practice of test situations is not of great importance in the attainment of these tests, inter-test data also reveal a marked discrepancy between human and Orang-utan developmental patterns.

Whereas Piaget and his co-workers claim that all problems within any one stage are all achieved at approximately the same time (Piaget, 1953; Woodward , 1959). The results of the foregoing experiments show that, for most stages this is not true for the Orang-utan. On no occasion do the tests corresponding to a single stage fall within even seven days of one another. In many cases, the stage-dates of many tests are found widely spaced (e.g. Stage V, attained during the 32nd week according to the String and Support tests, and in the 40th week according to the Cover test). Similarly, Stage III - IV Transition was attained during the 30th, 31st and 32nd weeks, according to the screen, teat-obscured, and cover tests respectively. Sometimes stages are inverted between tests, as when Stage V appears before Stage IV - V Transition, when comparison is made between the results of Stage V String or Support tests (32nd week) and that of Stage IV - V Transition cover and screen tests (33rd and 34th weeks respectively).

One explanation for such seeming anomalies is that a test may have been placed in the wrong stage category. In these investigations it would seem that the Long Toy Test has been so misclassified. Whereas Woodward (1959) cites this test as a Stage VI achievement, Flavell (1963) is of the opinion that this problem is a Stage V problem. From the data presented, the Long Toy Test was achieved at the same time (within 5 days) as the Stage V problems of String and Support. It may be, therefore, that this problem has been wrongly classified by Woodward. As the allocation of a problem to a given stage depends on its complexity, it does seem that a simple "90° turn and pull in" (the correct response to the Long Toy Test) corresponds to a much greater degree with the other Stage V problems than with the mental and physical manipulations of the Stage VI Stick Test.

However, such misclassification of tests cannot account for all discrepancies revealed by the data. It may simply be that the Orang-utan infant has a different psychological as well as physical developmental pattern compared to a human infant of the same age (compare Chap.2 - Gessel Test). Indeed, it would not be surprising considering the different habitat and evolutionary history of the two species. The Object Concept, for example, may be less important to an Orang-utan than the ability to pull in a branch laden with out-of-reach fruit. This may explain why the object concept stages were reached at a relatovely later date when compared to the String or Support tests. This postulated later development of less important behavioural domains may help to explain the lack of success in the stick test.

Wild adult Orang-utan are known to have this "stick" ability (Plage, pers. comm. 1977), yet Cody failed to achieve the problem up to the age of 55 weeks. If such an ability is of less importance than, say, pulling in of attached objects, it might be expected that competency would mature later in ontogenetic development. In line with this, and as mentioned on page 45, at the species level the evolutionary/ecological history of a species is thought to affect the presence or absence of cognitive structures (eg. Object Concept) within that species.

CHAPTER FOUR

THE DEVELOPMENT OF VISUALLY-DIRECTED GRASPING

REVIEW OF RESEARCH

INTRODUCTION

Grasping constitutes an extremely important function in Homo sapiens (Napier, 1960). Without the act of manual prehension, tool-use, food-collection, aggressive and defensive behaviour - all would be impossible (or reduced to a very low level of complexity). Were visually directed grasping beyond the wit of Man, his ability to act effectively upon the environment would be negated.

Much the same can be said of the remaining Hominoidea, and of the Primate order generally. Reflex grasping in virtually all primates functions to maintain the infant in close physical contact with its mother, though this is lost in later life. Grasping and manipulation form an integral part of behaviour in chimps (Goodall, 1968; Reynolds & Reynolds, 1965; Teleki, 1973; Suzuki, 1971), Gorilla (Schaller, 1963; Fossey, 1972, 1974), Gibbon (Carpenter 1940) and the Orang-utan (Mackinnon, 1974; Davenport, 1967; Harrison, 1961). Primarily, its use is in food collection and locomotion, but other acts are also important (e.g. defense in chimpanzee (Kortlandt & Kooij, 1963) and Orang-utan (Mackinnon, 1974; Davenport, 1967)). Much the same can be said for the Simian and Prosimian groups.

At first sight the act of grasping an object seems a relatively simple manoeuvre. Closer analysis reveals, however, that many less complex movements must be coordinated to allow grasping on sight. It is a superordinate behaviour pattern.

Any major behavioural act can be broken down into smaller components, e.g. behaviour Λ can be analysed into suborder behaviours A, B and C. A can then be analysed into smaller parts, i and ii, B into iii, iv, and v, and C into vi and vii. (It is also important to realise that parts i, ii, iii, etc. can be grouped to form different patterns, thus producing other modes of behaviour, e.g. Ɛ may consist of D and E, but D may be i and v combined, and E iii and vi.) Segments at the lowest level are therefore joined to form larger sequences at the next level, and these in turn group to form yet higher levels. The organisation is thus hierarchical, and by describing only one level of organisation, many features of the behaviour may be omitted, especially its configurational aspects.

Successful grasping requires that the hand be brought to a point in space occupied by the object that has been fixated (this requires immobilising the head and eyes), and that the hand is opened and closed in the correct sequence around the object. The action is therefore made up of at least 5 component actions.

i/ Visual fixation of the object.

ii/ Activation of the hand on visual contact.

iii/ Moving the hand from outside the visual field so as to bring both hand and object simultaneously in sight.

iv/ Directing the hand towards the object.

v/ Opening and closing the hand at the appropriate time in the sequence (i.e. hand open as it approaches the object, and closing the hand upon tactile contact.)

Of course, this is by no means the lowest level of analysis. Each of the 5 components noted above can be broken down into smaller and smaller units until the level of "muscle group innervated" is reached (Miller, Gallanter and Pilbeam, 1960). For the present study the 5 components described above were considered the lowest level of analysis. Descriptions of the development of these motor functions are also included.

Grasping in the human subject has been fairly intensively studied. Gessel's work (Gessel, 1949) was subsumed to his primary goal of obtaining normative data concerning the general development of children. He believed that early behavioural development was almost exclusively due to an "unfolding" process of progressive neuromuscular maturation. Very little account was taken of the part played by sensory input (either from the environment or from the infant's own actions) in affecting performance levels.

Piaget's point of view is, perhaps, more realistic. (Piaget, 1953, 1955). In essence, he believes that development is a result of the continuous process of interaction between the infant's physiologically determined maturation, and its interaction with the environment. Interaction is accomplished in a variety of ways, though in the first year of life primarily by the behavioural schemata the infant erects. The schema is central to Piaget's theories, especially during infantile development. Piaget himself does not define a schema, seemingly preferring to let the reader come to an holistic, intuitive idea of the concept, but Flavell (1969) has attempted this daunting prospect. His definition follows: "A schema is a cognitive structure which has reference to a similar class of action sequences of necessity being strong, bounded totalities, in which the constituent behavioural elements are tightly inter-related". An example may clarify the concept; an early grasping schema is composed of reaching, opening and closing the hand, and retracting sequences. During early infancy such a "schema" will tend to be evoked and repeated whenever an object is placed close by the infant. This idea of repeat-ability is close to the idea of schema. A schema is also said to assimilate objects to itself (by eg. grasping at any object presented), and to accommodate the schema to the object (by e.g. producing a different finger conformation in the grasping movement for a large, as opposed to a small, object). In this system, assimilation takes three forms: repetition schemata as when the infant repeats the grasping action several times on one object; generalising schemata when the infant grasps at any object (so generalising from the objects already grasped to new forms); and recognitory schemata, as when, having grasped an object, the infant realises it to be not the one it desires, and releases it.

From detailed observation, Piaget has postulated the existence of "stages" in human development (see Object Concept section for detailed account). More germane to the problem of this section is his cataloguing of the schemata that precede the different levels of grasping ability. These have been summarised (from various authors) in the chart overpage (fig. 4.1), together with additional data derived from workers who subscribe (at least in part) to a Piagetian view of development. The chart does not claim to be exhaustive, but it does outline most of the important behavioural sequences (schemata) postulated as necessary (or at least present) prior to each level.

As is evident from the chart, there are many behavioural sequences said to operate prior to full "grasping on sight"

fig.4.1

LEVEL 1: REFLEX RESPONSE

- Visual Fixation
- Palm contact   decreased activity (ie. infant "attends" to object)
- Open and close hand (increases with manual contact of object)
- Increased hand movement with manual contact of object
- Scratching, then grasping
- Grasping, releasing, regrasping
- Mutual hand clasp
- Tactile exploration of face

LEVEL 2: GRASP WHEN OBJECT TOUCHED AGAINST FINGER TIPS (hand to mouth and suck at approximately the same time)

- Grasp object on oral contact
- Object grasped is taken to mouth
- Keeps moving hand in view
- Alternate sucking/looking at object held at mouth
- Visual contact   increased hand/arm activity

LEVEL 3: GRASP WHEN OBJECT AND HAND VERY CLOSE IN SAME VISUAL FIELD

- Bring hand close to object, and alternate looking between hand and object
- Bring hand from far, to close by object, then grasp

LEVEL 4: GRASP WHEN OBJECT AND HAND DISTANT IN SAME VISUAL FIELD

- Visual contact with object (hand outside visual field)   great increase in arm activity. When hand and object in same visual field, grasping and sucking
- No looking in direction of captive hand

LEVEL 5: GRASP WHEN HAND OUTSIDE VISUAL FIELD

- Extensive looking at object
- Looking in direction of captive hand

TYPES OF GRASPING

development. Each of them however, can be seen to contribute some form of sensory input which may be of use in informing the infant of the most efficacious manner in which to go about the action of grasping. Thus visual interest in the hands, in the form of holding the hand stationary and looking at it, looking while the hand opens and closes or the fingers are moved, watching the hand moving across the line of vision; all can be considered coordinations of kinaesthetic feedback information (from arm, hand and finger movements) with visual input (images on the retina of the hand moving. etc.) allowing the infant to gain visual control of hand movements. Recent work (Field,1977) has shown how important is visual feedback from the hands in grasping. Infants denied sight of their hands when reaching showed a marked decrease in their ability to reach and grasp. Similarly, coordination of tactile and buccal information is thought to occur when an object placed in the hand is grasped, carried to the mouth and sucked. (Piaget, 1953, Woodward, 1971). When later this behaviour pattern is extended, with the infant sucking, then removing and looking at the object, coordination of visual, buccal and manual input may be postulated. Thus, at first, the infant perceives the object with each modality in isolation. It is only with the inter-coordination of different sensory impressions that it is possible to produce some form of superordinate cognitive "structure" concerning the many properties of an object <u>in toto</u>. Visually directed grasping formas an integral part in such intercoordinations.*

What is interesting in Piaget's system is that those behaviour patterns said to develop earlier are found to be of lower complexity than those following after. For example, visual following of the

* Bower (1974) has argued that perception in the new-born is <u>supra-modal</u>, ie., perception is holistic and undifferentiated. From this stance, rather than a question of integration, the developmental problem is one of differentiation. However, recent work has tended not to confirm this hypothesis (eg. McGurk, Turnure and Creighton 1977; Twitchell, 1970; Field, 1977)

hand (requiring holding of the object at the fovea by eye and head movements, plus a holding action of the arm muscles) precedes holding the hand next to an object (requires all the above plus a directional component in the arm movement). This latter precedes grasping an object (requires the above plus opening and closing of the hand). Whether all the movements shown in fig.4.1 are prerequisites for grasping has not yet been elucidated. Some may be superfluous.

White, Castle and Held (1964) have given fairly detailed data on the ontogenesis of the grasping function, studying infants by means of a standard stimulus presented in a standard manner to each of their supine subjects. They found two types of visual following preceding adult following: "peripheral", the infant failing to follow until the object stimulates the peripheral receptors of the retina, when the eyes are then jerked so as to bring the object onto the fovea centralis; "central" pursuit, where the eyes anticipate, rather than lag behind the motion of the object.

White et al divided their six-month study into two week periods, and upon analysing the results obtained found, swiping at the object with fisted hand was common at 2 - 2½ months; at 2½ - 3 months sustained hand regard was present. Response to the object was immediate fixation and swiping, or the hand was raised to within 1 inch of the object and the hand and object looked at alternately; 3 - 3½ months saw similar behaviour as the prior two weeks, plus bilateral hand raising to the object and alternate looking. Hand clasping was also seen, plus raising one hand, while the other hand grasped the infant's clothing in mid-line; hand regard began to fall out around 3½ - 4 months, but hand clasping was much increased, together with visual monitoring of their approach and subsequent interplay. Response to the object was as at 3 - 3½ months, though some torso-turning towards the object was observed; 4 - 4½ months saw bilateral responses predominating when the object was presented, usually with alternate looking between object and hand. The clasped hands could also be raised towards the object. Presaging true grasping, during this period a hand was occasionally raised and moved slowly towards the object with alternate looking between hand and object. When the hand contacted the object it was fumbled and crudely grasped. Towards 4½ months, opening the hand in anticipation was seen (Also by Piaget). The final two week period (4½ - 5 months) showed top-level reaching (a rapid lifting of one hand from outside the visual field to the object, the hand opening as it approached the object). Hand-to-midline, and Piaget-type responses were more likely during this period, but they quickly fell out of the behavioural repertoire after 5 months of age.

In the light of Piaget's detailed study and postulations, White et al's is somewhat lacking in data. Without doubt it is an important work, and an excellent description of the supine human infant's development of grasping at a standard stimulus, yet, for the level of analysis described here, it is deficient in several respects. There is the size of the sample: for statistical and other purposes it is best to work with large groups of subjects. For the analysis of the ontogenesis of motor behaviour at the level of coordination of discrete motor patterns, it is necessary that a large corpus of behaviour is known for each individual. Given the funding and technological resources of the present day, large samples of behaviour can only be obtained from a small number of subjects. White et al's study, working as it does with 34 subjects, with 1 test sessions per week, and of only 20 minutes' duration (10 minutes pretest, 10 minutes test) with each infant, may give statistically valid results (undoubtedly necessary to our understanding of grasping development), yet it allows only a cursory look at the process of this development. To re-work an oft-used simile, it is as if a cine film of a man using a ladder to climb a house were stopped only at the frames showing him at the bottom of the ladder, at its top, and at the chimney. The man reaches the top of the ladder, yes - but in what manner? He gets to the top of the roof from here, but how? The infant moves from unilateral to bilateral arm actions towards the object - how? The ongoing process of interaction which leads to these advances is, for the most part, unknown.

This lack of detailed knowledge of each subject studied also leads to a dearth of information concerning the various hand-mouth, tactual-oral coordinations which the studies of Piaget have revealed. In addition, a description of concomitant behaviour patterns, such as motor behaviour of the torso and limbs, affectional behaviour and feeding responses are also lacking.

The larger the number of subjects the smaller the corpus of behaviour obtained from each. Thus, from White et al's work we do not know if the various stages of visually directed reaching are present before/after, the ability to move from prone to supine, or vice versa; go up on all fours; grasp the foot with the hand; move the body forward; cry when "mother" leaves; etc., etc. We are equally ignorant of the baby's accomplishment with regard to grasping when the object is touched against the tips of the fingers, or placed in the same visual field as the hand; coordination of hand to mouth and sucking; grasping on oral contact, etc. Nothing is said of the ontogenesis of these and other behaviour patterns which are held by some workers (Piaget, 1953; Woodward, 1971) to be of prime importance in achieving visually-directed grasping. Which of these behaviour patterns are present, which absent? Knowledge of this sort would do much to inform us whether such behavioural sequences are imperative to grasping development - they are not found in this study.

Similar work on infra human primates is not as detailed, nor has it been so consistently pursued. Research on the forms of grasping in adult primates has been performed by Napier (1961), but there is a great paucity of true developmental studies. Kellogg & Kellogg, (1933) give brief details of grasping data derived during a 5-month presentation of the Gessel test to a young chimpanzee, and a similar, though longer, report by Knobloch and Pasamanick (1959) details the results of Gorilla responses to the same test situations. Early development of grasping is only now being attempted for the Gorilla (Redshaw, pers. comm. 1974).

As ever, the Orang-utan has been disregarded at this and most other levels, the performance of the African apes apparently being assumed to accurately delimit the abilities of the Asian members of this group. It was the obvious falseness of this conception that led to the subject of the section presented here - an in-depth longtitudinal study of the behavioural ontogenesis of this important skill.

CHRONOLOGICAL ACCOUNT OF GRASPING DEVELOPMENT IN AN INFANT ORANG-UTAN

METHOD

To give a more complete picture of the infant's grasping development, descriptions of his earlier attempts at hand control are also considered in this section. Manifestly, grasping *per se* does not arise of itself, and we must seek its precursors in these earlier behaviour patterns. They include: - moving the hand in horizontal, vertical and 45° to the vertical hooking movements (ϕ_h, ϕ_v & ϕ_d respectively) moving the hand to the mouth (and vice versa); moving the hand to the face, usually with tactile exploration; moving the hand, arm, fingers (or any combination of these) with or without looking at the movements, and with or without contacting either another part of the infant's body, or any external object. All such movements can be thought of as producing input (kinaesthetic, visual, auditory, tactile, or any combination thereof) that would be of use in "informing" the young animal

a/ where his limbs are at any given point in time, and

b/ how to move his limbs with a greater degree of surety than prior to the input. Such information would then allow repetition of novel or habitual movements which had produced interesting stimulation in a given situation.

The data show many behavioural sequences to be very, very gradual accretions of motor ability; to divide such data into "sections" or "stages", (although extremely convenient for analysis) is to give the reader altogether too precise, too pretty a picture of what actually occurs. The strategy used was therefore to divide the information into week periods. This arbitrary procedure is, as far as much development is concerned, also very artificial. However, it possesses the advantage of being a well-understood temporal interval, and of not suggesting a well-defined, cut-off stage to the reader. The end of a week is simply a convenient place at which to draw breath, to view the achievements of the previous seven days, and to attempt to place these accomplishments in to some sort of perspective vis-à-vis past and future behaviour.

Within each week period, development was arbitrarily divided into several sections. Visual fixation and visual following of a desired object (prerequisites for any form of visually directed grasping) are considered separately, as are hand to mouth procedures and visual regard of the hands. Such categories are not mutually exclusive, and as development progressed it became increasingly difficult to categorise most of the behaviour patterns seen. Towards the end of the third month, the complexity of the infant's movements, his intercoordination of various motor functions (e.g. look to his hand, look to the object as it swings, then ϕ at it, then h to M) made simple classificatory patterns unworkable. Behaviours not falling neatly within the sections described above were placed under the heading "General grasping". This section, therefore, comes to constitute the main part of the work as development proceeds, and the particular coordinations, expansions and de novo behaviour patterns are explained in the text as the need arises. Naturalistic observational data are treated separately from the formal tests that were performed.

These latter consisted of four tests; (i) Object in Hand: where the object was placed by the experimenter on the palmar surface of the subject's hand; (ii) Object at Finger-tips: the object was touched against the tips of the subject's fingers three or four times in succession; (iii) Object Visually Presented: object held before the subject's face at a distance of approximately 8 cm; (iv) Object in Mouth: object placed in the subject's mouth (only those trials in which the object was held in the mouth for greater than eight seconds were counted). In all tests, the infant's responses to the test situation were noted. The infant was run for as long as he would cooperate.

Tests (i), (ii) and (iii) were instituted to test the applicability of Piaget's reports on the course of human infant grasping development to the Orang-utan, (Piaget, 1953). A more comprehensive test battery, including e.g. Object visually presented and held in same visual field as hand, would have been preferable, but considerations of time precluded this. Test (iv) with test (i) were designed to test the applicability of Piaget's statement that in the human infant, when a grasped object is taken to the mouth, the infant is able to grasp an object placed in the mouth.

BASELINE DATA (12. - 14.9.73 - infant's age: 6w 5d)

Naturalistic Observation

The infant was relatively immobile, having only a few simple motor movements (see Motor Behaviour). No hooking movements were observed in the prone position (the supine position was not seen). When carried - trunk vertical and supported by experimenter's chest - he would occasionally perform open-handed horizontal hooking actions in the plane of his eyes, as show in fig.4.2. This movement was designated Φ_h. Later, during the baseline period, a similar vertical action was seen and designated Φ_v. Although hand movements in most directions were observed, most were of the Φ_h and Φ_v varieties. A Φ_v action which clawed down the clothing of the experimenter was also seen. These behaviours were not seen while the infant was prone, although reflex grasping of the blanket on which he lay was seen often, with Cody in normal position, ie. lying flat on the cot floor, arms and

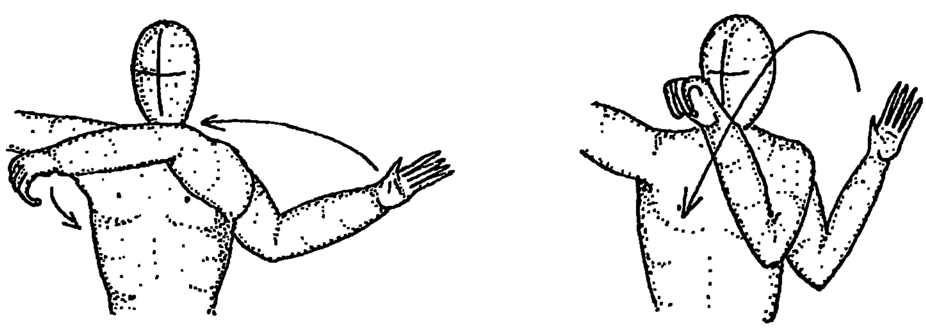


fig.4.2

legs bent at 90 , and usually gripping the blanket on which he lay (normal position abbreviated to n.p. in the text).

Formal Testing

(i) Object in Hand. (9 trials). Any long cylindrical object placed across the palm of the hand was enough to induce reflex grasping of the object in prone or sitting. On 8 trials the infant simply grasped, then dropped, the object within 5 seconds. On T7, the infant grasped, then held the object (a Pen) for 30 seconds before release. No grasping, partial release, and regrasping of the object was seen (compare Piaget, 1953, Obs. 52). On only one trial was a brief glance at the object given, and here fixation was doubtful. There was no attempt to bring the hand and object to the mouth.

(ii) Object at Finger-tips. (6 trials). No response was given on each trial given.

(iii) Object Visually Presented (8 trials). No response was observed on each trial and it was uncertain that the infant was fixating the object presented.

(iv) Object in Mouth (4 trials). The object was a small 2-inch diameter plastic disc. It was sucked lethargically until lost from the mouth. No movement of the hand to either mouth or object was noted.

Hand to Mouth

Success at the hand to mouth manoeuvre was considered total when the infant could place part of his hand either on the lips or in the buccal cavity of an already opened mouth, from any position. This may be regarded as the completion of this action, but in reality it is but a single point on an ever-flowing continuum of motor expertise. Below this point were many movements which by a number of degrees failed to meet the criteria set out above. And above it were behaviour patterns, like grasping an object and taking the hand and the object to the mouth, which formed yet higher order coordinations. Be that as it may, success at hand to mouth activity under the conditions stated forms a convenient point whither to lead the discussion of this function. Moving the hand to the mouth for sucking, without the benefit of a support was, during the latter 3 days of the seventh week, very difficult for the infant. Indeed, it is questionable whether he was capable of such a precise degree of coordination, except by chance. In

14 observed hand to mouth region movements, only three were successfully placed at the mouth. The remainder contacted either the face or the side of the head, i.e. hand to head coordination seems to have been present, but the fine control necessary for placement at a particular spot was quite absent, the infant several times almost losing an eye from his flying fingers. Once in contact with the head region, the young creature could bring hand to mouth by way of his face, and it was very noticeable that this was done without ever once losing contact with his face. For example, the hand would be raised and hit the nose; from here it moved down, the bent index finger eventually finding the mouth, which opened as the finger touched the lips. Thus tactile input seems important in informing the infant of the position of his hand on his face in relation to his mouth (though it may simply act as a support). The conclusion that kinaesthetic input alone was insufficient, at this point, to allow hand to mouth movements is greatly strengthened by observations of the infant trying to suck at his hand which was out of oral contact (13.9.73). Cody was seen fixating his hand (in a prone position), the hand being approximately 5 cms. away, thumb pointing towards his mouth, and making pouting and sucking movements, as if desirous of sucking the "object" yet ignorant of his ability (or unable) to move same.

On the other hand, the addition of any form of tactile feedback, (not necessarily the reciprocal tactual input deriving from hand-on-face contact) was sufficient to allow successful placement of the hand. This was usually by movement along some form of substrate (e.g., the floor of the cot while the infant was prone, the clothing of the "nurse" whilst being carried.). In seven observed hand to mouth movements along a substrate, all were accomplished with facility.

Presumably, on such occasions, along with kinaesthetic information, tactile feedback will play an important part in the "input" side of the successful movement. It may be postulated, though it was not observed, that the movement from face to mouth will be made with greater ease before that of moving the hand an equal distance along a substratum. In the former case, two "bits" of tactile information are involved (from facial pressure receptors and from those located in the dermal layers of the hand), whereas in the latter movement, only those of the hand will be responsible for input. An alternative explanation is that the infant, lacking the neuromuscular wherewithal to perform the movement in the air, uses any object it can find to act as a support (i.e. tactile information derived from the hand on the support is of relatively minor importance in the execution of this movement). That visual input is negligible at this stage is evident from the fact that in the majority of cases the eyes were shut as the movement was performed.

Visual Regard of the Hands

Except for the looking and sucking protocol described above, this was not seen during the period of baseline collection.

Vision

At most times the infant's regard of objects near to him was very brief, his gaze lingering but shortly on the object. At other times eye accommodation was marked and he fixated one object for long periods of time, e.g. blankets of cot, door, myself, (12.9.73). It appeared that the infant focussed in one plane of vision (i.e. at one distance) and took account solely of objects in that plane. Evidence for this falls into two categories:

i/ Blink reflex. At times the infant was hypersensitive, startling when e.g. my hand, or his own, passed across his line of sight. At other times, and within minutes of demonstrating such hypersensitivity, a plastic object (2 times), my fingers, (3 times) , and the hand of another person (1 time) brought swiftly to within two inches of his face elicited no startling, and no blink reflex. On one occasion, one minute after such non-response, as my hand passed heedlessly across the cot, Cody startled. The most probable explanation for such behaviour is that, attending to objects only in his focussed plane, the infant completely disregarded other visual impressions. This conclusion is supported by

ii/ Visual following. No visual following was evinced on numerous occasions during the first day of observation. Several objects were ignored as they were passed across his line of vision within one to two feet of the infant's face, parallel to the ground. They might not have been there. The following day, having swung a small woollen doll at 45° to his line of vision and elicited head turning and regard of the object, the doll was moved (approximately 18" from his face and parallel to the floor) across his face. The infant followed with eye movements only (no head turning) and following was saccadic, i.e. by a series of small jerks. Later, following was at times unsuccessful, and at times successful. In these latter instances, the infant had, just prior to the test, focussed on the object, and each time following was saccadic. That the infant followed only when the object was definitely focussed on, speaks strongly for the hypothesis that the objects outside his plane of focus were disregarded (see especially 8th week - visual following).

Directional looking at the source of a sound was not present at this period of development.

Whilst in the prone and sitting positions, the infant was observed to look round him, though fixation of any one object was very rare. When placed supine, his eyes and head ran seemingly along the ceilings and walls, then fastened onto one part (usually without any observable distinctive features) of the visual scene.

Summary

Reflex grasping is present in this period for both hand and foot; Φ_h and Φ_v hooking movements performed only in upright (carried position); Object in hand reflexly grasped, not looked at with any degree of concentration; no evidence that grasped object is carried to mouth and sucked; no evidence that object sucked in mouth elicits hand to mouth or to the sucked object; no response to visually presented object. Hand to mouth: is possible on a substrate (clothes of nurse, floor of cot); hand swings (probably uncoordinated) sometimes hit face, once on can bring hand to mouth by maintaining tactile contact with face; probable that the hand he looks at not yet cognised as the object he sucks, - with this one exception, no visual regard of the hands; accommodation of eyes to object very rare, may be he looks at objects which are present at the plane of focus he has accommodated to at that time; blink reflex not consistent; visual following inconsistent, when evinced is saccadic. Probable that eyes follow edge of objects in preference to centre.

EIGHTH WEEK (15.9.73 - 21.9.73)

Naturalistic Observation

Prone

Self-directed Movements: Initiation of the clawing action previously seen only when the infant was carried or prone began in the cot on 16.9.73. The vertical upward and downward hooking movements (upward Φ_v and Φ_h) were also seen this day, the infant continually "practising" these actions. Following these movements, the same day (16.9.73) sees an expansion of the horizontal hooking action similar to that seen in the baseline data. With the infant in the prone position (u o es or in n.p.) the hand made Φ_h movements along the floor of the cot, fig. 4.3.

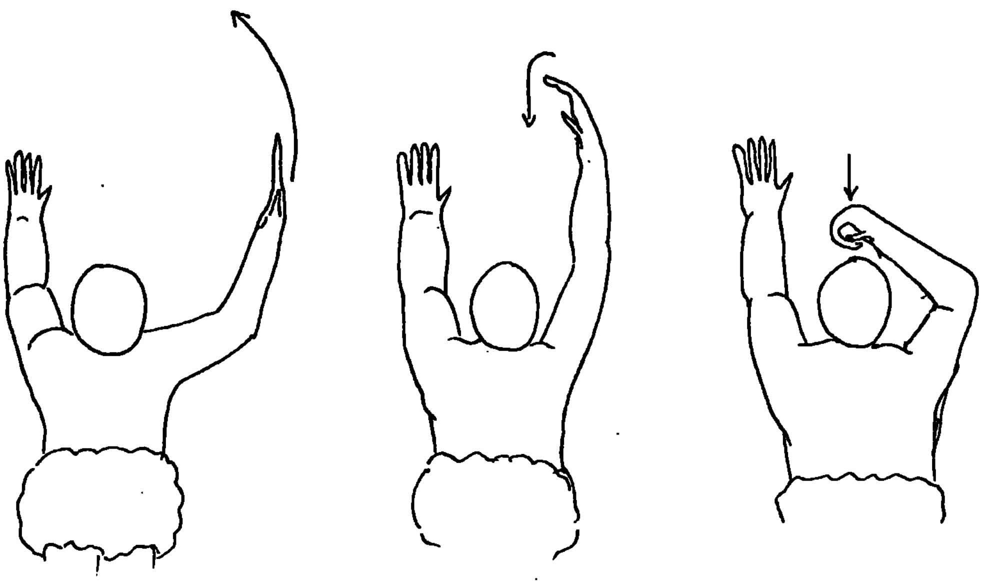


fig. 4.3

On the outward movement the fingers of the hand were open, and with the inward (pulling in) motion they clasped tightly in a grasping movement. This is identical to the finger movements present in the Φ_v movement, and its possible significance will be discussed later, (page 172). The 17.9.73 saw the first signs of hand-clasping. In prone and uoes, the hands were brought together in mid-line and though not fully clasped, inter-twining of the distal phalanges of left and right hands was observed.

During the remaining days of the eighth week very little in the way of advance on the previous behaviour patterns was noted, the infant being seemingly content to practise the movements he already possessed many many times.

<u>Object-directed movements:</u> At this early stage of development there were no object-directed movements. An object was simply fortuitously struck, grasped, etc. In no way did the infant give evidence of directing, or attempting to direct his hand(s) towards an object he had fixated. The sole example of such movements were towards the top wall of the cot whilst the infant was prone. This occurred on the fifth day when, while performing Φ_{vs} in the air in prone, the hooking hand happened to come to rest on the top of the top wall of the cot. It rested there

lightly and briefly and was then withdrawn. No grasping of the structure was observed at this date. That the infant was concerned primarily with the movement <u>per se</u>, and not with grasping seems probable as on three occasions immediately following this, an object was given into the hand performing the hooking movements. Each time it was grasped momentarily, then lost from the hand and the hooking actions began again (on this date, during observation, no less than 77 hooking movements were seen in 1 minute 20 seconds.). One day later (20.9.73), Φ_v movements were again performed in the direction of the top of the cot but, as the infant was farther down the cot on this occasion, the hand simply scraped against the front wall. Grasping of the top wall of the cot was not seen until 21.9.73 when, as he again performed Φ_v movement towards the top wall of the cot (the hand opening and closing as the action was performed as previously described) the hand hit, and grasped the wall. Grasping was maintained for 4 seconds, the hand removed and a little later replaced, though this time the hand was fisted.

<u>Formal Testing</u>

<u>Object in hand:</u> On 20.9.73 an object placed in the hand was grasped reflexly. Of great interest is the fact that, immediately preceding placement of the object, hand and arm had been engaged in vigorous arm movements. With the object reflexly grasped, however, arm movement decreased to zero for the duration of the infant's grasp of the object (4 trials, longest recorded grasp 1 minute 45 seconds), and as soon as the object was dropped (lost) from the hand, arm movements recommenced at their former level of activity. Thus, it does seem that the infant has begun to "attend to" the novel tactile input from his hands, an important step in achieving directed grasping (see discussion).
<u>Object at finger-tips:</u> Manual contact with an object (a pan - 5 trials) did not produce opening and closing of the hand (15.9.73).
Object in mouth: there was no movement of the hand to the object on each of 4 trials. On T5 the hand went to the mouth and was sucked independently.
<u>Object at face:</u> 5 trials, no attempts at grasping were observed (16.9.73).

Hand to Mouth

By the end of the eighth week some noteworthy advances in hand to mouth coordination had been achieved, though deficiencies were still much in evidence.

Up to the 20.9.73 in the prone position, u o es, the infant was seen to bring his hand (free of support from the elbow) up to the mouth area and to place his hand either in the mouth or within 1 cm. of it. This action was not well coordinated, and improvement of accuracy was inconsistent, ranging from one successful hand to mouth movement in 4 observed attempts (25% success rate) on 15.9.73, to 100% success rate (3 observed attempts) on 18.9.73 . These latter were to the side of the mouth and almost certainly chance successes as, the following day, only 2 out of 5 hand to mouth movements reached their target (success rate 40%).

At the beginning of the week (15.9.73), the mouth did not open to receive the hand (even on those occasions that the hand was brought to the mouth along some substrate), only opening after the hand had made tactile contact with the face, and was moving down to the mouth. The 17.9.73 saw the first observed "anticipatory" mouth-opening: as the hand was 3 - 4 mm. from the mouth (along the floor of the cot), the mouth opened in a very tiny pout and the hand moved up to it. No anticipatory mouth-opening was observed in unsupported hand to mouth manoeuvres.

There seems to have been several reasons for the overall increase in efficacy of this particular movement. They fall conveniently under three headings.

i/ Expansion of Pre-existing Behaviour Patterns. Expansion is very evident in hand to mouth movements of the seventh week, being manifested in the several types of "practising" these movements from a "safe distance". While prone in n.p., the infant was observed to bring his hand to his mouth from a very close distance, approximately 2 mm. (17.9.73). The hand was then removed from the mouth to a distance of approximately 2 mm. once again, and the procedure repeated (along floor of cot). Later, following an increased visual component (see increased visual awareness section below) the infant began pulling his hand further and further from his mouth (approximately 50 mm. at 18.9.73, and approximately 75 mm. at 19.9.73) and then replacing it.

ii/ Increased Visual Awareness. At the same time as the infant evidenced an increased interest in motor control of the arms (in the hand to mouth movement), a concomitant increased visual interest was noted. Following the 15.9.73 "practice from a safe distance" described in i/ above, on 16.9.73 Cody began placing his hands 1 - 2 mm. in front of his eyes, opening and closing the fingers of this hand, and then bringing the hand up to, and rubbing it against, his eyes. Following this, the hand was usually brought down the face to the mouth and sucked briefly. Three days later, a very similar behaviour pattern was seen, but without the oral component, the hand being brought before the eyes, at a distance of 5 cm. then to the face, which was tactilely explored, the whole procedure being then repeated. Two points are of interest: a/ The lack of sucking during these movements, which suggests an interest in the tactile and visual sensations in themselves. b/ The increase in distance between hand and eye (5 cm. as compared to 2 mm. previously). This demonstrates the increasing ability to control the hand and bring it to the point desired (while supported). The day following observation of this behaviour (20.9.73), a very long visual/oral/tactile sequence was noted. From a hand in mouth position (infant prone, n.p., head to the right), the hand was removed and the infant seemed to view it at face height. The hand was then, (with the infant still observing events) pulled slowly away to a distance of approximately 8 cm. (hand still at face height). At this distance the hand was opened and closed, then brought to the face which it tactilely explored briefly. The whole sequence was repeated the hand going then to the mouth where it was sucked. Following this (sucking lasted 4 seconds) it was removed and held just touching the lips, then pulled slowly away to a distance (at face height) of approximately 8 cm. This hand-to-lips-and-pull-away sequence was repeated two times more, the hand then being removed from the lips and the infant busying himself with some other behaviour. Later, a further advance in coordination was noted: after opening and closing the hand at 8 cm. distance from the face, the hand was then pushed down into the mattress before being returned to the mouth.

Here we can see an increase in visual awareness, plus an extension of the distance the hand may be removed from the mouth and still returned "safely". In addition, in the last instance, there is now the interpolation of a previously discrete behaviour pattern (pushing the hand into the mattress). Further, the time of the complete sequence has elongated (i.e. more repetitions) indicating a tendency for the infant to "concentrate" or attend to the action he is performing.

Along with this increase in visual awareness and interest in the hands, and the greater coordination of hand to mouth, there came a decrease in the number of startle reaction given when, in the course of his many ϕ_v and ϕ_h his hand came from outside the visual field into it. On 15.9.73 and 16.9.73, there was much startling, after which this behaviour decreased.

iii/ Increased Tactile Exploration of the Face. This has already been alluded to briefly in section ii/. On certain occasions it appeared that Cody had no interest in getting hand to mouth, what <u>was</u> of interest was putting his hand on, and clawing it down, his face. Such behaviour was seen several times during the eighth week, e.g. 15.9.73, when only once in ten hand to face movements was the hand brought to the mouth, and even then sucking was cursory.

Vision

Visual activity in the eighth week becomes much less diffuse, objects are looked at much more by the end of this period, and the infant concentrated more on objects of novelty. This increased looking around him at objects in the room was seen on every day of the week from 15.9.73 (7 w, 1 d) the infant being in the u o es position for a good part of his walking hours, and looking round him at top wall of the cot, sides of the cot, into the workroom, at the observer, at the ceiling, etc., (see also next paragraph). Interest in novel stimuli manifested itself on numerous occasions, most notably on 15.9.73, when, carrying the infant into a (for him) new room, resulted in noticeable quieting, and much looking round, giving every impression of fascination at the new views opened up to him. Two days later the infant showed intent regard of both a novel yellow rectangle and a new blue equilateral triangle (dimensions 6" x 6', and 6", respectively) when they were placed in his line of vision. The day following (18.9.73) Cody stared for approximately 30 seconds at each of four novel objects presented to him. This was the longest time spent on prolonged observation yet seen. The 19.9.73 saw a decrease in activity and much looking in response to two novel plastic discs. Occasionally, observation of some object seemed to elicit fear (eyes open widely, skin of forehead tightens across skull, eyebrows raised, and pulling away) as when, 19.9.73, in hanging from my hands by his hands, the infant turned his head to the left as if to suck his hand. Seeing his hand, plus my hand and a bright red pencil produced the "fear reaction" described above, and the infant withdrew his head.

Coordination of head movement and vision, body movement and vision, and head and body movement and vision are much improved by the end of the eighth week. As in the seventh week, head turning and fixation to view an object outside the line of vision was observed, though fixation in the eighth week was longer duration. Thus, there was much looking round from a variety of new positions; u o es, up on one hand arm straightened and hand fisted, ditto with hand open, palm down, u o hs. At 7 w 5 d (19.9.73) the

the infant was observed raising himself high u o es, and looking over the top of the wall of the cot, then lowering himself down. The movement was repeated four times. On 15.9.73, the infant, after feeding, instead of clinging tightly to the chest of the attendant, leant slowly backwards a considerable distance (out and away from the chest) all the time looking at various aspects of the wall. One day later an identical behaviour pattern was seen, but only one part of the wall was looked at as the movement backwards and forwards occurred. Alteration of visual input, and especially changes in perspective may be postulated for this behaviour. Jerking of the head was also observed (16.9.73) while watching the ceiling. The infant's head several times fell slightly and would then be jerked back up to its original position. Slight autogenous bodily movements were also seen to be compensated for during this period. As well as compensating for his own movements, the infant appeared aware of his position in space to the extent that he could compensate for exogenous movements. For example, while carrying the infant, he fixated a white shelf attached to the wall in the workroom. As I turned 180° to the left the infant appeared to attempt to compensate for this movement, so that as the turn was completed, he was once again looking at the shelf.

When fixating an object, observation of eye movements suggested that the infant looked primarily at the edges of the object presented, and mainly at the top and sides (the observer positioned himself behind the object, which was held approximately two feet in front of the infant's face. Alternate looking was seen but once during this week, Cody fixating my hand (8 seconds), then my face (2 seconds), then my hand once again (8 seconds).

The infant was becoming more visually aware during the eighth week as when, in prone, he was observed to look at his hand; for the first time the gaze was noted to travel from his hand up his arm to a level just before the elbow.

<u>Vision and Hearing</u>: Throughout the week the production of a noise elicited one of two reactions - either quieting and a decrease in

activity, or a startle reaction. Looking in the direction of the sound was not observed (tested 15 - 19.9.73).

Visual Following: Following was tested on all days of this period except the last, and each time it was found to be saccadic, the infant being capable of following for at least 170°. The response was identical with a large number of objects passed across his line of sight (twiddling fingers, books, my hand, etc.). By the end of the week the infant appeared to actively focus much more upon objects that moved and there was thus less looking in one plane of focus and "screening out" of other visual imporessions. That focusing in one plane of vision was the case in the seventh week, as postulated above, is confirmed by an intervention at 7w 1d (15.9.73). The infant was seated on the observer's lap, watching his face which was approximately three feet distant from the infant's eyes. No following of a pencil passed across his line of vision, approximately one foot from his face, was recorded, the infant continuing to stare at the observer's face. However, when the pencil was moved accross his line of vision at three feet distant, i.e. the level at which the infant was focussed, he followed the movement with his eyes, and following was saccadic. Later the same day, the infant failed to follow at three feet, when he was seemingly focussed on a wall junction nine feet away, yet when the object was passed at approximately nine feet, following occurred and was saccadic.

Visual regard of the hands during hand to mouth procedures has already been described (see Hand to Mouth section). With regard to viewing the hands during Φ_v and Φ_h hooking movements, though this was not seen with any degree of certainty, it is considered quite a likely occurrence as many were performed directly before his face. However, coordination was extremely poor and although (without suggesting intentionality) the infant no doubt "ordered" the hand and arm movements, it seems he was not yet able to predict their approach, or their direction, as he often "startled" as a hand came into the visual field. This latter also speaks for some sort of visual recognition of the Φ movement. Watching the hand as it moved from the mouth was observed (see Hand to Mouth Section).

Finally, people seemed to be observed for much longer periods than objects, e.g. the Head Keeper as he moved about the room.

Summary

Prone, general: Φ_v , Φ_h and clawing movements performed when carried <u>and</u> in cot; practice of movement, not grasping of the object seems important: hits and once grasps top of wall of cot. Object in hand: grasps reflexly (up to 1 min. 45 secs) and great decrease in arm-activity at the same time.
Object at finger tips: No searching for touched object was observed in 5 trials (15.9.73).
Hand to mouth: not well coordinated when hand free from elbow; anticipatory mouth opening begins 17.9.73 (only in the fully supported movement, along floor of cot). Increase in hand to mouth efficacy probably due to (i) Expansion of pre-existing behaviour patterns, notably strategy of "practice from a safe distance"; (ii) Increased visual awareness of hands. (iii) Increased tactile exploration. More interest in tactile exploration than sucking of hands on occasions.

Supine (placed so by observer) uncoordinated hand movements and mouth movements, hands never to face.

Vision. Less diffuse, looks to objects, especially novel objects (latter for greater periods), decrease in activity at same time; occasionally disconcerted by particular objects; coordination of head movements with vision, body movements with vision, and head and body movements with vision are much improved; looking round in u o es posture etc., looking <u>over</u> wall of cot four times; leaning backward when sitting, looking at wall. Compensation for head drop, body movements and for exogenous movements.
Fixation: Looks primarily at edges of objects, and mainly at the top and sides; alternate looking seen but once; looks from hand he sucking all way up arm to just below elbow.

Visual Following: Saccadic. By end of week active focus on moving objects at different distances, i.e. less focusing in one plane of vision only. Φ_v and Φ_h arm movements probably seen, as he startles with some. People looked at for longer periods than objects.

NINTH WEEK

Prone

Self-Directed Movements: These consisted of many repetitions of the Φ_v and Φ_h actions (before the infant's face) as seen in Week 8. One expansion of behaviour was the simultaneous performance of Φ_h actions along the floor of the cot by both hands 22.9.73.

Object-Directed Movements: As in the eighth week there is no definite directed behaviour towards discrete objects. It was with solid structures, the side walls and the top wall of the cot, that most grasping progress was made during the eighth week. Grasping of the top wall of the cot had been achieved during the eighth week. However, its frequency of occurrence greatly increased during the ninth, being seen, for example, six times concurrently during 23.9.73; here the infant was observed to look at his right hand three times as it maintained its grasp on the top wall, to grasp, relax and regrasp up to eight times during one grasping event, and to retain his hold on the wall for up to 43 seconds. Later the same week (26.9.73) hand grasping the ipsilateral cot wall (e.g. right hand grasp right side wall of cot) was observed. On occasion the hand was merely rested on the top of the wall and not grasped. Coordination of "hand grasping top wall of cot" with other behaviour patterns was also seen 26.9.73, with Cody grasping this area with his right hand, and upon release stroking his chin before his head was lowered and the hand sucked.

Sitting/Carried Self-Directed Movements: Apart from the ubiquitous Φ movements which were seen whenever this posture was attained, self-directed actions are primarily concerned with hand to mouth actions.

Object-Directed Movements: During this week the infant was in a sitting/carried position only when taken from cot to feeding chair, and consequently had no opportunity to direct any arm movements towards objects.

Formal Testing

Object in Hand, (22.9.73 - 5 trials): As for the baseline data, simple reflex grasping and dropping was observed. On one trial, reflex grasping lasted 49 seconds, and on another, relaxation and regrasping with one digit was seen. There was no looking at the grasped object.

Object in Mouth (22.9.73 - 8 trials): The object was sucked, but no hand to mouth or hand to object was observed on any trial.

Object at Finger-tips (27.9.73 - 6 trials): There was no attempt at "searching" following contact of the object with the finger-tips.

Object Visually Presented (24. & 27.9.73 - 22 trials): In supine (24.9.73 - 8 trials) the presented objects (three) produced only a cessation of activity, mouthing movements and intense visual regard. No arm movements were elicited. In prone (24.9.73 - 6 and 8 trials respectively) Φ_V movements were seen in the general direction of the object, following fixation and mouthing movements. Intentional direction of the hand is not thought to have occurred, merely that the object was held in a position corresponding to the infant's usual arm movements. It may be that the sight of the object in some way "provoked" the schema for making Φ actions without the infant intending to make contact with object. Indeed, on 28.9.73 Cody was seen to make a Φ_V action and to pull in approximately 4 cm. an object on the floor of the cot. Despite this, he made no attempt to grasp the object. However, later in development, when contact is made by such chance movements, it is to be expected that the infant will attempt to replicate (by reproductory assimilation) this interesting occurrence.

Hand to Mouth

Movements under this heading can once again be classified into three sections. Advances are notably in coordination of the previous week's behaviour patterns with other motor functions, and especially those associated with posture. A greater degree of accuracy in hand to mouth ability was noted in u o es and in sitting postures. At the beginning of this period, on 22.9.73 (8w 1d), not one in six attempts while sitting hit the mouth though all struck within 2 cm. of it. Typically, there was a very short pause, then the hand was moved, always against the skin, to the mouth. Hand-observation (which continued during this week, the infant looking at his hands in the u o es position) may have resulted, in the latter part of this week, in the infant's ability to (a) place his hand very near to, and occasionally straight in his mouth while prone, and (b) within 1 - 2 mm. of his mouth when sitting supported. The mouth opened to receive the hand to a wider degree than the tiny pout seen previously.

Expansion and Coordination of Pre-existing Behaviour Patterns: The infant had by this time developed several variations of the postures present when observation first began. These were now coordinated with the hand to mouth, tactile and visual patterns previously described for Week 8.

While in a prone u o es position (23.9.73) the infant made Φ_v movements at the top wall of the cot, immediately following which the arm and hand were moved along the floor of the cot directly to the infant's mouth. During the fifth day of the ninth week, the infant scratched the right side of the cot with a downward circular movement of his right hand, immediately after which his hand went to his mouth. One day later (26.9.73) the circular movement was performed on the floor of the cot, then hand to mouth and sucked. That same day the arm was moved so that his hand extended to the corner of the cot, following which it was pulled back along floor of cot to his mouth.

In the prone, u o es, position we have fairly detailed data as to the probable path to development of hand to mouth ability. At 23.9.73 the infant was observed to assume an up on one hand posture the other arm being held bent at the elbow, palm facing face, fingers extended, directly below the face, fig.4.4. The infant regarded the hand with open eyes and sucking movements of his lips. It was hard to avoid the conclusion that hand-sucking was being attempted, but that the infant did not yet have sufficient coordinative ability to bring his hand to the mouth in this new posture.

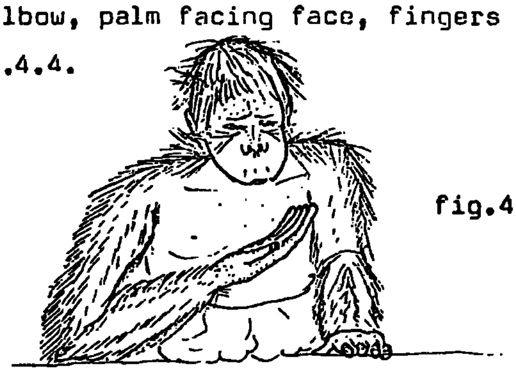


fig.4.4

The hand opened and closed several times, Cody frowned and then brought his head down to, and sucked, the right hand. The hand to mouth movement is therefore not possible at this stage, though it is noteworthy that head to hand coordination is at a higher level of integration (Gessel,1948). One day later the same posture was assumed. This time the infant brought hand to chin and stroked the chin 11 times at varying rates. Though no hand sucking was observed, the two movements were comparable, requiring only the lowering of the head to suck the hand. (Whilst this behaviour pattern can also be classified under tactile stimulation, it should not be forgotten that these divisions are arbitrary and that in the development of the infant all movements, etc. act in concert). Thus, bringing the hand to the chin to stroke would furnish tactile and kinaesthetic feedback information to allow learning of the pathway up to the face.

This seems confirmed somewhat by an observation made the following day. From the same posture the right hand was brought, waveringly, but very near, to the mouth. Chin stroking followed by hand to mouth was seen the same day. In certain cases opening and closing of the hand was seen while the hand was sucked.

Increased Visual Awareness of the Hands: As with the other sections, increase in visual interest is bound inextricably with visual interest in the hands <u>in a variety of positions</u>, (unlike the eighth week when these were almost totally confined to a n.p. position). Thus, at 24.9.73 the infant, in an u o es posture, leant to his left and looked at, and opened and closed the right hand three times. The next day the hand was raised to the forehead, then moved out slightly and held, with slight finger movement, for three seconds while Cody looked at it, after which it was sucked. This behaviour is reminiscent of the eighth week (p. 121), except that it was then performed in n.p. with the hand moving along the substratum, and here it is performed in the air (N.B. with the elbow resting on the ground). Later, the hand was raised in u o es posture so that it merely touched the mouth. The hand was then removed, looked at and brought to the mouth, though no sucking occurred. On 26.9.73 the hand was three times brought to face height in this position (u o es) and looked at.

Tactile Exploration of the Face: These motor movements are characterised by an absence of hand sucking once the hand has found the face. The primary interest would appear to be in the tactile stimulation (probably reciprocal) of the hand on the face. While in the u o es posture, the movement was typically an upward ϕv, hitting the face and then clawing down over it (seen on 22, 23 and 26.9.73, the hand being sucked very briefly on 5 of 23 movements). Variations during the ninth week included: hand to face and held relatively stationary, the fingers drumming on the face (seen 23 and 25.9.73); right hand on upper face, opening and closing hand and grasping hair of head occasionally (25.9.73); right hand at face level, and left there, fingers and thumb moving slightly on face (25.9.73); sucks open palm, fingers playing on nose and eyes (25.9.73); left hand to face and scrape <u>face up hand</u> (note order) (26.9.73). Although tactile input is very probably the main feedback stimulation here, visual feedback may also play an important (though subordinate) part.

Vision

As in the eighth week there is much u o es and looking round. Objects seem to be scrutinised more closely, as when (25.9.73) Cody was seen to follow the vertical beam of a door upwards with head and eyes, before reversing this action. On 22.9.73, while sitting-supine on the experimenter's lap, the infant's eyes were observed to "rove" around the ceiling, eventually "locking on" to one area. After several seconds, "roving" recommenced. The "roving"/staring cycle was repeated many times.

Visual regard of the hand (and finger movement) was a favourite "pastime" of the infant, being observed each day. On one occasion (24.9.73) the infant coordinated finger twiddling with hand sucking, performing the former immediately after bringing his hand to his mouth. Holding the hand stationary in the air for visual scrutiny (sometimes with finger movement) was also seen (25 and 26.9.73). On the last day of the ninth week, Cody finally achieved visual following of his hand. While sitting, the infant was seen to position his hand above his face, fixate it, and to follow its movement as the hand was brought to his body. The importance of this action in the development of visually directed grasping has already been alluded to in the introduction.

Brief visual regard of the experimenter's face was noted when in a sitting position (25.9.73).

Visual Following

This was saccadic during the six days that testing was given. Occasionally, a "smooth patch" in the infant's eye movement was observed, (notably 23.9.73), and on one occasion (24.9.73), following was accomplished partly by head turning. In addition to horizontal following, vertical following was also saccadic.

Audition-Vision

The infant observed his hand while audibly scratching his mattress (24.9.73). Whether such behaviour aids the infant in becoming aware that actions produce a noise, and that noise emanates from a certain direction is conjectural. However, observations that day do suggest that the infant has some nascent idea of looking for a sound. Thus, when a noise was made outside, Cody ceased sucking his hand, went u o es, and looked into the next room. Direction of looking was not appropriate, but the behaviour may indicate that the infant "knows" that if he scans his surroundings after novel auditory input, he may see something of interest. Appropriate directional looking may have been achieved 27.9.73 when (4 trials) the infant turned to view the experimenter after he had produced a noise. However, the experimenter did not change his position on these trials, so the question still remains open to speculation in this week.

Summary

Prone: Φ_h and Φ_v action in air and on floor of cot; both hands Φ simultaneously on occasion. Grasping of top cot wall increases, maximum hold 43s. Grasps ipsilateral cot wall.

Supine: no arm movements.

Sitting/Carried: Φ actions in air.

Object in hand: grasps reflexly; relaxation/regrasping with one digit seen.

Object in mouth: sucked, no hand to mouth or object.

Object at fingers: no searching behaviour.

Object visually presented: Supine: cessation of activity, mouthing movements, intent visual regard. Prone: mouthing movements, intent visual regard and indirected Φ actions.

Hand to mouth: hand strikes within 2mm. of mouth in sitting/uoes position, coordination of hand to mouth along floor of cot with other behaviour patterns.

Vision: Increased visual interest in hands in a variety of position. Much more looking round at objects and surroundings. Visual following of hand achieved.

Visual following: horizontal: saccadic, with occasional smooth patch. Vertical: saccadic.

Audition Vision: Directional looking not achieved, does look in all directions at sound of loud noise.

TENTH WEEK

Naturalistic Observation

Prone.

Self-directed Movements: Φ_v and Φ_h actions in the air were common during the tenth week.

Object-directed Movements: Hooking movements in prone became better coordinated in this week. Directed grasping of objects was not seen, but 29.9.73 saw the infant pull in an object his hand had fortuitously hooked over while performing the Φ movement (4 times). Hooking was seen in the air, as well as over wall of cot and top wall of cot (with brief grasp) on 29.9.73, 1.10.73. Additionally, Φ_v down the side of a wall of the cot (17 times) was observed 30.9.73) and down the hood of the cot (9 times) on 4.10.73. The 29.9.73 observation deserves more detailed study.

Having grasped the left side of the cot with his left hand, the infant was observed to move his hand from A to B (fig.4.5) looking towards the hand as it appeared in his field of vision, and following it as it moved.

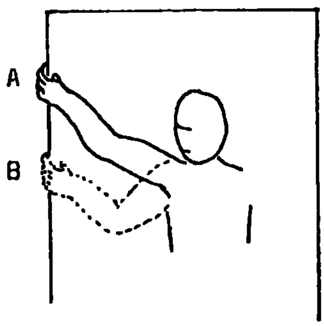


fig. 4.5

Sitting/Carried

<u>Self-directed Movements</u>: Hooking movements were also observed on 30.9.73, 2.10.73 and 4.10.73, while the infant was carried upright or sitting.

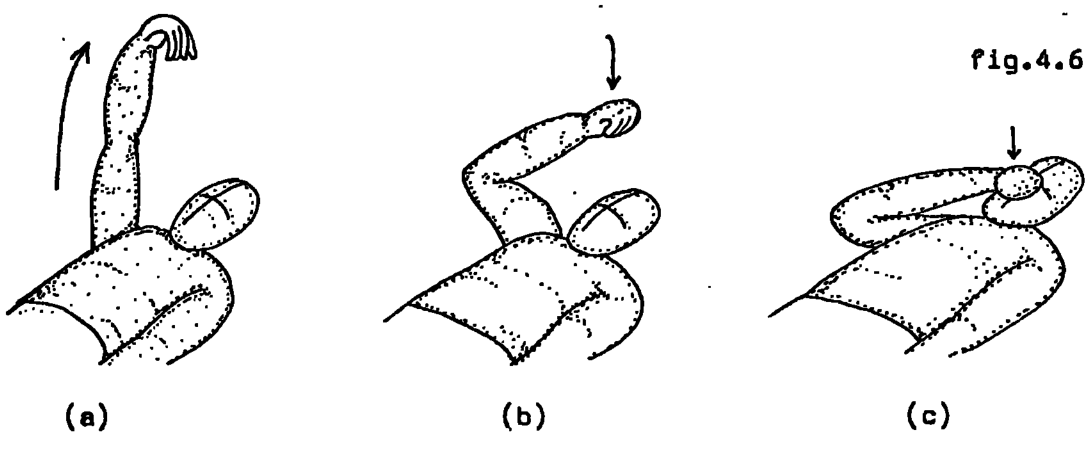
<u>Object-directed Movements</u>: More actions were directed towards objects (albeit in a very general way) than in previous weeks. Thus, on 2.10.73, while in a pram, the infant grasped the blanket and pulled it up quickly and seemingly unintentionally, hitting the blanket against his face. When carried to a food-box on the wall, Cody made 14 Φ_v in its general direction, sometimes staring at it, sometimes looking away. Identical behaviour was seen when carried to a wire cage (3.10.73). On this occasion the infant was carried closer and his hooking hand hit and rubbed against the wire making audible sound. The infant revealed his attention to this by a complete cessation of activity and by looking fixedly at the spot he had struck. Two more Φ_v followed quickly, as if the infant were trying to repeat this interesting spectacle. The 4.10.73 saw similar behaviour.

Supine

The process by which the infant turned from prone to supine is described in the Motor Development section.

<u>Self-directed Movements</u>: The ubiquitous Φ_v and Φ_h actions were immediately forthcoming in this new position. However, a new behaviour pattern was quickly apparent, and was performed so repetitiously that it was given the symbol <u>A</u>. Typically <u>A</u> performance was as follows:

fig.4.6



Initially the movement corresponded to a simple hooking action (ϕ_h) over the face region while in supine. The hand was arrested at the zenith of the motion and looked at for approximately 2 seconds, after which it was pulled down to the mouth. This was first seen on 30.9.73. The infant was interested in performing the movement for its own sake as evidenced by (a) my hand in his mouth produced no cessation of the A behaviour pattern, nor was my hand sucked; (b) same response when his hand placed in his mouth - it was immediately retracted and the A movement repeated. Later this same day the pattern was elaborated, the hand being brought down to the side of the face and not to the mouth.

In one 3-minute section of observation 20 A movements were recorded, and immediately following this 10 more were performed with the left hand.

The following day (1.10.73) the A behaviour pattern had achieved its characteristic mode of action (fig. 4.6). The right hand was brought up to its fullest extension, the hand hooked (fig.4.6 a), and looked at as it was brought down the fingers clenched into a fist (fig.4.6 b), the movement ending with the fisted hand located between the eyes touching the nose (fig.4.6c) from whence it was brought down to the mouth.

The 1.10.73 saw a further new behaviour, possibly related to the A pattern. After playing at striking a rattle string stretched across the cot the infant held up his right hand as in fig.4.6a. The left hand assumed a similar posture and the hands then clasped briefly, after which they were brought down to the face and the left hand sucked. Similar behaviour (hand clasping) was also seen on 2.10.73.

Object-directed Movements: Rattle String: A string of six spherical rattles of blue, red, and yellow had been positioned across the cot approximately eight inches from the top wall of the cot on several occasions while the infant was prone. No attention had been given to this object but the new position (supine) virtually impelled the infant to take note, as the string extended across the cot only three inches above his chest at approximately the level of his xiphisternum, and was therefore easily within his visual field. And, indeed, along with the walls of the cot, the rattle string was very quickly assimilated into the infant's behavioural repertoire. The performance of simple ϕ_{VS} was sufficient to strike the rattle string and he repeated this movement again and again (25 times in 2 minutes) on 1.10.73. As with the hooking movements to the top of the cot Cody occasionally grasped one of the balls of the rattle string. Alternate striking of the balls with both hands was also noted. Having hooked a hand over the rattle string and grasped a ball, the infant (keeping his hand in virtually the same position all the time) opened and regrasped the ball six times (compare holding object in hand tests) finally ending this sequence with an A behaviour pattern. That same day (1.10.73) the infant moved the rattle-balls by pushing at them with fisted hand, the rattle string producing a noise as the hand slid past.

As well as interacting with the rattle string by ϕ_V movements, upward ϕ_V were also employed, and this led to the first recorded pulling down of the rattle string in an apparent attempt to suck the (otherwise out-of-oral-contact) balls. The infant watched the ball throughout this action, the mouth opening as his hand pulled down hard on the object. Unfortunately, the hand grasping the ball slipped and the string sprang back to its original position. This same behaviour was seen 3.10.73 and the first successful grasping and pulling down to the mouth for sucking observed 4.10.73 (this is consistent with greater degree of arm control (see below). A less demanding but equally efficient method of attaining the same end was discovered at this time, and consisted of placing the arm (following an upward ϕ_V) over the top of the cot and pulling down to mouth.

A behaviour pattern having a probable similar function to that seen with the object in the hand (page 127 other details) was evident on the 3.10.73 when the infant, after a ϕ movement, grasped one of the balls and then released the ball and regrasped it, repeating the manoeuvre three times. Identical behaviour then occurred with the other hand. The same day Cody grasped at the rattle string with both hands, while watching his movements intently.

The 4.10.73 saw an advance of great importance. The infant, supine in the cot, had the rattle string (removed during the night) replaced in its usual position. Cody fixated the object and moved his arm upwards, much more slowly than on prior occasions, and gently touched the rattle string, following this with a hand to mouth movement. The action was repeated, with very intent visual regard. Later the infant raised his right hand and touched the object on three successive occasions, this time with the back of his hand.

Another variation in hooking at the rattle string was plucking. This began on 2.10.73, the infant raising his arm vertically, the hand slightly hooked, so that it was positioned just above the rattle string, it was then retracted, the finger-tips pulling at one of the rattle-balls as they passed (and producing a noise). The 4.10.73 saw what may be termed "true plucking". As might be supposed with the ensuing increase of fine control, this was a slightly more sophisticated movement, the rattle-ball being lightly grasped and the hand pulled down so that the object slid through the fingers.

Whilst supine, the objects that vied most strongly with the rattle string for the infant's attention were the cot wall and a suspended collar.

Cody spent approximately as much time "practising" his arm movements on the two side walls of the cot as he did on the rattle string. Supine arm activity directed towards the cot walls began one day later than that towards the rattle string (former on 2.10.73). It began with rubbing the ipsilateral wall of cot and progressed to a simple hand over the side of the cot, the movement being very similar to a Φ_V directed laterally (see fig.4.7). Later, this behaviour was combined alternately with arm-waving. Later a behaviour pattern similar to "grasping the rattle string and pulling down" (p. 135) was observed, the infant hooking his hand over the wall of the cot (Φ_V, not upward as for rattle string) and pulling strongly enough to cause the wall of the cot to bend inwards. Two days later (4.10.73) the infant appeared to practise grasping by a novel method. After grasping, he would continually change the number of digits which he held over the side of the cot, holding on first by one digit, then two, then one, then three, etc.

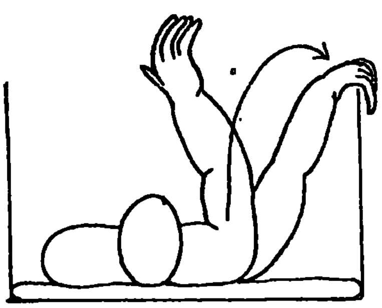


fig. 4.7

When rattle string removed, the infant spent three minutes waving his hand in air,(Compare Laurent waving his hand in air after the the matchbox he was holding was lost - Piaget, 1955).

As well as grasping at the side of the cot, during the final day of this period (4.10.73) the infant stretched his hand above his head towards the top wall of the cot, as if trying to reach this structure. The attempt was unsuccessful.

This young Orang-utan's great interest in objects was further attested to by his behaviour with a large leather dog-collar (diameter 18 cm., width 1.5 cm., thickness 0.3 cm.) hung up on 2.10.73 at a height of 8 - 10 cm. from the infant's face at an approximate level of his sternum. The infant's first reaction to this stimulus was not seen for 1.5 minutes, the infant spending this time with arm and leg movements, until he fortuitously hit the collar. The collar was watched as it swung, the infant making slight mouth movements. The left hand was sucked briefly, waved in the air and brought down to the face. The collar was then hit with a Φ_h , then grasped in the same manner, and immediately released the left hand grasping the side of the cot. From here the left hand (the infant watching all the time) slowly touched the object twice, then the hand was lowered. Following this there were 6 Φ_v , 4 of which hit the collar. Later, 13 Φ_v were directed towards the collar sometimes with eyes open and looking at the object, sometimes not. For the next 16 minutes the greater proportion of his actions were Φ_v toward the collar.

This same day, (2.10.73) grasping of the collar was achieved though this was probably the result of a normal Φ_v and therefore fortuitous. Once grasped, the infant displayed the same differential release of fingers as seen with the side of the cot on 4.10.73. The following day, after several Φ_v towards the object, Cody finally grasped the collar with his right hand.

Formal Testing

Object in Hand (4.10.73 - 7 trials): Reflex grasping occurred on each occasion. No looking to hand or object was observed and on only one occasion was the hand and object taken to the mouth. The hand, and not the object was sucked.

Object in Mouth (4.10.73 - 8 trials): The object was sucked, but on only one trial was a hand to mouth action observed. Even here, the hand was sucked quite independently of the object.

Object at Finger Tips (4.10.73 - 5 trials): There were no attempts at "searching" or "groping" for an object touched against the fingers on all 5 trials.

Object Visually Presented (5.10.73 - 8 trials): Φ_v and Φ_h actions were performed towards the two objects presented. No touching was seen as was the case for Naturalistic Observation.

Hand to Mouth

Expansion and Coordination of Pre-existing Behaviour Patterns: Coordination of the hand to mouth movements with other behaviour patterns continued, and by the end of the tenth week, in all positions the infant was seen to assume, hand to mouth efficiency was very close to optimum, i.e. the hand, if not going directly to the mouth, hit the lips not more than 3 - 4 mm. from it. Thus, on 29.9.73 the infant was seen to place his hand perfectly both in prone, n.p. (hand along floor of cot) and in u o es. This latter posture was observed from a very close range (less than 3 feet). On each of four occasions the finger-tips struck just below the mouth, then both head and lower lip moved slightly down, the mouth opened wider, and the hand slid into the mouth. One day later (30.9.73) hand to mouth behaviour whilst sitting was also observed several times and recorded as "if not in, then very close (3 - 4 mm.)". However, as might be expected, hand to mouth behaviour in the newly acquired supine position was less efficient during the beginning of the week.
Visual Interest in the Hands: Visual interest was less marked during this week, being now a component (i.e. coordinated with other movements of various superordinate behaviours, e.g. the A behaviour pattern (see general Grasping section and below). Visual interest in the hands was seen only four times in the six days' observation of this period, on 29.9.73 (looks to hand and twiddles fingers); 30.9.73 (right open hand held in front of face in supine position); and 4.10.73 (left hand waved over eyes, and fisted left hand passed across face several times).

The A pattern described in general Grasping section was soon expanded into A and hand to mouth, though only with difficulty. This movement was perfected the following day (1.10.73) and became very stereotyped, (see general Grasping, fig.4.6). The A "schema" was expanded the same day with the hand (from its fully extended position) moving first to the left and then to the right side of the chin, then to the mouth and briefly sucked, after which it was moved up the face to the eyes (without another A) and finally down to the mouth. Another A expansion was pulling the hand down, not to the face but to the chest. 2.10.73 saw lots of A and down to the mouth, and three further expansion/coordination patterns, beginning with a simultaneous A movement with both arms and an

A movement with both hands and clasping the hands while extended, the hands being then brought down and held above the eyes. Following the beginning of an A movement, a grasping of the side of the cot pattern was interpolated after which the hand was brought down to the mouth.

Tactile Exploration of the Face: As well as the visual component Cody used the A behaviour pattern with a tactile component added (and oral portion omitted) on 3.10.73 performing the A action and screwing his hand into nose, eyes and cheek, after the downward retraction of his arm.

Other tactile procedures were in evidence, with several variations. Thus, 29.9.73, the infant was observed in prone holding his hand against his face (eyes closed) the fingers resting on the nose and eyes, and drumming the finger-tips around this region. Two days later, in supine, the hand was taken to the top of the head and pulled down over the whole of the face to the chin or neck (fig.4.8).

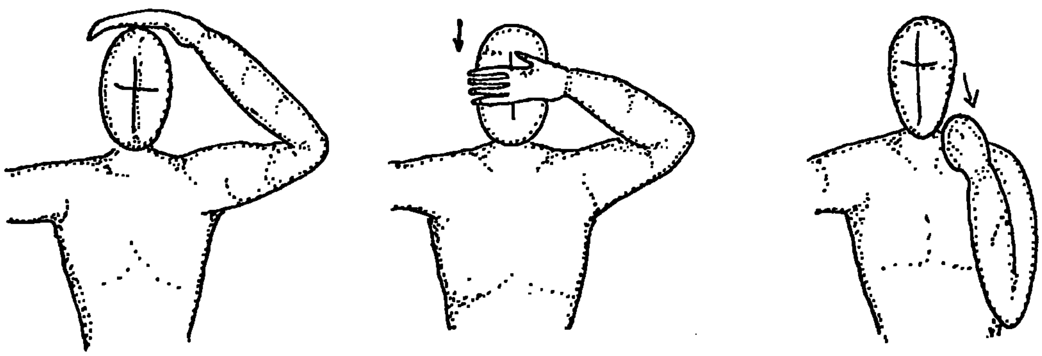


fig. 4.8

The 2.10.73 saw the hand clawed in a similar fashion down to the mouth, which was open to receive it.

Vision

There is much more looking at the infant's own actions during this period, both when the action is performed in vacuo and when it is object-directed.

Self-directed Looking: As well as looking at his moving fingers, on more than 50% of the Φ_V performed in the air, the infant looked at his hand as it reached the fullest extension of the movement. This was also true of the A behaviour pattern (see above). Although it was difficult to observe, the fact that hand-waving was performed near to, or directly above the eyes (2. and 4.10.73) makes it very possible that such hand movement was also visually monitored.

Object-directed Looking: These centred mainly, but not exclusively, on the rattle string. On the 1.10.73 the infant began to watch his hand as it contacted the rattle string. Observation was accompanied by a startle reaction each time the hand hit the rattle string and it produced a noise. Watching was by no means consistent. 2.10.73 saw similar behaviour. In addition, after striking blindly at the rattle string the infant rested his hand upon it and brought the hand to a point above his head, where he stared at his limb for several seconds. The 4.10.73 also saw Cody watching his hand and object as he interacted with the rattle string by grasping, touching and plucking. On one occasion, the infant hit the rattle string two times (ϕ_V) then paused and watched its movements very intently. Later, after plucking the rattle string, he watched the balls as they vibrated.

An interest in the object per se, before hand-action was initiated, was also noted in the final day of the tenth week. The rattle string (removed for the night) was replaced across the cot. Cody fixated the object and looked along its whole length three times in succession following which the right hand activated and the rattle string was touched. Other objects were also acted upon and looked at simultaneously, as when Cody, after having grasped a keeper's hand, pulled his hand with the "object" up towards his face to a distance of approximately 7 cm., suddenly checking this movement towards his face and studying the hand with great concentration. Also looked at was the action of his hand striking the cot wall (4.10.73), and, of great interest because of its relation to hand control, observing his hand when, with one finger held over the top of the cot, Cody attempted to move more of his fingers over the top of the cot. So intent was he that I was able to move in to within three feet of the infant, and could observe that his gaze was absolutely concentrated on the hand attempting this manoeuvre.

In addition to watching his own movements and their results, the young Orang was fascinated by novel visual stimulation and changes in his visual field. He seemed (as in the prior week) to once more actively seek such changes in going u o es and looking round at walls, ceiling, door, me, top of cot, etc. (29.9.73, 30.9.73). 3.10.73 saw cases of multiple looking at various objects. To a greater degree movements of the trunk and limbs helped these attempts to discover novel visual input (u o left arm and leg and looking down left wall of cot towards bottom of cot, 29.9.73; falling almost backwards while sitting in a very intent attempt to follow a door stanchion.

Hanging objects were also scrutinised, e.g. a rotating rattle-ball for 7 seconds (1.10.73), collar when first hung up on 2. and 3.10.73. Cody also often scrutinised the string from which the object was suspended.

A very obvious cessation in movement was present whenever the infant was carried about, and his eye movement attested to the interest taken in specific objects seen during this time. Thus, 30.9.73, when carried to the workroom, the infant scrutinised a hanging Parka, a kettle, his bottle and various other paraphenalia. On 2.10.73 the window, scales on the floor, wooden laminate, hanging coverall, all were avidly assimilated into his pattern of looking. The 3.10.73 and 4.10.73 showed similar behaviour, Cody one time watching an electric light and changing the position of his head to maintain fixation as he was carried away. Visual interest was also seen when the infant was moved about in his small pram (30.9.73 and 1.10.73).

Visual interest in the face became very evident during the tenth week. Beginning 30.9.73 the infant was observed to look at my face three times while being carried. The day following he stared for long periods at my face from the pram, and on 2.10.73 while sitting. On this day too, while carried, he looked to my face and bobbed his head up and down several times. No face observation was noted 3.10.73, but the following day, while being carried the infant was noted to look to my face and smile.

Further evidence that visual cues were now becoming more important came in his ability to coordinate visual input with motor movement of the head, in following a pan held close to his head (after he had sucked it) and moved to left and right. Each time the infant brought his head round in the correct direction and sucked the pan.

Further to this, on the final day of this period (4.10.73) it was noticed that the infant made very slight mouth movements towards the bottle as it approached during feeding (four trials). The head was raised and the eyes fell into and out of focus on the bottle, the mouth slightly pouted. This response could be elicited with a variety of objects (e.g. pan, light meter, battery) of various sizes and shapes.

Visual Following

The mechanics of visual following become much more complicated during the tenth week. Following was by the "classical" saccadic movement on 29. and 30.9.73. However, on the latter day the infant was invited to follow the object vertically (i.e. along the long axis of the animal, from head to foot and back). Here following was smooth. The position was further complicated the day after when, having obtained saccadic lateral following of my hand with the infant supine and the distance between the subject and object of approximately two feet, it was found that at a subject-object distance of four feet, following consisted of part saccadic eye-following and part head turning in the correct direction. Much head turning, with only occasional eye movements was elicited the next day (2.10.73) when I was at a distance of eight feet from the infant.

Vision - Audition

Three protocols point to the infant's ability at localising sounds during the tenth week. On 3.10.73, upon entering and calling to Cody, the experimenter found that the infant was looking directly at him. However, such an ability might be due to the infant looking to the place where it was usual for the experimenter to appear, or movement may have been the cue to direct the infant's gaze. To test this, the experimenter waited for the infant to look away, then moved his position before calling again, making sure that the infant was continuing to look elsewhere. Cody once again successfully localised the sound. Similar looking to the point of emanation of a sound (with the experimenter behind the infant) was seen on two occasions on the following day .

<u>Summary</u>

Φ actions, (though still performed on the air) now increasingly object-directed, (e.g. cot wall, rattle string, collar). Objects are more often struck than grasped. Touching and plucking of rattle string, <u>A</u> behaviour pattern and hand clasping appear in supine.

Formal Testing: No visual regard of grasped object; "hand grasped object to mouth" and "hand to object sucked"(no contact with object) appear, but are rare; object at finger tips ignored.

Hand to mouth: close to optimum in all positions.

Vision: Looking at objects, and attempts to vary visual input increase. Watches hand in the air, contacting objects, and hand and finger movement when an object grasped. Watches object after striking it; visual interest in face appears.

Visual following: saccadic at 2 feet distant, part saccadic/part head turning at 4 feet, almost complete head turning at 8 feet. Localisation of a sound is achieved.

ELEVENTH WEEK

Naturalistic Observation

Coordination of vision and hand movements once again predominate, and most arm movements are directed towards objects, less being performed purely for the movement itself. Hand up to/Groping appears during this period rather than striking/grasping fortuitously seen almost exclusively up to this point. The former begins in supine first and then is found in the prone position. Similar to, and probably serving the same function, (hand, eye and object coordination) were
a/ momentarily arresting the movement of the arm and hand (during ϕ_v or ϕ_h) at a point on the arm's trajectory nearest to the object, and
b/ performing slow and exaggerated arm movements, notably ϕ_v, at the object.

Prone

Self-directed Movements: These were very few, being restricted to ϕ_v movements in the air (7. and 8.10.73) and hand grasping the wrist of the other hand. One noteworthy point during this latter behaviour pattern was, after grasping the wrist, the grasping hand's fingers were continually changing their position (compare hand over side of cot, 10th week, hand on rattle string 9w 5 d, hand on collar 9w 4d). Visual interest in the hand per se was slight, being observed only two times in this position (both occasions , 11.10.73).

Object-directed movements: Of great importance was the evidence of the infant's increasing ability to direct his hands towards an object he was viewing. Fixation and slowing down of the hand was noted 8.10.73, the infant making three long, slow and exaggerated ϕ_v movements, at the end of which plucking at the blanket on which he was lying. Following this, the hand was waved or held in front of the face the behaviour being repeated in toto two further times. Such behaviour suggests very strongly an attempt by the infant to place his hand movements under better visual control. Later observation that same day greatly strengthened this assumption. An object was hung up over the infant, easily visible but at the limit of his reach. Cody fixated the object then raised his left hand. The hand was held stationary and opened and closed three times, all fingers flexing inwards at the same time. Then the hand was lowered, or rather collapsed downwards, any hint of control being absent. Later the right hand performed a similar behaviour pattern, the fingers flexing inwards five times. The infant gave almost undivided attention to the object, with the distinct impression of frustrated attempts at grasping. N.B. this is not the first example of groping, see supine behaviour, 6.10.73, page 145. Following this, the object was lowered to a more easily graspable height, close to the hood of the cot. The infant responded by making three ϕ_v and grasping the hood of the cot. Three more ϕ_v in the air followed, after which the hood of the cot was again grasped. The left hand then struck the object with ϕ_v, after which the right hand made a similar movement ending by once again grasping the hood of the cot. Watching his right hand, Cody slowly edged it along the hood of the cot towards the hanging object; when approximately two inches from it he relinquished his hold on the hood of the cot, raised his hand, struck the object and immediately regrasped the hood. Similarly, approximately one minute later, after grasping the hood with both hands, the infant then grasped the topmost part of the left side of the cot with his left hand; fixating the object, he brought his left hand from its position, along the hood of the cot, towards and very close to the hanging object. Then, as above, there followed a quick strike at the rattle, and regrasping of the hood. Thus, although coordination of hand and arm movements are much improved during this week, grasping of a freely suspended object is not achieved in the prone position.

Sitting/Carried

Self-directed Movements: Occasional ϕ_h and ϕ_v movements were performed on the open air, the infant spending only 6 minutes in this position.

Object-directed Movements: Owing to the short time spent in this posture, only one arm action towards an object was noted. On 10.10.73, the infant grasped the hand of the attendant six times during feeding (each time after an upward ϕ_v) and held onto it for several seconds. On the fifth of these occasions, the number of digits involved in grasping was changed until finally only one finger held the hand in position. At no time was the infant observed to visually monitor his movements.

Supine

Self-directed Movements: Self directed actions are now more sophisticated, more complex in their movements and execution. Simple behaviours are still to be found in the behavioural corpus, e.g. moving the left hand across the face in a ϕ_h movement (6 successive occasions, 6.10.73). Playing with both hands in front of the face took up a great deal of time in this position. Typically, there was continual clasping and unclasping of the hands, when unclasped the hands were rubbed against each other in midline position, then separated by about one to two inches from each other and then reclasped. On most occasions the hands were closely watched, though clasping with the eyes tightly closed was also observed. Visual monitoring of clasping before tactile exploration of the face was also observed (see hand to mouth section (tactile exploration)).

Object-directed Movements: These were many and, as in the previous week, centred primarily around the various hanging objects.
Collar: Various behaviour patterns towards this object were seen, notably raising the fisted hand and touching the collar; grasp, partial release and regrasp of this object several times; grasping the object and trying to suck it by raising the head (hand found first and it sucked). Later, successful grasping of the collar four times was seen, the infant pulling on the object in an attempt to bring it to the mouth, and sucking his hand instead. By far the most important behaviour enacted on this object during the eleventh week is groping, i.e. holding the hand relatively immobile, close to the object and attempting to grasp it. This behaviour was noted on the first day of the eleventh week. The infant made a Φ_h towards the object; the object was struck and then the infant seemed to try to hold this close position to the object, the hand opening and closing in the air near to the collar. The behaviour was terminated with a right hand to mouth movement. The 7.10.73 saw the infant grasp the collar with both hands, after which the left hand went to the mouth. When unsuccessful in this bilateral grasping of the collar (same day) the hands were seen to clasp and were then brought down to the face. Later, this behaviour pattern was extended when, having missed a bilateral grasp, the infant then grasped the right side of the cot, then clasped hands, and then brought the hands to the face.

Rattle String: Behavioural sequences seen during the previous week also appeared within the eleventh week period, (looking to the newly put up rattle string, then grasping it (6.10.73); "plucking" the rattle string (6.10.73); plucking and ending with pulling the object down to the mouth (6.10.73). New behaviour patterns were several. A double handed grasp of the rattle string was seen 5.10.73, the infant grasping the string of the object with an upward Φ and pulling it down strongly, the right hand coming up at the same time and grasping it. Later the same day, after a further bilateral grasp, the right hand released its grip and was waved around the rattle string, sometimes touching it. The infant watched this procedure intently and the question of visual motor feedback again arises, as it did when, later that same day, both hands were waved in the air, occasionally striking the rattle string.

To judge the response to a perceptually similar, though solid object strung across the cot a wooden bar was placed in approximately the same position on 6.10.73. The response seemed to indicate that this object elicited all those schemata attached to the rattle string, in that it was struck with upward and downward Φ_v, grasped, and the infant's hand ran along its length and back several times. Also observed was grasping/ partial release/regrasping of the object. Grasping and pulling down was attempted, but the bar being firm, this resulted in the infant's body moving upwards. Later the infant grasped the object with both hands and, pulling strongly, raised his head sufficiently to strike it against the centre of the wooden bar.

Rattle: In place of the collar, a rattle was suspended above the infant on 7.10.73. This evoked behaviour patterns previously seen with the collar, viz:- Φ_h at rattle, miss and grasp side of cot (7.10.73); Φ_h at object and attempting to follow it with the hand while it moves (10.10.73); left hand up and touching the object three times (10.10.73); and several variations of such behaviours, namely clasping the hands and using the clasped hands to strike the rattle (8.10.73); hitting the object with a sideways swipe (variation of Φ_v) (8.10.73); Φ_h, hitting the rattle and watching it swing (10.10.73); looking at the rattle and hitting it with the back of the fisted hand (10.10.73).

<u>Formal Testing</u> - 10.10.73 - 3 Trials

<u>Object in Hand</u> (11.10.73 - 7 trials): The infant finally looked at an object in his hand on the 10.10.73, (outside formal testing). The event seemed quite traumatic for the infant in that as soon as his gaze fell upon hand and object (a pen), he gave a very great startle reaction, dropping the pen and throwing the grasping hand high above his head. The infant gave every indication of being shocked to see the object in his hand. A similar, though less forceful reaction was noted on the following two trials. Fixation of grasped objects was by no means invariable, on 4 of the 7 trials of 12.10.73 the object was simply dropped. Object to Mouth on grasping was seen only once in both sessions.
<u>Object in Mouth</u> (11.10.73 - 9 trials): On three trials a hand to mouth action was seen, and on two of these trials the hand was sucked separately

to the object. Only once did the hand briefly grasp the object in the mouth.

Object at Finger Tips: This test was not performed during the eleventh week.

Object Visually Presented (6.10.73 - 4 trials, 10.10.73 - 5 trials): On 6.10.73 a flower held to the left of the infant produced fixation, then activitation of the left hand and four Φ_v in the general direction of the object. Cody then leant to the left (still fixating the flower) and the right hand performed eight Φ_v movements. Each time the hand was directed quite definitely to the left (not, as normally, in the midline). Similar directed arm behaviour was seen with a woollen doll located at the right side (two presentations). A total of 16 Φ_v were made in its direction. Of great interest is the fact that, on six of these, the hand was held momentarily when at a point closest to the object. Similar directed movements (but without the arrested sequence) were seen 10.10.73 for a rattle, and a key ring.

Hand to Mouth

The observation of this period showed a complete mastery of hand to mouth movements in all postures available to the infant. Thus, in supine hand to mouth "easily" 6.10.73 (3 times) and 10.10.73 (1 time); when prone 7.10.73 7 times); and sitting (5 times). This ease of movement is reflected, as in the previous week, by a much greater preponderance of hand to mouth movements as a part of some larger action directed towards an object. Thus, after supine grasping of collar with both hands, the left hand was brought to the mouth (6.10.73); Sitting: right hand Φ_v to the hand of the attendant, scratches it, then brings his right hand to his mouth, after which the movements are repeated (8.10.73); Prone: right hand scrapes down the front wall of cot, then held in front of face after which it brought to the mouth easily (8.10.73 and 11.10.73); left hand grasp hood of cot and then hand to mouth, several times (11.10.73); holds fisted hand in front of face and then to mouth (7.10.73); hands extend forward, clasp and then both to mouth (8.10.73); double A movement and left hand brought to mouth (11.10.73).

Hand to mouth movements are, thus, now possible from a wide variety of postures in which the infant is observed. The movements are now such an integrated part of general behaviour that it was decided to incorporate this section with general grasping for all the remaining weeks.

Vision

Interest in the visual mode also continued to stimulate the infant, he being noted to look at his hands and open and close the fingers three times (7.10.73) and to visually monitor the prone hand clasping seen 8.10.73. Cody also watched his hands during the more complex hand-play described in general grasping and in the tactile sequences described below.

Tactile exploration of the face was observed many times in supine during the course of the eleventh week, the movements ranging from simple hand to, then worked over various parts of the face with (7.10.73) and without (8.10.73) hair pulling, through holding the hand above the face, looking at it and bringing it down onto the eyes, etc., with (6.10.73) and without (10.10.73) taking it to the mouth, to the relatively complex movements of clasping and rubbing the hands before the face and bringing them down onto the face (three occasions with eyes tightly closed). The action was performed with intensity (and decrease in other movements) which attested to the infant's concentration to the task.

Visual Following

6.10.73 shows important behaviour for visual following. The object , a flower held three feet from the infant was passed across his line of sight. The object was followed with the eyes, but with a movement that proves difficult to describe; it was not so obviously saccadic as in previous days (no well defined jerks as the object moves) but it was not yet true following. The eyes, although following in the appropriate direction did not keep "spot on" the object, seemingly over and under-shooting and very very occasionally "jerking" back onto the object. One day later, (8.10.73) visual following at three feet, was smooth, with no over or undershooting recorded. Also of interest is the infant's following, by head rather than eye movements, of the experimenter's hand when this object was at a distance of eight feet from the subject.

Vision - Audition 7.10.73 - 8 Trials

Using the experimenter's voice or a transistor radio as the sound source, the infant was successful in localising the sound on each trial. It was concluded that this ability was now established in the infant.

Summary

Hand clasping increases, but most arm actions object directed; touching and plucking continue; Hand up/Groping appears in prone; arrested and slow Φ movements appear, and use of cot wall in arm support for grasping.

Formal Testing: "Shock" at seeing object in hand for first time; grasped object to mouth once in 10 trials; object in mouth, hand to mouth on

3 of 9 trials, hand sucked separately on two occasions. Fixation and arm activation in general direction of visually presented object; arrested Φ_v seen.
Hand to Mouth: now easily accomplished.
Vision: Great interest in hand-hand, and hand-object interactions.
Visual following: "Overshooting" observed, disappears later in week with object at 3 feet distant, but at 8 feet following is predominantly by head turning. Localisation of sound: easily achieved.

TWELFTH WEEK

Naturalistic Observation

Behaviour with regard to grasping is much the same as for the eleventh week, with much holding of the hand near to the object and looking between them, and arrested Φ_v and Φ_h. Bilateral grasping is also seen. A new achievement is holding the hand between (and in the line of vision of) head and object. Waving both hands in the air and grasping at the hanging toys (not merely the rattle string) also appears during the twelfth week, as does withholding an object from the mouth in order to look at it prior to sucking.

Despite these advances, the infant is still not capable of efficient grasping at a hanging object, primarily because he is not yet sufficiently well coordinated to keep his hand in one position for a long time, and also because, being suspended, the object moves easily and he is unable to track it successfully with his hand. Self-directed movements enjoy an upsurge at the middle of the week, with hand clasping and its variations predominating. This is thought to be due to a decrease in the time hanging toys were displayed above the infant.

Prone

Self-directed Movements: Apart from the behaviour seen in ensuing weeks, and especially eleven (see page 143), only one action of note is seen during the twelfth week. On 16.10.73, after holding the hood of the cot with a one-digit grasp (right hand) the infant released his grip and held his right hand horizontal and parallel to his face, watching it intently for five seconds, before taking it to the floor of the cot. The hand then performed nine Φ_h across the infant's line of vision in a slow and shaky manner, the infant visually monitoring its movement each time. There can be little doubt that such behaviour was designed to increase the efficiency of visually directed arm movements.

<u>Object-directed Movements</u>: Structures: grasping the left or right wall of the cot with the ipsilateral hand was seen 16. and 17.10.73. On the latter occasion, the infant watched the grasping hand and continually tightened and relaxed his grasp on the cot side. Grasping of the hood of the cot with one finger was seen 16.10.73 and later with both hands, the infant immediately going up on his hands. Seen for the first time on 16.10.73 in prone, was the hand grasping the contra-lateral wall of the cot.

Hanging Toys: There was much arm movement directed at these objects, and of especial note was the great preponderance of slow, shaky striking movements. Thus, 13.10.73, the right hand made a slow Φv and grasped a hanging toy, the whole procedure being visually monitored; similar behaviour was seen 14.10.73 (four times); nine slow Φh each time hitting the object and five times grasping it briefly were seen 15.10.73 and on 16.10.73; after attempting to grasp a hanging toy with a rapid upward Φv and failing, the infant then performed a slow identical movement, pushing the object to his mouth. On 18.10.73, Cody made three slow Φv down upon the hanging toy and attempted to grasp with a horizontal movement. On each occasion, hand and arm movements were carefully scrutinised by the infant during the twelfth week, and for each type of Φ action, Cody began to substitute for wild, flourishing movements the slower, yet more accurate and controllable, visually monitored actions.

Another behaviour pattern evolved from the earlier Φv and Φh movements and designed, apparently, to aid a greater degree of control in grasping was that of the <u>arrested</u> Φv or Φh . This type of movement was seen briefly during the eleventh week. On 14.10.73 the infant fixated and made sucking movements at a hanging toy, and three times making a Φd movement. When, during the action his hand neared the object, Cody tried to hold his hand at the hanging toy whilst the fingers opened and closed as he tried to grasp it. Even as, unable to hold his hand in one position for more than two seconds, the hand fell away from the desired object, the fingers continued to open and close. Similar Φ_h behaviour was seen on 17.10.73, and later with a Φv movement, (three times) the infant each time watching his hand and stopping it at face level at a point closest to the object.

Possibly derived from the Φv and Φh actions also, was "touching" of the object, seen 13.10.73 and three separate occasions 18.10.73. The matter has been mentioned in supine development (see p. 155) but it should be noted in this case that the object touched was one with which the infant was very familiar. This behaviour is therefore not "tentative exploration of a new object". If one could phrase the most likely explanation of the action in words it would be "When I see my hand in such-and-such a position and my kinaesthetic feedback reports such-and-such a degree of tension, then my hand is stationary in the visual field. When I move it so as to take on a new position in the visual field (resulting in a certain change in kinaesthetic input) I can hit the object before me. By changing back to the prior visual and kinaesthetic input, tactile feedback from the object ceases and the hand is in it former position".

The ability to move his hand to an object he has fixated and to hold it steady close by the object comprise two prerequisites for consistent, successful grasping, and it seems that the infant learns control of such precise hand movements, in part, by just such touching movements as described above. The touching action observed and described above was repeated several times implying a learning of the movement for future grasping attempts.

Another behaviour demonstrating the infant's present lack of true grasping on sight ability and implying his attempts to improve hand-eye coordination was seen on 14.10.73. The infant fixated an out-of-reach hanging toy, and made a Φ_h movement at it, arresting the action when the hand came immediately between his eye and the object. The hand was held shakily in this position for ten seconds, the infant's gaze never leaving the hand-object combination, and was then lowered briefly approximately three inches, after which the hand was raised to its former position, held twelve seconds, and then brought down to the floor of the cot. No grasping movements (i.e. closing of the fingers) were observed, the hand remained open throughout the action, suggesting that the infant was obtaining information on when an object was out of reach.

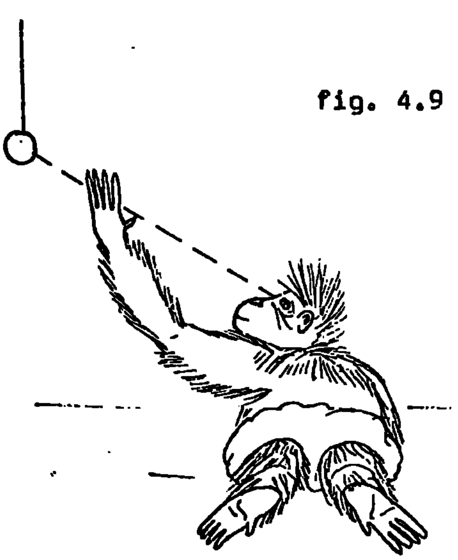


fig. 4.9

That information on the correct time of hand closure and distancing was lacking was seen (14.10.73) that same day when the infant several times made slow Φ_h movements towards a hanging rattle, the movement terminating (and the hand closing) several inches behind the rattle. Following this the hand was pulled back to the mouth and sucked.

Φ_v, Φ_h and Φ_d actions were observed on every day of observation, although, because of the introduction of the behaviours referred to above, their frequency of occurrence was lower. Grasping was accomplished during these fast Φ actions, but such seizure was in all probability fortuitous (hand hooked and closing as it contacted the object). Whenever an object was grasped (slow or fast Φ actions) it was brought to the mouth and sucked.

One grasping behaviour seen briefly on 18.10.73 was an attempt to seize a hanging object by a double-handed grasp. The attempt was unsuccessful and terminated with hand-clasping.

Sitting/carried.

Very little time was spent in this position and there is a paucity of behavioural data during this period.

<u>Self-directed Movements</u>: Self directed arm movements were virtually non-existent (due possibly to the infant's increasing attention to objects) and were confined to occasional Φ_v or Φ_h actions.

<u>Object Directed Movements</u>: When carried, the infant showed an obvious interest in his surroundings and arm activation on fixating especially interesting objects was common. Visually monitored Φ_v movements at furniture were seen 16.10.73 as was a hand out and scraping up and down wall movement (compare prone and supine on wall of cot). Similarly, the infant watched intently when the door of a cupboard was opened and closed. Upon cessation of the door movement, several Φ_d actions were directed towards the door. Similar behaviour was seen two days later.

Another behaviour pattern to develop (and of importance to the sensorimotor screen problem, see page 61) was grasping the experimenter's thumb and pulling it to the mouth for sucking. It was observed on 15.10.73 (two occasions) and 18.10.73. On this latter occasion, having grasped the experimenter's hand at a distance of nine inches, the hand was brought to within 1 cm. of the infant's half-open mouth. The infant was then observed to stare intently at the "object" he was holding, and all arm activity ceased at that moment. Still watching, he then moved his hand so that the experimenter's hand was pushed to and fro three times before it was brought to his mouth for sucking. This action is the first recorded instance of delaying sucking to visually monitor a grasped object in the sitting position. Observation of the effects of the infant's hand movements on the shape and perspective of the object held may also be involved in such actions.

Standing: This posture was attained only with the aid of the experimenter and was seen but once during week 12 (15.10.73). No self- or object-directed movements were seen, the infant being unable to release his hand from the experimenter. However, throughout standing the hands did continually grasp, relax and regrasp the experimenter's supporting fingers.

Supine.

Self-directed Movements: Double A movements were seen several times during this period, although with quite a range of variation. 13.10.73, 15.10.73 and 17.10.73 saw "typical" double A behaviour patterns, the hands being looked at very intently at the apex of their upward movement. Variations seen were a double A movement but with the hands left extended for intent visual regard (13.10.73) and, observed 16.10.73, the infant lying on his side to perform the action.

Very similar to this movement, hand clasping was noticeably absent from the supine behavioural repertoire between 13. and 14.10.73. It was, however, seen five times during 15.10.73, the infant holding his hands above his face and continually clasping and unclasping the hands. Each time the hands were then brought to the face and pushed in and around the eyes, nose and mouth regions. A later variation had the infant bringing his hand down to the stomach region after clasping, the infant's eyes being fixed firmly on the ceiling of his playcage. Clasping after bringing one hand from the mouth was seen six times, 16.10.73, both hands then being returned to the mouth. Later, both hands were waved in the air, then clasped and sucked.

In addition to clasping, a very similar behaviour of one hand grasping the other was seen to emerge during this week. Although seen on several occasions it was not visually monitored until 15.10.73. The grasped hand was typically fisted, and the other grasping hand brought to it (fingers unflexed). As the hands made contact, the fingers of the grasping hand closed round and tightened on their target. The infant, when first performing this visually monitored grasping, brought the right hand to face level, raised the left hand vertically, fixated the left hand, opened and closed it, and still looking, placed it over the right fist and grasped. This behaviour was seen on two further occasions during the same day.

Appearing a little earlier during this period (13.10.73) though not visually monitored, was grasping of the left foot by the ipsilateral hand. Two days later the right hand was seen to explore first the right leg and then the right foot (2 occasions). Manual exploration of the arms was also evident during the twelfth week, with one hand scratching or pulling at the contralateral hand on 14., 15. and 17.10.73. Simple hand before face movements should not be thought absent, although their incidence decreased compared to earlier weeks. Two such examples were seen; 16.10.73 Φ_V across the face five times (visually monitored) and 18.10.73 hands helf in front of face and looked at.

Independently performed tactile exploration was likewise seen but rarely: 17.10.173 while sucking fingers they occasionally wandered over the face: 13.10.73 fisted right hand held against face.

<u>Object Directed Movements</u>: Structures: The infant continued his attempts at movement by grasping the side of the cot with one hand and pulling himself up using this anchor (13. and 18.10.73). Grasping the side of the cot formed a starting point for many movements which included action by the other hand, usually an <u>A</u> behaviour pattern, and which terminated in tactile exploration. Three variations of this movement were seen during 15.10.73: Right hand grasps right side of cot (8 times) then left hand up and touch right hand, right hand immediately releases grip on wall and does an <u>A</u> movement: right hand grasps right side of cot but when released does an <u>A</u> behaviour pattern, ending with hand at chest; an identical movement to the above but with the left hand grasping the right side of the cot immediately prior to the <u>A</u> movement.

The "left hand grasping right side of cot" movement was first seen as part of the above behaviour. However, one day following the movement appeared independently with the infant watching the left hand intently, and also visually monitoring the right hand which was raised to touch the left. Later that day, after arm waving above the head, the left hand again grasped the right side of the cot. The 16.10.73 saw the first recorded grasping of both sides of the cot with the hands of the respective side. The infant was observed to grasp, relax and retighten the grip of each hand many times (16 times for the left hand). Visual monitoring of this action occurred on the great majority of occasions.

Hanging Toys: Much less <u>striking</u> of the objects is observed this week while in the supine position, the infant seeming more concerned with attempts at grasping at the object while keeping it visually fixated.

With attempts at grasping, the hand was characteristically brought towards the object, and the hand opened and closed in an apparent attempt at grasping, (e.g. 13.10.73). In this supine posture a certain degree of position-holding was possible as when the left hand was raised close to the object, the fingers being opened and closed three times before the hand fell away (13.10.73). On one occasion the infant touched a diabolo-toy, before then becoming engrossed in a study of his hand, to the exclusion of the object (16.10.73). Another problem faced by the infant was a seeming inflexibility of behaviour as manifested by the "firing off" of a particular behaviour pattern at an inappropriate time. Thus, during day 1 of his 12th week, Cody several times fixated a hanging toy, and, raising his left arm in what appeared to be an attempt at grasping, the right hand moved upwards just in retard of the left, and, even as the left hand made to grasp the object it seemed compelled to join with the right hand in a double A behaviour pattern. On other occasions a grasping movement towards the object (hand opening and closing) also terminated in a seemingly "compulsory" A behaviour pattern (see also Piagetian section with regard to inappropriate behaviours, page 62). That such stereotypy was not always the case is seen by observations taken that same day in which, after attempting a two handed grasp at the hanging toy three times, and failing each time, the infant held one hand up and fixated the rattle for several seconds.

Further novel grasping behaviour was noted 18.10.73. Cody slowly and shakily extended his left hand and "gingerly" touched the hanging toy, then the left hand was retracted and the hanging toy grasped at. Although the action was performed "gingerly" it is probable that the infant was not afraid of the object but that he was attempting a visually-directed reach, with visual monitoring of the hands movements coordinating with kinaesthetic information to achieve this action. Such coordination and control is not yet perfected, and in addition it is probable that the infant did not know <u>when</u> his hand would reach the object. Hence, the slow, unsteady, seemingly hesitant reaching and touching of the object. Such an action could also conceivably function as a ranging manoeuvre, informing the infant <u>when</u> his hand would touch the object; hence the touching action followed immediately by a successful grasp.

Examples of visual interest in an object after sucking were seen 13.10.73. Having grasped the collar toy with two hands, Cody was observed to fixate it, while the left hand was brought to the mouth and sucked. As sucking proceeded the infant moved his right hand and with it the collar laterally in line with the head for several inches, visually following the collar throughout. Later that day the infant grasped the collar with his right hand (after several ϕ_v attempts) and sucked at it for several seconds. The collar was removed from the mouth and scrutinised briefly before being returned to his mouth. The procedure was then repeated. Such behaviour may, in part, serve to coordinate buccal (sucking) tactile/kinaesthetic (holding/moving) and visual input so as to make the infant aware of his ability to actively alter the sensory stimulation which he receives (i.e. to act upon the environment and to "know"what movements will produce what visual, etc., result).

Formal Testing

Object in hand: (14.10.73 - 9 trials): In all trials, the infant grasped the object and conveyed it to his mouth. The object, and sometimes the fist, was sucked. This 100% response contrasts sharply with the results of the eleventh week (10%, see page 146).

Object in Mouth: (14.10.73 - 4 trials): Sucking until the object was lost from the mouth was seen on all trials, but the infant's hand was never observed to move towards the object in the mouth.

Object at Finger-tips: (14.10.73 - 5 trials): On three trials of this session, the infant visually fixated the object and then made a ϕ_v action, landing on the object and partly grasping, dragging it to his mouth. No response was forthcoming on the remaining two trials.

Object Visually Presented (13.10.73 - 7 trials, 15.10.73 - 5 trials): Arrested ϕ_h movements were seen on three trials of 13.10.73, Cody "fumbling" with the object on one occasion, but failing to grasp it successfully. Arm activation followed by fast ϕ actions, and one double-handed grasping attempt were seen on remaining trials. The 15.10.73 saw some improvement on this performance. Two trials yielded a touch-then-grasp strategy (as described on p.155) both of which were successful. The remaining trials were arrested ϕ_h , one of which resulted in a successful grasp.

Vision

The infant took much visual interest in hand-object interaction in all postures, as has been described in the relevant sections above. In all cases (e.g. slow and arrested ϕ actions, and touching in prone, double A movements left extended in supine) the purpose of the behaviours would seem to be in an increase in efficiency of hand-eye co-ordination.

Visual Following: This was tested on 5 occasions (15.10.73). Very occasionally the eyes would "jump" in following, but most tracking on each trial (and on three trials all tracking) was smooth.

Summary

Hand grasps contralateral cot wall; hands grasp respective walls of cot; moving body by grasping cot wall and pulling; less striking of objects, more attempts at directed grasping. Slow ϕ actions predominate, also seen are arrested ϕ/groping, overshooting in "ϕ and grasp" attempts; slow touching of object may act as ranging manoeuvre; compulsory "firing off of a common behaviour pattern when attempting to grasp also observed. Delay sucking to look at a grasped object, and suck-look-suck cycle seen.
Formal Testing: grasped object taken to mouth (hand or object sucked); object in mouth sucked, but no hand to mouth; object at finger tips, fixation and grasping attempts on 3 of 5 trials; increasing use of arrested ϕ actions, or touch-then-grasp when presented with an object.

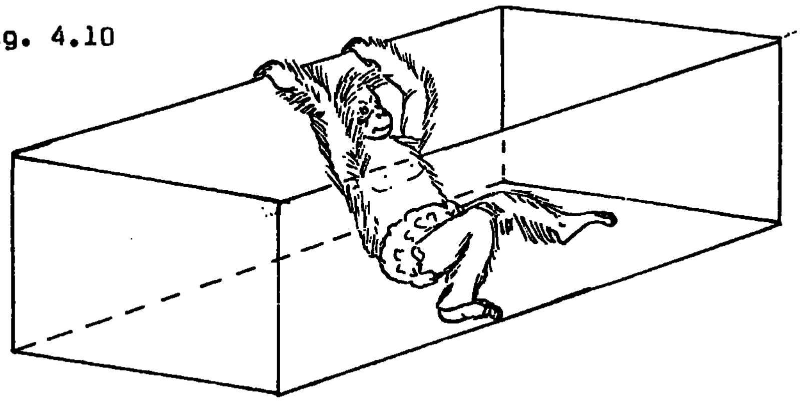
Vision. Intent visual regard of hand-object interaction. Visual following smooth.

THIRTEENTH WEEK

This week marks a rather large increase in the infant's locomotor abilities, primarily because of the more active use of grasping a stable object, and by pulling on this "anchor" to move his body about the cot. Such a capacity tends to cut across the divisions of "sitting", "prone" or "carried" used in this analysis. The infant moves from one position to the next with a rapidity not previously seen. Thus, at 20.10.73 and on each day following (except 23.10.73) the infant was seen to grasp the experimenter's proffered finger (usually after several ϕ's in its direction), and to pull himself unaided to a sitting position. Although the data are far from complete, it may be that this manoeuvre (and indeed all early "grasp, pull and move body" actions) derive from simple "grasp object and take to mouth" movements in which the object refuses to move. By contracting those muscles required to bring an object to the mouth, the infant may then find that he himself moves. If this spectacle is interesting, attempts will be made to repeat it, and to expand it (Piaget, 1953, 1955).

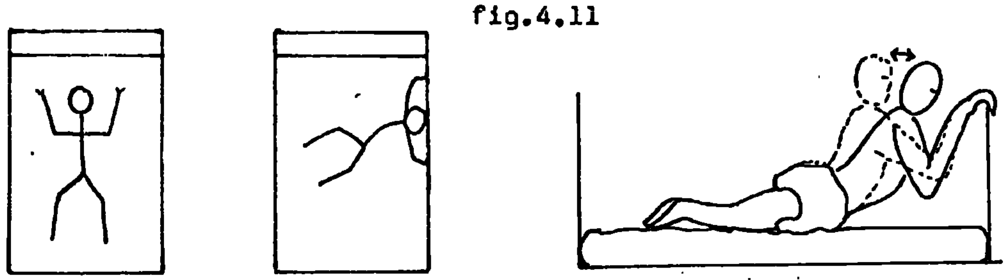
On the 21. and 23.10. 73 by pulling with both hands on the cot wall the infant assumed a half-sitting position from supine (see fig. 4.10).

fig. 4.10



Movement from the position shown in fig.4.11(a) to that in fig. 4.11(b) began 25.10.73, Cody in prone, grasped the right cot wall with his right hand, then pulled his body 90^{0} to the right and grasped the right cot wall with his left hand. The right hand was then placed briefly on the bottom cot wall grasping and regrasping this structure several times. That same day the position in fig.4.11(b) was again assumed. By pushing hard against the side of the cot Cody moved head and upper body forward and back in the manner shown in fig. 4.11(c).

fig.4.11



(a) (b) (c)

Another movement aided by grasping was lying on the left side. Here the infant steadied himself by grasping the right cot wall with his right hand. The hand was removed (it appeared in a systematic manner) and then replaced as the infant began to fall to prone.

Supine

<u>Self-directed Movements:</u> The infant seemed to become more aware of his lower limbs during the thirteenth week. Grasping his left foot with his left hand, and then sucking his left foot began 21.10.73. Later the left foot was again grasped but simply looked at. The following days saw many repetitions, with the reciprocal "left foot grasp left hand" appearing once (22.10.73). Following 23.10.73 foot grasping lapsed to a much lower level. Hand clasping was also seen during the thirteenth week and, at a very much reduced frequency, the <u>A</u> behaviour pattern.

<u>Object-directed Movements:</u> As for most positions in this thirteenth week, Cody showed a definite predisposition to move slowly (albeit shakily) with

Visual monitoring of his hand movements, when approaching a graspable object. At least 60% of all hand grasping occasions were slow and visually monitored.

Slow $\emptyset_v$ and $\emptyset_h$ were not the only strategies employed to bring the hand to the object; on several occasions (22., 23. and 25.10.73) the hand contacted the object briefly one or two times, after which grasping (usually successful) was attempted, and the object conveyed to the mouth. Such behaviour gave a distinct impression of the infant first "finding the range" of the object by the touching movement, and then using this information to make a more efficient grasp. This touch-grasp combination did undoubtedly increase the incidence of one-time grasping. On one occasion (22.10.73) when a second grasp did prove necessary, readjustment of the hand (instead of simple repetition of the grasping movement) was observed. The infant was trying to grasp a pen held vertically. The object was first touched, and a grasping movement, which missed, followed. Watching carefully, and without moving his hand from its position close to the object, the infant reopened his fingers, readjusted his hand's position vis-a-vis the object and then grasped successfully. The object was then conveyed to the mouth and sucked.

Other object-directed movements seen were using the cot wall as a support to allow close apposition of hand and object, then striking and regrasping the wall; clasping the hands and striking the object with clasped hands; holding the object with one hand, while sucking, and visually monitoring the second hand's grasp of the object's supporting string; and simple hitting/striking of the objects.

Prone

<u>Self-directed Movements:</u> Rare Φv and Φh movements on the air were seen, virtually all arm and hand movements being now organised around some object.

<u>Object-directed Movements</u>: Actions directed towards the cot and its pillow are still seen in prone, with arrested ϕ_v down the pillow being seen (three times) on 25.10.73. In addition, the infant seemed to practise a ϕ_v movement and to systematically alter its direction; thus on 21.10.73 Cody made many "hand over side of cot" movements, (essentially ϕ_v actions displaced to either right or left). Following this there were ϕ_v movements against the side of the cot, so that scraping of the hand on the wall occurred. Such alteration of direction may have aided the infant in learning which effects might be expected from the displacement of his arm movement in each direction.

Much later (25.10.73) and following the assumption of a position 90^o to the long axis of the cot, forearm-scraping was seen as shown in fig.4.12(a) and (b).

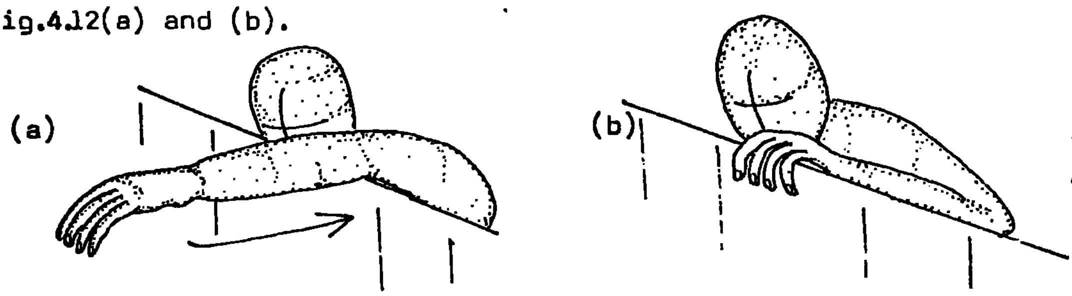


fig. 4.12

Thus, the arm was passed far outside the cot wall, and then retracted, scraping back across the top of the wall and terminating with the hand grasping the cot wall.

With regard to discrete objects such as hanging toys, proffered hand, etc., Cody responded very much as in the supine position. ϕ_v actions towards the object were common (20., 21., 22., 25.10.73) with grasping occurring approximately 60% of the time. Raising of the hand and <u>touching</u> or <u>tapping</u> against a fixated object prior to grasping was seen (21., 23. (2 occasions) 24., (many repetitions on second of two occasions) and 25.10.73). Watching and touching was best demonstrated during 21.10.73; looking to the bulbous end of a hanging rattle, Cody raised his hand and touched this area two times. His gaze then shifted to the thin stem of the object and once again the hand was brought to the area looked at. During 25.10.73 the infant was also observed to look at the object, bring up his hand and, with his hand very close to the object, open and close his fingers five times, before tapping gently at the object with his closed fist. No attempt was made to grasp the object at this time.

During 23.10.73, after unsuccessful attempts at grasping, the infant repeated the behaviour of raising and holding hand stationary between the object and his eye. More ϕ_h (usually slow) movements followed and grasping was finally achieved. Upon grasping, partial release/regrasping of the object occurred 5 times. Immediately after release of this object Cody fixated his hands while opening and closing his fist several times. Grasping of the rattle was also achieved (21.10.73 and 22.10.73) by hand clasping with the rattle caught between the two limbs, and by using the side of the cot as a support from which to launch a grasping movement (21. and 22.10.73). Once grasped, the object was sucked.

A behaviour pattern involving both hand and rattle seen on 21.10.73 demonstrated well the Piagetian concept of "secondary circular reaction" (Piaget, 1953). The infant was at this time sucking his fingers, with the hanging rattle lying against his digits. Cody was observed to extend digits 4 and 5, so moving the rattle away from his face. The extended digits were then retracted and the rattle then moved back to its original position against the "bulk" of the hand. The infant observed this movement with great concentration, and repeated the action five times. The question of alteration of the retinal image of the rattle by his own actions arises here.

During the final day of this week, the infant grasped another object and in so doing extended his sphere of activity. The object was one leg of a metal A-frame which was at times positioned above his cot to carry the hanging toys.

Sitting/Carried:

On the only occasion he was carried, Cody made 17 Φ_h actions towards a light switch he had been shown, 10 of which hit the switch. The relevance of this behaviour would seem to lie in the learning of visuo-motor control.

Formal Testing

Object in Mouth: (23.10.73 - 5 Trials) Piaget believes reciprocal assimilation acts so that when a grasped object is taken to the mouth, a mouthed object activates hand to mouth (or object) behaviour. During this session, on none of the five trials was hand to mouth (or object) movement seen, despite the fact that object sucking continued for up to 12 seconds. Thus, in the Orang-utan it seems that hand-to-mouth-with-object does not automatically presuppose a hand-object-in-mouth schema.

Object in Hand: (22.10.73 - 8 Trials): When of interest, the object was grasped, taken to mouth and sucked (6 Trials). Unwanted objects were not grasped (2 Trials).

Object at Fingertips: Not tested.

Object Visually Presented (22.10.73 - 7 Trials): Slow Φ_h and grasping movements predominate (5 Trials). On two occasions Touch-then-Grasp strategy was employed.

Vision

Vision is very well integrated with other behaviour by this time (see above). "It seems as if everything he does at the moment is preceded, combined, or followed by looking" is a passage from the diary notes of 23.10.73 and effectively sums up the situation of the thirteenth week. Not only did the infant visually monitor grasping, touching, etc., but the assumption of new body positions were also accompanied by much looking round at various parts of his room and at people, e.g., a visit by a TV team provoked much watching as did the presence of onlookers outside the cage (up to now ignored). The 22., 23. and 25.10.73 also saw the resurgence of interest in the experimenter's face, during feeding and in the "quiet period" following mealtimes. The infant (22.10.73) looked to his hand when an object was placed in it while his gaze was directed elsewhere (7 trials).

Visual Following

Following is now completely smooth when the object (at a distance of 2 to 3 feet) is passed horizontally across the infant's line of vision (23.10.73).

Audition Vision

The infant looked in the appropriate direction whenever a novel sound was made on either his right, or left side (5 trials - 23.10.73).

Summary

"Grasp pull and move" appears in all positions.

Supine: Increased awareness of lower limbs; slow, visually monitored hand movements predominate; "Touch and grasp" strategy (rangefinding?); readjustment of hand after unsuccessful grasping attempt; close approach of hand to object before grasping using cot wall as support (also in prone); striking object with clasped hands.

Prone: Almost all ϕ actions object directed; practise ϕ_v and systematically alter its direction; scraping arm over cot wall; "touch/tap then grasp" strategy seen; hand held stationary between object and eye after unsuccessful grasping attempt; grasp object outside cot (A-frame).

Sitting/carried: ϕ actions made in general direction of visually interesting object.

Formal Testing

Object in mouth: No hand to mouth or object.
Object in hand: If interesting, object grasped, taken to mouth and sucked. Not grasped if uninterested.
Object visually presented: Slow Φ_h and grasp actions predominate, with occasional "touch and grasp".
Vision: Ubiquitous, and very well integrated with other behaviour; increased interest in experimenter's face; looks to object placed in hand when infant looking elsewhere.
Visual following: Smooth.
Audition-Vision: Complete.

FOURTEENTH WEEK

Successful grasping on sight (more than 75% success at the first attempt in all positions) is achieved somewhere between the fourth and the seventh day of the fourteenth week. Behaviour seen in the earlier part of the week indicates that learning was still taking place at this time. Considering first the three days preceding competency, there are several points concerning the final stages of mastery of this ability.

Supine

Self-directed Movements: Such movements are few, being Φ_h movements in the air (27. and 28.10.73) and "one hand grasping the other" (27.10.73).

Object-Directed Movements: Only one grasping movement served to aid a postural change by the infant in supine. The infant was seen (27.10.73) to grasp the contralateral cot wall with one foot and, by pulling, to turn from supine to prone. Apart from this action, the infant's spontaneous, observed postures were completely in the prone position during the first three days of the fourteenth week.

Formal Testing

In order to determine supine grasping the infant was placed in this position and objects presented to him during 27. and 28.10.73 at a distance of approximately 8 cm. above the infant's face.

On 27.10.73 when shown a crumpled piece of paper (approx. 4 cm. in diameter), Cody first made two short, curtailed Φ_v actions, his hand being very close to his chest. He then followed this by two fast Φ_v movements at the object grasping on the second of these. A yellow pan immediately elicited a Φ_d action (from outside the visual field) which moved slowly and shakily towards the object and touched it. The hand was then moved back slightly (the infant watching with great concentration), then forward, and slowly around the object. There was a great deal of touching as the fingers moved round the object before it was grasped, as if the infant were feeling <u>and</u> seeing his way through this action. The grasped object was taken straight to the mouth.

Grasping immediately, i.e. with no reverses or readjustments, was seen on the first trial of 29.10.73 (the hand coming from outside the visual field). The second trial saw the infant make a small curtailed Φ movement, reminiscent of those seen on 27.10.73, after which the object was grasped with a Φ_h action. The object in the trial following was grasped immediately. The experimenter's finger was then offered for two trials, and upon each occasion the "object" was first touched, the infant's hand withdrew, (1 - 2 cms.), and the finger was then grasped successfully.

Such results seem to indicate a progressive reduction in the need to "range up" on an object, i.e. the infant is now more capable of bringing his hand to the correct position with respect to the object he wishes to grasp. Learning effects, (the number of times the infant was required previously to perform the grasping action in this position) seem to account for the increase in competency. It is interesting that the infant is apparently incapable of bringing his hand from outside the visual field in the <u>prone</u> position (see below) when this capacity is present in supine. Thus abilities do not seem to be easily generalised across postures, and experience for each individual position may be necessary.

Of lesser importance with regard to grasping, but of considerable Piagetian interest, was the infant's striking of a grasped object against the wall of the cot, so producing a noise. The object was lost in the process, but the infant, watching his own actions throughout, proceeded to strike the wall a further six times with the same (empty) hand, producing a noise each time. The action may undoubtedly be classified as a secondary circular reaction.

Prone

Self-directed Movements: There was a noticeable lack of such actions. Φ_v movements were occasionally seen on empty air (27. and 28.10.73) as were handclasping and reclasping (28.10.73), right hand scratching left arm, and scratching jaw (27.10.73).

Object-directed Movements: Grasping of structures (cot and (since thirteenth week) the A-frame) and thus increasing mobility continues in prone with the infant twice grasping the A-frame and pulling on it (28.10.73). In addition, change in position from facing the top, to the bottom cot wall was seen on the same date. Cody assumed a position as in fig.4.11(b). He watched his hands on the cot wall while continually grasping, relaxing and regrasping his hands. Then, by placing his right hand on the mattress below the bottom cot wall and at the same time pushing with his left hand, the infant assumed the position shown in fig.4.13. Following this, the infant's left hand grasped the bottom wall of the cot, Cody raised his head high and scrutinised his surroundings. Another postural change was seizing one cot wall, pulling hard, and so moving the head and upper body to the wall for sucking.

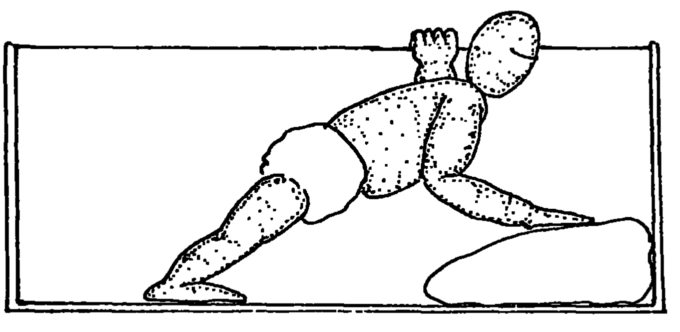


fig. 4.13

Objects: Evidence for attempts at increased visuo-motor control of hand movements is seen on each of the three days considered. Φ_h and Φ_v movements during day 1 were both slow and fast, both being visually monitored. On 27.10.73, having grasped one object, the free hand made a slow Φ_h movement to a second hanging toy and, upon missing, grasped the first. The 28.10.73 likewise saw fast and slow Φ_h, Φ_v movements but little grasping. The infant's tolerable grasping performance on previous occasions, and his fixation of the objects' oscillations after he had struck them, made it likely that such actions were designed simply to swing the hanging toys.

Two limitations in the infant's grasping ability were seen during 27.10.73, with the infant in a prone position on the experimenter's knee. To quote from my notes:

" Show my pen, looks but no grasping movements, even when I place by (<u>next to</u>) his right hand (it already grasping coverall). Put pen in hand, no grasp. Same response three more times. Try pen at left hand, he Φ_V with left hand, he grasp, looks to it briefly then to mouth and sucks end of pen 15 secs., then out, looks to it then back in, sucks 5 secs. and lost. Try with light meter (present at right side of face (fig.4.14) he tries to suck it without hands and I note that it is the left arm which activates. Left hand is free, right hand is holding the coverall. The light meter is thus presented completely out of sight of the left hand, i.e. no chance of peripheral vision of that limb. His left hand, although activating, only performs the Φ_V movements on his left side, while he looks with obvious desire (staring and sucking movements) at the light meter. Makes Φ_V action with his left hand ten times, then I slowly move light meter to the left. His head follows and when left hand and light meter are in same visual field, left hand grasp the object and to mouth. Repeat the whole sequence on four more occasions with same result."

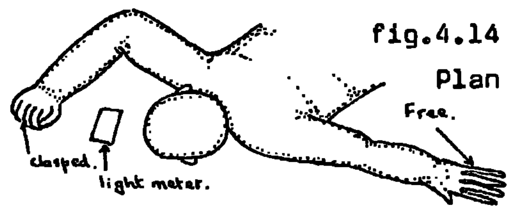


fig.4.14

Plan view

Thus, the first limitation appears to be an inability to release one object (the coverall) so as to secure another (the light meter) as is witnessed by the immobility of the infant's right hand even though the object is strongly desired. The activation of the left arm in response to the visual stimulus of the object demonstrates the second limitation: an inability to bring his left hand from outside the visual field to a position within it or close to the object. Such a lack of competence is not general, as is shown by the infant's ability in this regard while in the supine position. This non-competence may not even include the prone position totally, and may be due to the extremely unfamiliar prone-on-knee position. As has been suggested in the foregoing account, the infant seems to require experience and practice in specific contexts before competence in a given skill is achieved. In addition, although in many Φ_V actions in prone, the grasping/striking hand moves out of the visual field in the course of the movement, it is nevertheless seen and its position known at the onset of the action. In the protocol given above the infant's hand is not visible at the commencement of the action and it is possible that it is this information-gap which prevents hand to object movements being performed successfully.

Thus, the ability to move the hand from the visual field and back into sight may be achieved before the ability to move the unseen limb to a position close to the object. The latter manoeuvre is certainly more complex.

Also seen on 27.10.73 was behaviour which mirrors that mentioned by Piaget for his son, Laurent (Piaget, 1955 , Obsn.101 , page 177). After grasping an object (light meter) (after 2 ϕ_d movements) the infant was again offered the object but it was placed on the cot floor as the grasping movement began, immediately in front of, and clearly visible to, the infant. Cody immediately terminated the ϕ movement and began looking around the room, as if the object had disappeared. The same response was elicited on three occasions, and it was noticeable that the infant reinitiated grasping as soon as the object was once again approximately 6 cm. above the cot floor. The same response was forthcoming on the fifth test-offer. However, on this occasion, the object was left on the floor so as to determine the effects of extended exposure to the situation. As before, grasping actions ceased as soon as the object was placed on the floor, and the infant grasped the left cot wall with his left hand. After 32 secs. the left hand went once again to the floor of the cot, Cody looked at the light meter, and grasped the object with his left hand. The same response was forthcoming on a further trial, (object grasped after 42 secs.).

It seems from these results that the infant, at this point, either does not cognise hanging objects as being identical with "sitting" ones, or he does not possess an appropriate grasping schema for objects on the floor. The latter explanation is not tenable in view of the infant's often-observed capacity for grasping objects on the floor. The suggestion that the limitation was due to the infant's hand being in the same visual field as the object when grasping was attempted, but outside when grasping was inhibited, is negated by the fact that at least two grasping actions were terminated with the hand and object in the same visual field. However, this does not exclude the unlikely occurrence of "screening out" of the hand when such an action is made. An alternative explanation to the two mooted above is that the infant finds difficulty in changing over from one grasping "programme" to another in so short a time. Hence, later grasping of the object-on-floor is possible. A point in favour of this explanation is Cody's "preserveration" when attempting grasping of hanging objects (see page 152,12th week) and certain Piagetian tests (see screen test, page 62). However, on these occasions, the alternative "incorrect" behaviour was seen (e.g. grasping on "thin" air) whilst in the behaviour described here Cody simply terminated his actions even though a familiar behaviour pattern (grasping at hanging object), was available to him. Hence, it is thought that the most probable explanation for the behaviour seen is that given in the first explanation above: that the infant at this age does not equate the visual image of the object on the ground as being the same as the image of the same object when it is suspended. The grasping of the same object after an approximate half-minute period may be due to the infant perceiving the same object as another altogether different, yet equally interesting object which he is then motivated to grasp.

Sitting/Carried

<u>Self-directed Movements</u>: These were infrequent Φ_v and Φ_h actions in the air.

<u>Object-directed Movements</u>: In this position Cody demonstrated some of the clearest examples of his skills and limitations in hand-eye coordination. Limitation seems to be totally confined to the lack of fine control in grasping movements. Thus, at 27.10.73, with the infant seated on the experimenter's knee and an object (small pen) presented at approximately 8 cm. from his face, the infant fixated the object and produced a slow Φd movement which ended just touching the pen but to the front, as shown in fig. 4.15.

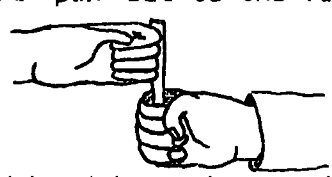


fig. 4.15

The infant then reversed his hand, and made a second pass at the object (Φ_d), bringing his fully opened hand to such a position that his finger-tips were approximately 3 cms. behind the pen. The fingers were closed, the pen grasped, and carried to the mouth. Throughout these actions the infant visually-monitored the proceedings intently. Grasping with no reverses or readjustments was accomplished on three of four trials in which the infant was offered the experimenter's index finger as an object. The fourth trial required one reverse and one regrasping movement.

Very similar behaviour was seen on 28.10.73 in the sitting position. Having been shown a red screwdriver and fixating the object and smiling, the infant made a Φ_h action at the object, but did not make contact (the fingers of the grasping hand did not close after this action). The hand was then withdrawn, but instead of the second Φ_h movement seen with the pen on 27.10.73 the infant raised his hand directly and <u>touched</u> the screwdriver with the tips of his fingers; the hand then reversed slightly, was brought forward and touched the object, reversed slightly once more and was again brought forward, the fingers on this occasion moving behind the object, after which the hand was closed and the object grasped. Visual monitoring of the whole action was most intent and the object when grasped was again taken briefly to the mouth and sucked.

In sum, grasping behaviour seen during this 3-day period seems already to be competent visually-directed reaching, but not yet efficient visually-directed grasping. As soon as the infant (whose visual monitoring of the movements seems to completely absorb him) sees that the movement is likely to fail, the hand is reversed and its position vis-à-vis the object altered, primarily by visual, and perhaps by tactile feedback, until grasping is possible. Thus, what seems to be lacking is the co-ordination of the finer grasping movements of the hand with the spatial positioning of the object. This disability is overcome in the majority of cases during the next four days of week 14.

Also of interest in a Piagetian sense is the observation that, as in earlier weeks, there is no movement of the hand to the mouth when an object placed in the mouth is sucked (3 trials, 27.10.73).

Vision: As has been detailed in the foregoing sections, the infant utilises sight in almost all cases of hand and object interaction. Looking invariably precedes hand action (and on at least one occasion the infant smiled at the sight of a particularly interesting object (also at the experimenter's face)). In addition to grasping, the infant's interest in objects beyond the limited universe of his cot takes a more prominent place, with Cody scrutinising walls, ceilings, people, etc., with more than passing interest. Looking is also seen during sucking of an object (27.10.73). Later that day sucking and looking makes an appearance for the first time. Alternate looking (5 times, duration of fixation 1 to 1½ seconds) was seen in but one context, between a swinging hanging toy and the pillow of his cot. This observation may be spurious, it was noted that the infant looked at the hanging toy whenever it swung closest to him. Further, duration of fixation corresponded to the object's frequency of oscillation. It is probable therefore that the hanging toy "imposed itself" upon the infant's consciousness on each near approach, thus giving merely the outward appearance of alternate looking without the comparison of two objects which such looking normally implies.

Coordination of vision with hearing is complete by this week. On each of six trials the infant turned his head to the appropriate side on production of a novel, or loud, sound.

With an object placed in the hand, the infant regarded the hand and object within 5 seconds of placement on each of 5 trials (27.10.73).

Grasping during the dates 30.10.73 and 2.11.73.

Only three of the four days were observed, the experimenter being absent on 31.10.73.

Supine

Self-directed Movements: not seen.

Object-directed Movements: On the 30.10.73 the infant simply struck the objects with Φ_h and Φ_v movements, and watched them intently as they swung. The infant maintained a prone posture throughout 30.10.73 and it was not until 1.11.73 that the infant was tested with objects in supine. Objects were presented above the infant's face at a distance of approximately 8 cm. On each of 5 trials performance was faultless, the infant grasping each time (2 objects given) with no touching, reversing, or readjustment. Similar competency in an identical situation was also seen during weeks 15 (5.11.73), 16 (11.11.73), 17 (21.11.73) and 18 (29.11.73)

Prone

Self-directed Movements: It is notable that on no occasion was a slow Φ_v or Φ_h self-directed movement observed in the infant, implying that such learning actions were by now redundant. On only 1 occasion (30.10.73) was a fast Φ movement performed apparently for its own sake, with 2 fast Φ_v upward actions observed. Other self-directed movements were sucking. the hand and fingers (30.10.73, 1.11.73), hand clasping (30.10.73, 1.11.73) and holding the head at the centre of the forehead (30.10.73).

Object-directed Movements: Virtually every Φ movement seems to be directed towards an object. Grasping in prone was in the main one-handed although occasional two-handed grasps and grasping attempts were seen (30.10.73 & 1.11.73). Grasping success in prone did not reach a 100% successful level during this week, nor for several weeks to come. However, when the total number of prone successful grasping attempts are compared with the number of "grasp and fail" actions, the infant's success rate is seen to be at a greater than 75% level on 30.10.73 (78.9%, 15 out of 19 grasping attempts successful). The level did not fall below 70.5% (1.11.73) on the remaining days of this week, and by the end of the following week levels of $>$75% on all dates except week 15 day 1, (3.11.73) were recorded.

The infant's failure to achieve near 100% grasping in the prone posture can be explained by the nature and position of the objects he attempted to grasp. Unlike the toys of the sitting and, (in the majority of cases) supine positions, which were stable, essentially unmoveable objects, the objects upon which grasping was attempted in prone were hanging toys, suspended by twine and extremely mobile. Thus a very great degree of extremely fine control of finger and hand movements was necessary to prevent the object slipping from the infant's grasp, and it is thought that these conditions were responsible for the less than perfect showing in prone. It is probable that, had stationary objects been provided for grasping in this posture, then an equal competence with those of sitting and supine would have been manifest. Because of the unusual features of this position, and because the prone position was very soon superseded by standing and sitting in spontaneous movement (see motor behaviour), 75% successful grasping was, perforce, taken as an arbitrary level at which to terminate detailed observation of the skill in this position.

Sitting/Carried: Of 11 trials given (30.10.73) using various objects (bottle, experimenter's hand, scissors) presented approximately 8 cm. from the infant's face, the infant grasped each one first time (i.e. no reverses, touches or readjustments). 8 further trials in the same conditions (1.11.73) showed an identical response. Grasping at the first attempt with the left hand when the object at the infant's right was also observed on three occasions (2.11.73). It was concluded that the infant had achieved grasping on sight in this position.

OVERVIEW AND DISCUSSION

It is possible to group all active hand/arm actions directed towards objects under 1 heading . This has been done in column 1 of Table 1. In addition, each behaviour has been ordered chronologically with regard to the remaining object-directed movements. The weeks given are the times of first appearance of the behaviour in question.

With regard to the actions of column 1, the infant's progress towards visually-directed grasping can be regarded as the parallel development of two skills - a/ the progressive control of the early, wild Φ actions, and b/ the expansion of temporally shorter and more direct methods of contacting the object.

a/ Φ movements on the air were present from the beginning of observation, i.e. from the seventh week. These, plus the reflex grasp when an ob touched the palm (see column 2) needed only the correct juxtaposition of Φ action, and striking the object with the palm of the hand, for grasping to be inevitable. This is not the case with the human infant. Twitchell (1970) found that at 3 months of age the human infant's hand was still fisted in reaching, a condition which persists until around the fifth month. Grasping in the Orang-utan however occured during the eighth week, when the $\emptyset_v$ action of the seventh week resulted, probably fortuitously in a "hand over top cot wall" and grasping. Grasping the ipsilateral cot wall appeared in the ninth week, with the infant seeming to expand the $\emptyset_v$ action from a median to a lateral position. Visual monitoring of wall grasping and hand movement along the cot wall was recorded in the tenth week (see pg 133). Of great importance to subsequent grasping development is the infant's initiation of arm movements (vaguely directed) on visual presentation of an object (ninth week). Such behaviour produces increased hand-object contact, as "peaking" of hand actions occurs whenever an interesting object is visible.

This same week, the first overt sign of attempt at hand control is seen, with brief regard of the stationary hand, and with slow $\emptyset$ actions, the hand being looked at at the termination of the movement. This behaviour does not seem to be present in the human infant (White et al.,1964). The assumption of a supine posture (tenth week), and with it the awareness of the hanging toys greatly aided the infant's control of his $\emptyset$ actions , with striking and (fortuitous) grasping of these objects. The supine posture is thought to have aided control by virtue of the lesser degree of muscular coordination required,

Table 1

WEEK	Active Object & Self-Directed Arm Actions	Passive Object Directed Movements (object in hand)	Hand to Mouth	Vision	Audition
7	$\emptyset_v$) $\emptyset_h$) on air	Reflex grasp	Hand to Mouth along substrate	Saccadic following Head turning and fixation of object outside line of vision	Startles to noise
8	$\emptyset_v$ over top of cot and grasp	Decreased activity with object in hands ie., infant attends to object	Anticipatory mouth opening.	Decreased activity, intent regard of novel objects Looking at more distant objects. Focussing in one plane of vision. Saccadic following	Startles to noise or decreases activity
9	$\emptyset_v$ over side of cot and grasp. Slow $\emptyset$ holding hand still to look at it. Increased arm movements on visual presentation.	Grasp, partially release and regrasp. Grasped object to mouth	Hand to mouth in prone.	Horizontal and vertical following saccadic.	Non-directional 'looking'
10	$\emptyset_v$) $\emptyset_h$) and strike object and occasionally strike object. Touching Plucking A behaviour pattern	Increased arm activity after producing an interesting spectacle. Object in mouth - hand to mouth on only 1 occasion. Hand sucked	Hand to mouth in air.	Delay sucking to look at grasped object. Visual interest in face and smiling. in looking at hand/object interactions Vertical visual following smooth Horizontal vision following saccadic (head turning distant)	Looks in the appropriate direction of a sound

continued....

Table 1 (continued)

WEEK	Active Object & Self-Directed Arm Actions	Passive Object Directed Movements (object in hand)	Hand to Mouth	Vision	Audition
11	Groping use of cot to bring hand close to object. Arrested $\emptyset$ to object Hand brought close to object in vision field and then grasped Hand clasping 2-handed grasping	Looks to a grasped object			
12	Arrested $\emptyset_h$ to object, hand in line with object and eye. Hand held beside object looking between them Touch then grasp Slow $\emptyset_v$ Slow $\emptyset_h$ and grasp Overshoot in grasping and give up.	No looking to trapped hand		Changing perspectives of an object grasped Changing what is seen by body movements	
13	1 hand grasp object other hand grasps	Object in mouth, no hand to mouth.			
14	Unable to grasp if hand completely out of sight Not grasping object on floor Grasping on sight	Object in hand, no hand to mouth			

in that the musculature moving the shoulder joint is not required at such a high level of coordination in this position, being partially supported by the floor of the cot, in addition, the supine posture not only allowed and made easier a greater degree of intercourse with the hanging toys, but also allowed a heightened awareness both of the hanging toys as objects of interest and novelty and of the "benefit" to be gained by a greater degree of control by the infant over his hands. This in turn allowes an increased skill in hand-object interplay, producing additional interesting results further feeding the desire of the infant to control his hands.

Attempts at greater hand control with respect to an interesting object continue during the eleventh week with the infant, in prone, attempting to halt his Φ_v movement at a point closest to the object (i.e. an arrested Φ_v action). Similar Φh movements are seen later, early in week 12. Also seen during the eleventh week, and attesting once again to attempts at hand-eye coordination, are the long slow Φ movements across the infant's line of vision with visual monitoring of the hand.

The slow Φ movement across the field of view is combined in the twelfth week with the infant's grasping ability. Thus, slow Φ actions directed at an object, with attempts (sometimes successful) at grasping when contact is made are seen. The first combination of Φ and more direct object orientated actions, in the form of touching followed by a Φ action is occasionally seen this week. Following such attempts, Φ movements fade out gradually in favour of more direct methods of approaching the object. Also of interest is the infant's "ruse" of utilising the Φv action and grasping the cot wall to bring hand and object close together in the visual field before attempting contact. Such behaviour gives further evidence of the infant's limitations in hand-eye coordination.

b/ Direct Approach to the Object.

More direct actions towards objects are not seen until the tenth week and the assumption of the supine posture. The most probable explanation for this behaviour is that referred to above the greater ease with which fine movements can be achieved in supine, as opposed to prone or sitting, the latter positions requiring simultaneous coordination of a higher number of joints and muscles to attain the same overt action. Direct approaches begin with touching, where the hand is raised from its position almost directly below the object, makes brief contact, (usually with the finger tips) and then returns to its original or to some similar position. Plucking (grasping, pulling down and releasing) is a somewhat anomalous behaviour, being seen only with the rattle string. This object, being extensive and strung across the cot in a relatively immobile position, may be considered as allowing easier manual interplay when compared to the hanging toys.

11th week: In the eleventh week the touching behaviour pattern seems to be expanded into attempts not simply of making contact with the object, but of seizing it. The hand is now brought to the object and attempts at hand closure around the object seen. Groping may also be regarded as an expanded ϕ movement, (probably derived from an arrested ϕ action with the addition of finger closure) as this behaviour was observed to follow both ϕ and direct approaches to the object. Two handed grasping, almost certainly derived from hand clasping, was also noted in the eleventh week, although its incidence was not high. This finding is quite different from that for the human subject. Both groping and two-handed grasping occur later in thehuman infant, after holding thehand close to the object (White et al., 1964). This latter behaviour , however, follows groping and two-handed grasping in this Orang-utan subject. The

The twelfth week shows evidence of the infant attempting a more efficient organisation of the spatial relationships of hand, eye and object. Raising the hand so that it lies on the eye-object line speaks for such an endeavour, as does the raising of the hand to a position close by the object, and then looking between object and hand. This behaviour seems identical to that seen in the human infant at 10 - 12 weeks (White et al., 1964) though, as mentioned above, the sequence of occurrence is different. A further stage in the Orang-utan's grasping development appears later in week 12, with the infant "ranging up" on an object before grasping, by first touching the object, retracting the hand, then attempting to seize the object by a direct, or a ϕ movement. Also of note is the infant's seeming inability to readjust his hand and arm once a grasping attempt has been made. In the twelfth week the grasping action is carried through to a high degree of completion, and, if unsuccessful, is repeated a second time.

This latter limitation is overcome during the thirteenth week, when the infant is able, after misjudging the relative positions of the hand and the object during a grasping attempt, and over- or under-shooting, to readjust his hand almost immediately and so make a successful seizure of the object. However, mistakes as to the relative position of hand and object are still common.

The fourteenth week shows full competency in grasping with the exception of the hanging toys. As explained previously, being highly mobile objects, the hanging toys pose the greatest test of grasping for the infant. Observation of Cody's grasping of hanging toys was not made to 100% competency, although the infant's grasping became increasingly precise over the next few months. In this, Cody mirrors the behaviour of human infants (McDonnel, 1975) although his development is in advance of the human subject (White et al (1964) found that the human infant did not achieve a level of grasping equivalent to Cody's competency of week fourteen until between the twentieth and twenty-second weeks.

Passive Object-directed Movements refers to the behaviour of the infant when an object was placed by the experimenter either in the hand or the mouth. As has been stated previously, reflex grasping of an object in the hand was evident from at least the seventh week. "Attending" to a grasped object, as evidenced a decrease or a cessation of movement does not occur until the eighth week. However, at this time neither movement of the hand and grasped object to the mouth, nor looking at the object in the hand was observed, the infant being seemingly incapable of coordinating tactile space with buccal or visual sensations. The first limitation is overcome in the ninth week when a grasped object is for the first time carried to the mouth. The reciprocal behaviour (an object in the mouth causing raising of the hand to the object and grasping) is said by Piaget to occur invariably once a grasped object is conveyed to the mouth. Throughout testing, the most common reaction to an object placed in the mouth was to suck the object, without a hand to mouth movement, until it was lost from the mouth. Onlyon very few occasions was a hand to mouth seen (first noted during the tenth week) and in most cases the hand was placed in the mouth and object and hand sucked separately. This condition (grasped object taken to mouth, no grasping of object placed in mouth) persisted until termination of this particular segment of the work (the end of the fourteenth week). Thus it appears that, in this Orang-utan subject, reciprocity of the two behaviours detailed above does not pertain during the early weeks of development. Further, Piagetian theory states that grasping on oral contact precedes grasping on sight (Woodward, 1971, p.55). As grasping on sight is accomplished in the Orang-utan in the fourteenth week and grasping on oral contact is not, it appears that this sequence of events is not, in this species, a rigid prerequisite for grasping.

Also seen for the first time during the ninth week is grasping of an object, partial release and regrasping. Such behaviour was also reported by Piaget for the human infant (Piaget, 1953 , Obsn.52.) and may form a necessary link in the ability of the infant to grasp at an object his hand has fortuitously touched (Woodward, 1971.).

The tenth week sees the infant increasing arm activity following an arm movement which produced an apparently interesting result, (a

Piagetian secondary circular reaction). Hand to mouth when an object was placed in the mouth was also seen, with the qualifications mentioned in the preceding paragraphs.

Coordination of tactile and visual spaces occurs in the eleventh week, with the infant "starting" at the sight of an object in his hand (pg.146). This reaction would seem to attest to the novelty of this situation for the infant, and the observations chart his rather swift adaptation to this innovation by the thirteenth week. Thus the coordination of visual, tactile and buccal sensations seem to have been attained in this Orang-utan subject by the thirteenth week, sucking and looking at a grasped object having been achieved.

However, a further limitation is still in operation at this time and also during the twelfth week. This is the infant's failure to look towards his trapped hand which does not become part of the infant's behavioural repertoire until the seventeenth week. Such a failure to visually seek his trapped hand would seem to speak for the infant's having a not complete mastery over his hand; it appears that, up until the seventeenth week, the infant is aware that his hand is trapped but does not know where to look for it. Such a failure implies an incomplete control over hand and arm.

<u>Hand to Mouth</u>

Hand to mouth behaviour is thought to be important in the development of grasping and sucking. If the infant cannot bring his hand to his face and mouth then it is not possible (except by chance) for him to bring a grasped object to the eyes or mouth for visual or tactile inspection. Comparison of columns 2 and 3 of Table 4.1 confirms this to some degree; the infant achieves the hand to mouth movement in advance of the action of taking a grasped object to the mouth. The development of the hand to mouth ability once again demonstrates the gradual accretion of ever more complex behaviour to previous behaviour.

The infant possessed one type of hand to mouth skill from at least the beginning of observation (seventh week)). This consisted of bringing the hand to the mouth along some substrate, be it floor or experimenter's coverall, the hand maintaining contact with the substrate throughout the manoeuvre. Anticipatory mouth opening to receive the hand was seen the following week, and, during the ninth week, the infant demonstrated an increased competence in hand to mouth ability, performing the action when in an "up-on-elbows" position, while in the prone posture. Here, the lower arm (forearm and hand) left the substrate and consistently reached the mouth area for the first time. One week later, hand to mouth without substrate support and in all postures was observed. Thus, the evidence from this Orang-utan is in agreement with that of Piaget (1953) and with Woodward's analysis of the action (Woodward,1971.). In addition, it has been shown that an up-on-elbows prone posture allowed hand to mouth success at an earlier date than, e.g. sitting with no substrate support. This finding may be explained in the same way as the direct actions seen only when the supine position was attained (page 172), viz: that different postures require differing numbers of intercoordinating muscle groups to attain the same overt ends. Thus, we find hand to mouth in a position where the whole limb is supported, next where it is supported only up to the elbow, and finally where there is no support whatsoever. This finding appears logical, as it is very likely that it is easier to coordinate the free movement of forearm and arm in space (i.e. in the prone, up on elbows posture) than to coordinate upper arm, forearm and hand (e.g. in sitting unsupported hand to mouth movements.). Thus it is seen that less complex actions appear in advance of more complex behaviours.

Vision

The data presented allow fairly detailed analysis of two aspects of looking, the development of scanning the environment, and visual following.

Scanning: Head turning and fixation of an object outside the infant's direct line of vision was seen, infrequently, from the beginning of the study, although fixation at six weeks was very much a hit-and-miss affair. More definite evidence of the infant's visual awareness of objects is found in the eighth week, with a decrease in activity and relatively intent regard of novel objects (of object in hand data, 8th week, column 2). Of interest also is the infant's apparent ability to focus in one plane of vision only, and to seemingly screen out other visual input. This was seen in both the seventh and eighth weeks (see e.g. page 125) and was responsible for the non-elicitation of the blink reflex and visual following on several occasions.

The infant's burgeoning awareness of objects outside the closetted environment of his cot is attested to by the increased looking round him at walls, ceilings, doors, etc. in the eighth week. From this time on, events outside the cot, but inside the room, became increasingly subject to visual scrutiny. Looking to objects outside his room appeared during week 8 also.

A further aspect of visual awareness was seen during the tenth week, with Cody showing a quite marked interest in the face of the experimenter. Smiling also first occurred at this age. This finding is of interest in view of Ambrose's findings with human infants (Ambrose, 1961). Cody's response falls within the range given for the onset of smiling in home-raised human infants (6 - 10 weeks) or at the beginning of the institutionalised human infants (9 - 14 weeks). Whether the infant Orang-utan's smile serves the same purpose with regard to infant mother attachment as this response is said to serve in man could not be determined from the data collected here. Observations on smiling and its response in Orang-raised Orang-utan infants may help to cast some light on this question.

The tenth week shows an upsurge in looking at objects and hand/object interactions, with the infant watching his hand striking, touching and plucking at diverse objects. It is considered that the assumption of a supine posture, with its accompanying facility for object/arm interplay was a major factor in the initiation of such an advance. It is very probable that a reciprocal visual-motor stimulation occurred during this time, with the acts of object-striking, etc., providing novel and interesting visual aliments (thus stimulating looking) and the act of watching increasing the amount of hand play seen. Also seen for the first time during this week was delay of sucking a grasped object so as to scrutinise it. This behaviour is important in the coordination of visual/buccal input and serves also to demonstrate the increasing importance of vision. Whereas, previously, the grasped object was given over immediately to sucking, it is now, on occasions and with increasing frequency from the tenth week, visually monitored before oral contact is made.

Visual Following

Horizontal following with the eyes was inconsistent during the seventh week (probably due to focussing in one plane of vision as described, or to an inability to accommodate the eye to the object). When evinced following was saccadic. Saccadic following continued in the eighth and ninth week, with the additional finding that vertical following was also saccadic. The next week saw horizontal following remain saccadic at short distances, whereas vertical following was seen to be relatively smooth. As far as is known, this aspect of following has not previously been reported, and if it is duplicated in other studies (on human as well as Orang-utan subjects) then the question of why vertical following precedes horizontal following in the assumption of smooth eye movements must then be asked. As a tentative explanation, it is suggested here that such asynchrony in directional following may be related to the incidence of vertical and horizontal experience. Thus it may be postulated that the infant has had greater opportunity to follow objects in a vertical direction and has therefore gained competence in this direction in advance of other, less-used movements. Evidence for this is not readily available, although it is true that Φ_v actions were more common than Φ_h movements at this time, and that the infant was continually raising and lowering his head during the course of attempts at bodily movement, although it could also be charged that (horizontal) head turning to right or left was by no means uncommon. Indeed, as has been mentioned previously, it is not known whether such vertical-before-smooth following is common-place, and further work is obviously required. However, the finding does seem to demand an increased effort in this direction.

Another finding of the tenth week once again emphasises the complexity of an apparently simple behaviour pattern, with visual following being given yet another facet. It appears that, from the (admittedly limited) data, this Orang-utan infant adopts varying strategies during the tenth week, depending on the distance of the object from himself. At far distances (at least 8 feet) head turning is the primary strategy adopted, whilst at shorter distances (approximately 2 feet) eye movements take over. If this finding is confirmed, it may then be possible to determine at what distance change over from one strategy to another occurs, if the change-over distance varies with age, and if there is a critical distance (at any one age) when the two strategies compete. The observation on page 142 seems to suggest that the distance of conflict in head and eye turning is, at the tenth week, with an object approximately four feet from the infant.

Visual following in the first part of week eleven is of great interest. The eye movements described on page 148 would seem to indicate that the infant has all but dispensed with saccadic eye following, and is attempting to follow the object by maintaining it at all times on the fovea centralis (and not awaiting the input from peripheral receptors in the retina to initiate eye movement and re-location of the object on the fovea, as in saccadic eye following). However, the over and under-shooting described would seem to indicate a lack of precision in his attempts. The behaviour is seemingly analogous to the behaviour of an adult human when asked to track a moving spot (Gregory, 1967). Such inexpertise is, however, short-lived, (which in itself may explain the fact that it has not previously been mentioned in other work) and the infant was found to follow smoothly one day later. This latter finding points to the advantages of detailed, almost round-the-clock observation of a single animal or child. The transition from one behaviour to another, which may be of considerable importance, may be so short as to be missed by all but the most detailed study. Thus, ten children examined for one hour each, once a week, may very well miss behaviours with such a short life-span as that described above. This is not to say that the contribution such studies make is not vital; it is past question that normative data from such a work would be as valuable as that achieved by directing one's efforts to a single subject. Research method should be tailored to suit the questions asked, and it is merely being suggested here, as has been pointed out several times before in the course of this work, that one should not be tied to a criterion of "high subject-number equals more reliable data" when this position so patently omits important aspects of what we term reality.

Audition

The main aspect of audition that can be analysed from the data presented concerns directional looking to the source of a sound. This ability was not present during the first week of observation, the infant giving notice of his auditory capacity simply by "starting" to various (not necessarily unusual) sound. Wertheimer (1961) claimed directional looking in 10 minute human neonates, but this finding has since been questioned (Turkawitz et al, 1966; McGurk et al, 1977). During the 8th.week decreased activity with any not-too-loud sound indicates that the infant "attended" to the sound (cp.Vision and Passive Object-Directed columns). Directional looking was absent during weeks

8 and 9. During this latter week, an important addition to the behavioural repertoire seems to have arisen, a non-directional looking in response to a sound. It is as if the infant is aware that a noise may mean an interesting spectacle somewhere in his environment which may be amenable to visual scanning. Hence the raised head and looking about at the commencement of an unusual sound, (see pg 131). This behaviour may be of great importance in the ontogenesis of directed looking . All that now seems to be required is the infant's "realisation" that the ear upon which the sound waves first impinge is the direction in which the head must be turned in order to locate the interesting spectacle (ie., the source of the sound) more efficiently. This additional ability (ie., true directional looking) is first seen in the following (10th) week, and continues throughout the developmental span until termination of the experiment.

One of the most important conclusions to be gleaned from the foregoing results is the great complexity of behavioural development when viewed in a naturalistic way. It is one thing to place 50 infants in a standardised position in a standard environment and to present them with a standard stimulus for one session each fortnight, it is quite another to attempt to unravel how behavioural development actually proceeds in the infant's "native habitat". The former procedure yields firm, clear results which serve splendidly in constructing a simplified conceptual framework of the behaviour investigated, but they are marrowless bones of reality when compared to the wealth of complex confusing behaviours seen when utilising the naturalistic approach. With this latter form of analysis, even the smallest skill is seen to develop by small definite accretions. And yet, such accretions occur in a seemingly logical fashion, each advance being just slightly more complex than the behaviour which proceeded it. It is possible to argue that vision, hand movements, etc., are all interrelated and that any may be held back by another, e.g. until the hand hits the object, the open and closing movement mentioned (see page 118) cannot be utilised in grasping. Conversely, if the hand is not open when striking (as is the case for human infants (White et al,1964; Twitchell 1970) then grasping is again precluded. The present work serves to give an insight into how some of these accretions and inter-coordinations come about in the infant Orang-utan subject, when raised in the conditions described. The logicality of progress is compelling, and it is thought that similar work on human infants (and other anthropoids) would show similar progressive results.

This is not to say that identical behaviours will be seen, only that advance will be by small additions of skill. Some behaviours might be species-specific (e.g. the infant Orang seems to be "wired in" for an open hand outsard swing where the fingers clasp on the inward movement, whereas the infant human is not). Other actions may be chance-made, with conservation of the "useful" movements. There may also be a limit on the number of actions that an infant can possess with respect to any particular behaviour type. The behaviour in question may be satisfied by any one of several actions and which-ever is fortuitously discovered first may then be utilised to the exclusion of other, equally suitable, actions which would lead to the acquisition of the same behaviour. The sort of environment in which the child develops will also certainly affect the acquisition of types of behaviour. Examples of retardation and acceleration of hand coordination in the normal human infant have been shown by B.L.White (1969) whilst Umansky (1973) has shown how coverage of one hand can produce restrictions in its use. In the subject here, "plucking" seems to have been dependent on the presence of the rattle string. It is likely that, had this object not been part of the infant's environment, plucking would not have been seen. Thus, if infants are followed in great detail, it is to be expected that no rigidly standard and identical corpus of behaviour will be seen.

Piaget. The slowly increasing complexity of behaviour seen in grasping, vision and audition corresponds in general to the developmental scenario given by Piaget (1953 , 1955). Piaget's observation on his children, and the work of other researchers was summarised in fig.4.1. of the introduction. When this chart is duplicated (fig.4.16)together with the dates of the corresponding Orang-utan behaviours a very close similarity is seen in comparable behaviours, the infant following an essentially identical temporal sequence in his progress towards grasping. The behaviours included in each level are found, in the

Fig.4.16

Behaviour	First Seen (week)
LEVEL 1: REFLEX RESPONSE	
Visual fixation	7 - 8
Palm contact → decrease activity (ie. infant "attends" to object)	8
Open and close hand (increases with manual contact of object)	?
Increased hand movement with manual contact of object	?
Scratching, then grasping	not seen
Grasping, releasing, regrasping	9
Mutual hand clasp	11*
Tactile exploration of face	8
LEVEL 2: GRASP WHEN OBJECT TOUCHED AGAINST FINGER TIPS (hand to mouth and suck at approximately the same time)	10
Grasp object on oral contact	not seen consistently
Object grasped is taken to mouth	10
Keeps moving hand in view	11
Alternate sucking/looking at object held at mouth	10
Visual contact → increased hand/arm activity	9*
LEVEL 3: GRASP WHEN OBJECT AND HAND VERY CLOSE IN SAME VISUAL FIELD	11
Bring hand close to object, and alternate looking between hand and object	12
Bring hand from far, to close by object, then grasp	11
LEVEL 4: GRASP WHEN OBJECT AND HAND DISTANT IN SAME VISUAL FIELD	?
Visual contact with object (hand outside visual field) → great increase in arm activity. When hand and object in same visual field, grasping and sucking	14
No looking in direction of captive hand	Yes - see below
LEVEL 5: GRASP WHEN HAND OUTSIDE VISUAL FIELD	15
Extensive looking at object	
Looking in direction of captive hand	17

TYPES OF GRASPING

Orang-utan, to occur at the same time. At level 1, the behaviour occurs during weeks 8 and 9, in advance of the definitive behaviour for level 2 (hand to mouth and suck in air), this latter being seen in the tenth week. All behaviours of level 2 are seen during week 10, i.e. prior to level 3 (11th week, grasp object and hand very close in visual field). Level 3 actions are found in weeks 11 and 12 before the behaviours of level 4. Level 4 behaviours precede level 5.

Mismatches of the Piagetian pattern are few, but do nevertheless occur. Mutual hand clasping, said by Piaget to occur at a time corresponding to level 1 behaviour, was not seen in Cody until week 11. White et al (1964) also place this action later in grasping development although his work does have hand clasping at level 3.

Increased hand and arm activity on visual contact with an object occurs earlier in this Orang-utan than in Piaget's human subjects, being seen before, rather than during level 2. Such a finding does not seem to be at variance with other data collected in this regard (see table 4.1) as Cody, during the ninth week, was capable of slow ϕ movements, holding the hand still to look at it, and, in the previous week had shown himself to be capable of attending to an object upon visual presentation. Thus, all components for an increase in manual activity upon visual presentation were present at the time that this behaviour occurred. It may either be that the infant Orang was in advance of his human contempories because of innate, genetic patterns, or that further study on human infants will show that a rise in hand actions when an object is presented is not necessarily possible only after the ability to grasp an object when it is touched against his finger-tips (cf. Flavell, 1969).

Although not anomalous as far as time-sequencing is concerned two further behaviours are worthy of note.

Scratching, then grasping was put forward by Piaget as one of the initial behaviors in the emancipation of grasping from a purely reflex action. Although Cody was in an environment which was extremely favourable for the initiation of such a scratch-grasp-scratch cycle (lying on a blanket which he reflexly grasped) this behaviour was in fact never seen. Nevertheless, the liberation of finger actions from the reflex grasp did occur, indicating that, between species at least, the attainment of an identical behaviour does not always presuppose an identical developmental path to that behaviour.

A similar comment can be made for the action "grasping an object on oral contact". Piaget claims such behaviour occurs on a reciprocal basis with "object grasped taken to mouth". This is not the case with the Orang-utan subject described here. The latter behaviour did occur, and at the level in which Piagetian theory predicts that it should come about; however, the former behaviour was almost completely absent in the infant. This finding was again indicative that behaviours seen in man do not necessarily follow in the development of an identical behaviour (in this case grasping on sight) in other species. Considering the small number of human infants investigated, its ubiquity in human infants is not thought to be beyond question.

CHAPTER FIVE

TRAINED VOCALISATIONS AND LANGUAGE POTENTIAL OF AN INFANT ORANG-UTAN

VOCAL LANGUAGE CAPACITY

Animal Communication

Within the Animal Kingdom there are a vast number of specialised systems and structures which subserve communication, from fragile hormonal balances to intricate behavioural repertoires, (e.g. von Frisch, 1954; Wheeler, 1923; Basset and Wilson, 1963; Thorpe, 1961; Darling, 1937). Many of the most complex are to be found within the primate order, and all serve to maintain an easily understood flow of information from the initiator to the recipient without hazarding unselective risks of predation.

In primates, signals are the sine qua non of group and pair interaction. Even in so solitary a species as the Orang-utan, there must be the capability to identify conspecifics, the appropriate sex and its mating condition, and of broadcasting and responding to signals during the sometimes intricate choreography of mating. No matter what species, or aspect is studied, all work in this field serves to underline the vital part that communication plays in the maintenance of primate social relationships.

Communicative Exchange in Primates

The dominant communicative mode differs with different primates, but it is with audition that this section is most concerned. As several studies have shown, the breaking of branches and other unvoiced sounds can function in communication. Thus, Gorillas make use of hand-chest slapping (Schaller, 1963; Fossey, 1970), chimpanzees drum on wood trunks (Goodall, 1968; Reynolds & Reynolds, 1965) and the Orang-utan (together with many species of monkeys) possesses a leaf-shaking display (Harrison, 1961; MacKinnon, 1974). Such behaviour is taken to an extreme position by the Japanese Macacque (Hill, 1972). Marler (1965) has also commented that the cessation of noise is also an effective signal, indicating, perhaps, the close proximity of a predator.

With voiced signals, it is in general found that a facilitation in vocalisation is seen as we move through the Lemuroidea (Jolly, 1972), to the Ceboidea, the Cercopithecoidea, and the Anthropoidea. Characteristically, within any taxonomic grouping, the more social the species the greater the repertoire of vocalisation.

According to Andrews (1963), primate calls are said to have originated from a "startling reflex". Under this reflex Andrews includes several 'protective responses', namely, lips retracted and mouth corners drawn back, head shaken from side to side, eyes closed, eyebrows lowered and glottis lips closed. It is from this latter movement, plus the violent expiration which usually follows it, that vocalisations are said to have their genesis.

Few primates are capable of producing pure tones (Marler, 1965). Most species produce coarse sounds which may be developed into a complicated sound continuum (e.g. Rowell, 1962). Infra human primates are said to possess only as many communicative responses as other infra human vertebrates. Marler states that a repertoire of approximately 10 - 15 basic signals occur within the former, much the same as other vertebrate groups, e.g. the prairie dog has 10 sounds, the chaffinch 12.

Although carrying a considerable amount of information the content of non-human primates' communication is almost always emotional, and very rarely environmental. Primate "speech" is much more about self and conspecifics than about the external referents (Jolley, 1972; Marler, 1965, 1969; Ploog, 1968, 1971; Young, 1970), however, see Struhsaker (1967) for a primate species whose alarm calls specify a particular predator.

Human Vocalisations

Man responds to two different types of vocalisation from his fellows: (i) non-linguistic, and (ii) linguistic sounds.

(i) Non-linguistic. These sounds correspond to the calls of non-human primates, and are neither more nor less complex than other calls of members of the Order (Bastian, 1965). Indeed, they seem to have much the same signal function. Such calls have probably been "wired in" during the course of evolution; no one teaches an infant to cry, and, though not all respond appropriately, its message is clear to all <u>Homo sapiens</u>. Andrews (1963) found a high degree of comparability between the calls of his human subject (the infant J) and those of the chimpanzee, suggesting to Andrews "a not too remote common ancestor". *

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* It is interesting to note that baby chimpanzee are also said to babble during the first few months of life (Kortlandt, 1965).

(ii) Linguistic Sounds. Human language (sounds produced by rapid synergiistic variations of different regions of the vocal tract and subject to the rules of grammar) differs in many ways from the vocal communication of the remaining species of the Order primates. Hockett (1963) cited 16 Design Features (DFs) which are shared by all human languages. For example DF 10 is displacement, or the ability to talk about things remote in space and time, and DF 14 Prevarication (Lying).

In the absence of any of these design features, the communicative system under investigation is held not to be a "language". Thus the honey bee's dance (von Frisch, 1954) which allows transfer of information between the forager bee and those remaining in the hive does possess displacement, but not (as far as we know) prevarication, and cannot therefore be considered homologous with human language. However, not all workers are prepared to accept each of the design features as being necessary for "language" as they understand the term (e.g. Premack (1971); Gardner and Gardner (1971)). Lieberman (1974) does not believe it advantageous to define language in terms of Design Features as there is, as yet, no complete knowledge of the properties which characterise human language. Moreover, linguists are not a little anthropocentric in the definition of language as human language; "A language is a communication system that is capable of transmitting new information." (Lieberman, 1974). This definition seems to be a useful way of viewing the information-transfer systems of early hominids which presumably paved the way for human vocal language.

Chomsky (1968) and others (e.g. McNeill, 1970) believe that human vocal language is species specific to <u>Homo sapiens</u>. Language is said to be innate, and they cite the fact that the language of any country or tribe is very easily learned by its children. Chomsky concludes that there appear to be certain basic ground rules upon which all natural languages are based, and that these rules are in some fashion "pre-wired" into our brains. The basis of these rules are said to lie within the neural matrix of the brain.

The Neurobasis for Language and Vocalisation.

Localisation of specific motor functions has only partially been achieved, both in man and these infra-human primates, but enough is known to allow some generalisations to be made on this subject.

Evidence from brain lesions (eg.Wernicke,1874; Geschwind,1971) and from electrical stimulation (Robinson, 1967; Brickner, 1940; Jurgens, 1969; Jurgens, Maurusm, Ploog and Winter, 1967) all point to much the same conclusion: that in all Primates the loci for non-linguistic vocalisation are to be found in the limbic system of the C.N.S., the same area wherein are found the loci for emotional states. Such a system speaks for the mediation of the diverse types of vocalisation with the various emotional states of the animal. There is no evidence that neocortical areas participate in the production or origin of such sounds.

By contrast, the neocortex appears to be in almost sole charge (except for emotional ejaculations which originate, as with other primates, in the limbic system) of linguistic vocalisation in man. Here the evolutionarily more recent assocation areas have separated the five earlier so-called primordial areas (Flachsig, 1901, 1927). Each primordial area has an association area closely related to it. Man has thus a greater area of cortex than any animal, and this advantage is accompanied by an absolute increase in the number of cortical cells (approximately twice as many as in the Great Apes). Increased dendrogenesis may also have occurred. The highest increase in both area and neurone counts in the neocortex of man are in the frontal, and temporal lobes, and in the inferior parietal regions; these latter two are known to be implicated in language production (Quarton, quoted in Ploog and Melnuchek, 1969).

Man's brain also shows unique asymmetry among the Mammalia (however, see Nottebohm (1970) for Aves). This asymmetry is both functional (language and handedness being the usual province of the dominant left side) and anatomical (Geschwind 1970, and Wada and Rasmussen, 1960, have shown that the area behind the primary auditory cortex in the upper surface of the temporal lobe is approximately one-third larger on the left than right side. The same is apparently true for neonates (Wada, 1960)).

Geschwind (1970) has put forward evidence which to some degree correlates language function with neural topography in Wernicke's and Broca's areas. The same author has argued that language is based on the angular gyrus of the brain. More pertinent to this discussion, a forerunner of this region is said to exist in the brain of the macacque.

Anatomical Correlates of Vocalisation

Although all the Hominoidea show gross morphological similarities in the anatomy of the vocal tract, there are several respects in which each species differs from other species of this superfamily.

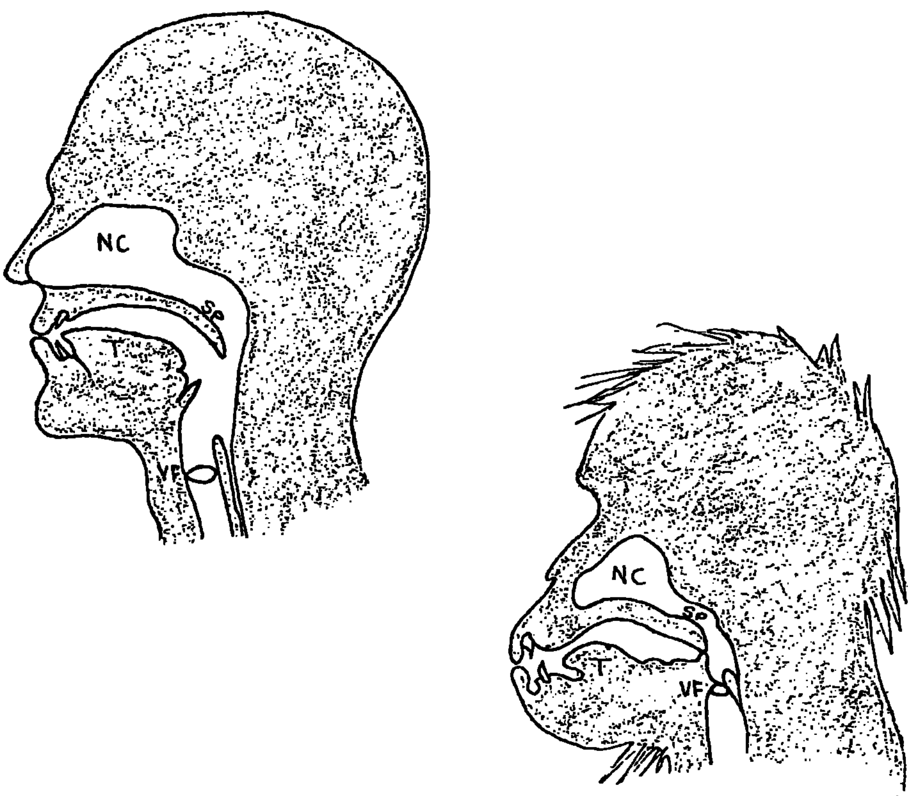
Considering first the language source of sound production, the larynx.. The gibbon is said to contrast most markedly from the basic Hominoid plan, possessing a well-differentiated functional double vocal cord system, which is homologous with the true and false chords of man, but which, unlike man, are both utilised in phonation. The vocal folds of the larynx are histologically distinct from all other Hominoidea, although, as in man, the aretynoid cartilages suggest a capacity for control of vocal chord tension (Nemai & Keleman, 1933).

Laryngeal morphology in the Orang-utan is marked by quite heavy calcification of the cartilaginous structures (Nemai and Keleman, 1929) more so than is found in either <u>Pan</u> or <u>Homo</u>. The aretynoid cartilages are relatively small. Laryngeal musculature was found to be comparatively weak and undeveloped, and the vocal folds, while lined with muscle fibres, showed a dissimilar orientation when compared to Man. Nemai and Keleman opine that, because of such calcification and undeveloped musculature, the Orang-utan's larynx would be incapable of producing delicately modulated or controlled sounds. Similarly, Keleman (1948, 1961) has demonstrated that the chimpanzee larynx is not identical to the human larynx. However, Lieberman has shown that such laryngeal discrepancies in no way preclude the chimpanzee from producing a potential chimpanzee language (Lieberman, 1974). A chimpanzee "voice" would simply be "breathier" and perhaps not as pleasing as a human voice, but it would, presumably, not be directed at humans, but at other chimpanzees. However, it appears that, while the chimpanzee's larynx in no way bars it from a human-type language, other features of its anatomy do.

A preoccupation with laryngeal morphology in comparative studies has led to neglect of a more important feature of human language. Lieberman (1974) has shown that the supralaryngeal vocal tract (SVT) may legitimately be regarded as of far more importance in human language. In Man, this structure (which includes the whole of the Pharyngeal, Oral and Nasal cavities) acts as an acoustic filter.

Acoustic energy (generated by the larynx) is expelled at a certain fundamental frequency, and its higher harmonics, (depending on the tension of the vocal cords and/or the pulmonary air pressure). The length, and cross-sectional area of man's SVT can be varied to a great extent. The length and shape of the SVT determine the frequencies (formant frequencies) at which maximum energy will be transferred from the larynx to the lips. These changes in formant frequency are very important in human language (e.g. the vowels (a) and (i) are determined solely by changes in SVT shape and length. Such rapid articulatory manoeuvres are vital to human language in that they allow speech encoding and decoding to occur. In all other primates, SVT anatomy is different. In the Orang-utan (fig.5.1), as in all other Pongids, there are four main points of difference with Man.

fig. 5.1



(i) The tongue is completely at rest in the oral cavity whereas in Man it forms the anterior wall of the supropharyngeal cavity.

(ii) Epiglottis and soft palate can be approximated in the Orang-utan, closing off the oral cavity. This is not possible in Man.

(iii) The larynx opens out into the topmost portion of the pharynx in the Orang-utan, whereas in Man the larynx has descended down the pharynx (Du Brul, 1958; Lieberman, 1974), allowing its full resonating potential to be utilised. The level of the vocal cords is also higher in the Orang-utan than in Man.

(iv) The SVT of the Orang-utan approximates a single tube. This is not the case in Man, where the supralaryngeal pharynx is set at right angles to the oral cavity.

This latter discrepancy is perhaps the most important. Without it, it does not appear to be possible to produce the acoustically stable vowels, (a), (i) and (u). These sounds are crucial to human vocal language as they are used by a listener to calibrate the size of a speaker's vocal tract (Lieberman, 1974). The process of speech decoding requires that such information be available, or mistakes in sound classification may arise. The first formant frequency and the resultant resonant frequencies of a sound will vary throughout a range from adult men to young children depending on the size of the speaker's SVT (Peterson and Barney, 1952). For example, the resonant pattern of (ɔ) for an adult may overlap with that of (d) for a child. The listener must therefore be able to calculate the size of the SVT of any given speaker before he can give an acoustic signal the correct classification. Computer modelling of the SVT of a chimpanzee has apparently shown that these acoustically stable vowels ((a), (i) and (u)) and thus the ability to calibrate and decode, are not possible in this species.

The buccal cavity and lips of both apes and man also differ. The dental arcade is parabolic in man, whereas it forms a ∩-shape structure in the Pongidae. Lenneberg (1967) claims that this structure is essential for the spirant sounds such as f, v, s, sh and th.

The facial muscles are more distinct among the Hominoidea than among any of the monkeys, with the greatest degree of differentiation being seen in Man. The area showing the highest degree of differentiation is in the corner of the mouth (the modiolus). Lightholler (1929) has stated that the musculature of man most strongly resembles the chimp and gorilla, although both Huber (1931) and Duckworth (1910) have indicated areas where man's facial musculature is either more differentiated or more prominent.

Clearly, above all other primates, man seems uniquely possessed of the anatomical endowments for the production of the complex range of articulatory manoeuvres seen in speech. All the evidence points to the inability of any species (other than Man) to produce by vocalisation the rapid exchange of information we term language. Whether Man's perfect adaptation or the apes' non-competence automatically precludes the latter from the learning of simpler "working-languages" remains, in most cases, to be heuristically tested. If we hold to Lieberman's operation and definition of language (page 190) then vocal communication systems less complex than language, yet more sophisticated than "natural" primate communication may yet be possible. Such systems might tell us much about such communication in early hominids. Considering the absence of early hominids (each of which presumably possessed a varying degree of linguistic competence below that of Homo sapiens) a knowledge of the vocal competence of non-human primates may throw some light on language origins.

Pongid Vocal Competence Reassessed

In one respect, the assumption of vocal language non-competence in the Pongidae has greatly aided research on the language capacity of these creatures in the form of investigations into a variety of symbolic communicatory modes (see overpage). However, such neglect of vocal language potential may be a not unimportant oversight. Two bodies of fact counsel caution on the topic of ape vocal language.

Pongid Language Capacity

Table 5.1 outlines the published accounts of individuals home-raising (in the loosest sense of the term) one species of ape. Sub-table (i) (no language tuition attempts) is of lesser importance to this discussion. The main point to be extracted from these studies is that in no case did the ape-subject attempt to imitate spoken words, nor did they devise sounds (other than species-specific calls) for specific objects or referents. Whether they produced a gestural sign-system (Lock, 1977) has yet to be investigated. Physical imitation was however ubiquitous in these subjects.

TABLE 5.1

Infant Anthropoid Rearing

	Researcher	Name of Subject	Species	Sex	Age during xpt.
(i)	Kearton (1925)	Toto	Pan	?	2
	Jacobsen, Jacobsen & Yoshicka (1932)	Alpha	Pan	Female	1 week to 1 year
	Raven (1932) (1933)	?	Pan	?	?
	Kellogg & Kellogg (1932)	Gua	Pan	Female	7½ - 16½ months
	Ladygina - Kohts (1935)	Joni	Pan	Male	1½ - 4½ years
	Lintz (1942)				
	Finch (1942)	Fin	Pan	Male	3 days to 3 years
(ii)	Gardner & Gardner (1968, 1969, 1971a & 1971b)	Washoe	Pan	Female	8-14 months - 6 yrs.
	Premack & Schwarz (1966)	Sarah	Pan	Female	2½ - 4 years
	Premack (1976, 1970b, 1971)	Sarah	Pan	Female	5 - ?
(iii)	Garner (1896)	?	Pan	Male	1 year - 15 months
	Furness (1916)	?	Pongo	Male & Female	1 - 5½ years (language training 11 months)
	Hayes & Hayes (1950)	Viki	Pan	Female	3 days - 6½ years

Sub-table (ii) is concerned with completed studies carried out on the chimpanzee's ability to communicate using modes other than vocal language. Premack (1970a, 1970b, 1971a, 1971b) has side-stepped the problem of rapid fading of spoken (and signed) language by using magnetic word-symbols which are "written", Chinese-fashion on a metal board. Using a one-to-one substitution method, the ape is reported as successfully mastering common and proper nouns, adjectives, verbs, prepositions, particles and conjunctions (Ploog and Melnechuk, 1971). Sarah is also said to answer questions, obey commands, and has shown competence in the conditional if/then formulation of sentences.

Teaching a chimpanzee a deaf sign language has been attempted by R.A. and B.T.Gardner (Gardner and Gardner, 1969, 1971, 1975). The sign system (ASL) has been claimed to be a natural language on the basis of the work of Stokoe (1965). The Gardner's first subject, Washoe, learned 21 signs during the first 4 months. Further, upon mastering 8 signs, Washoe began putting them together in 2-sign combinations, e.g. "gimme-eat". An interesting parallel with human infant 2-word combinations arose, in that the sign combinations were very similar to the "Pivot" and "Open" classes of Brown's subjects (Brown, 1970). Three sign combinations followed, and 4-, and 5-sign combinations have been reported (Gardner and Gardner, 1971). The signs do seem to be used as symbols, they are generalised readily, and indeed, Washoe has devised her own signs for various objects, the first (a square shape made on the upper chest with both hands) being a sign for "napkin" (Gardner and Gardner, 1969). The Gardners have also shown that Washoe can provide the sentence constituents specified by different <u>Wh</u> questions with a competency superior to the replies given by human children of Brown's Stage III, (Gardner and Gardner, 1975; Brown, 1973).

Rumbaugh and his co-workers have built a computer-controlled language training situation to study the language capabilities of a young chimpanzee, Lana (Rumbaugh, von Glaserfeld, Warner, Pisani, Gill, Brown and Bell, 1973). Lana lives in a large plastic chamber from which she controls the events of her day by typing out a message in "Yerkish", a language whose rules are defined by a modified version of English correlational grammar (von Glaserfeld and Pisani, 1970). Each lexigram is projected above the chimp as she writes - all sentences must begin "please", conform to the rules of Yerkish, and end by the pressing of a "period" key. Lana learned 46 lexigrams within the first 6 months of the project, and continues to add to her vocabulary. She has been shown to read her own typing, complete unfinished sentences correctly (Rumbaugh, Gill and von Glaserfeld, 1973), and to understand the general concept that objects can have names, (Rumbaugh _et al_., 1975).

Of the three workers detailed in sub-table (iii), two are concerned with _Pan_'s vocal abilities, one with _Pongo_'s. R.L.Garner's haphazard work is of the least importance (Garner, 1896). The words chosen for tuition were a polyglot assemblage (the English "mamma", the French "feu", the German "wie" and a native word "nkgive"). Training lasted only three months, after which the ape died. It may be that the strain of attempting to be the world's first quadrilingual chimpanzee was the cause of the unfortunate ape's untimely demise. The subject apparently tried to imitate the sounds modelled, although to what extent he was successful remains speculative.

The Hayes' experiment with their chimpanzee "Viki" (Hayes and Hayes, 1950; Hayes, 1952, 1970) was marked by a far more scientific approach. A female, Viki was adopted three days after birth and spent over six years in speech training. This began at 5 months with a simple reward schedule. Each meal, food was witheld and only given when a vocalisation occurred. It was a further 5 months before Viki achieved the production of a harsh staccatto grunt each time food was offered. A so-called "shaping method" followed; Viki's mouth was manipulated during vocalisation, and only successively closer approximations to the model rewarded. From this came the word "mamma". At 3 years of age, (30 months after beginning speech training) Viki also possessed "papa" and "cup". She subsequently learned "up" and, at 6 years of age, possessed these three sounds, plus a clicking of the mouth and "tsk" sound. The sounds, to judge from cine recordings, were not well formed, and in at least two of them, Viki had to occlude her nose manually to prevent escape of air, indicating an inability to close off the nasal chamber by raising the velum.

Furness' attempts to teach non-emotional, voluntary sounds to an Orang-utan are briefly reported in one paper (1916). This worthy apparently achieved as many trained sounds in eleven months as was achieved by Viki during six years of experimentation. By dint of long, daily periods in the animal's company, modelling of the required word, lip and lingual manipulation, blockage of the nose, and social approval/patting as reward, Furness (after six months) taught his female subject to voice the word "papa". A "kah" sound was elicited by blockage of the nose and pushing a bone spatula against the tongue. Later, this subject learned to use her own finger for nasal occlusion. "Kah" was then prefixed to "pa" and the resulting word "kap" used as a synonym for "cup".

The subject mastered a "thuh" sound also, again after considerable mouth manipulation. Unfortunately, shortly after, the animal died of unspecified causes, 4 - 5 months after achieving its first sound. It is interesting to note that a second Orang-utan, and a chimpanzee (both subjected to a similar training schedule as the first Orang) were as lacking in language at the end of tuition (5 years for the chimpanzee) as when they began it.

Considering vocal language acquisition in the two species studied so far, of two attempts with Pan troglodytes, the work of the Hayes partnership is, as yet, the most successful. The single Orang-oriented study (Furness, 1916) resulted in three sounds in eleven months, equalling the chimp's performance in 1/6 of the time. While comparisons based on an "n" of one are very suspect, it was thought possible that the Orang-utan might prove at least as good a subject for language tuition as the chimpanzee. Equally, positive or negative results on language competence can generate little confidence for or against pongid language capacity. The personality, intelligence and morphology of the Great Apes are notoriously variable, and great gentleness/skill/size in one individual is no guarantee of similar attributes in the species as a whole. Further studies in this field are clearly necessary to give some idea of the range of linguistic and other abilities in the Great Apes. However, giving each ape maximum stimulation and tuition necessarily restricts the number of subjects, usually to a one-to-one system, and it may be some time before one can say with any degree of certainty just what the limits of any given species of ape might be. Nevertheless, the more studies that are performed, the nearer we will come to that position. With vocal language and ability, not only have too few subjects been studied, the most modern tuition techniques have also not been applied.

Language Tuition

The training procedures used by both Furness and Hayes and Hayes are by no means the apex of language tuition techniques. Recent advances have demonstrated a much greater degree of success in teaching a wide range of severely disturbed children, from schizophrenic (Isaacs and Goldiamond, 1960; Sherman, 1965) to autistic children (e.g. Hewett,1965).

The new methods remain firmly rooted in classical operant conditioning theory using prompting, fading, rewards, etc., to gain the desired modification.

With language training in human subjects, it has been found that imitation is probably the easiest means of achieving language-type responses, and coordinating these with the total behaviour of the child. One very efficacious method is to train the child to imitate complex motor movements first, then to imitate sounds, mouth positions, words, phrases and sentences, in that order (Risley, 1966; Bricker and Bricker, 1966; Larsen and Bricker, 1968 ; Baer, Peterson and Sherman, 1967; Guess, Sailor, Rutherford and Baer, 1968).

Several researchers have utilised these findings in comprehensive attempts at building language production capacity in disturbed children (see Sloane, Johnson and Harris, 1968; Hewett, 1965; Risley, 1966; Risley and Wolf, 1967). Of these, the work of Hewett (1965) was chosen as most applicable to the task of producing appropriate vocal responses in the Orang-utan. The research was well-planned, successful, and, more important, it was performed with an autistic child in a setting which would allow replication with materials and resources within the compass of the present study. It was the impression of the author that, superficially at least, the infant Orang-utan of the study resembled an autistic child, primarily in its self-, rather than other-directed actions. Experts at Newcastle speech therapy clinic endorsed this general assessment (Edwards, M. pers. comm.). Most interestingly, work cited at these meetings showed that a shaping method (similar to the Hayes' regimen with Viki) produced in human subjects "only a very restricted vocabulary" (Lovaas, 1966) whereas the new methods were far more successful.

Hewett, (1965) taught his subject, Peter, in a 2-sectioned talking booth, the two individuals communicating through a cavity, closed by a shutter. Peter was rewarded through the shutter (with food, drink, music, etc.) during the course of training, and punishment administered by removal of light and personal contact, the shutter being closed for this purpose.

Training was divided into four sections: (i) Introduction; (ii) Social Imitation (of various body movements); (iii) Speech Training (verbal imitation using the successive approximations technique (Isaacs, Thomas and Goldiamond, 1960)); and (iv) Transfer (of the word to the external environment). In all four sections reward was contingent upon an appropriate response from the subject. Hewett reports that 150 words were learnt during the 14-month period of intensive training, after which Peter showed "an insatiable desire to learn new words and phrases" (Hewett, 1965).

LANGUAGE TUITION WITH AN INFANT ORANG-UTAN

RATIONALE

From the outset it was decided that a functional approach to vocal communication would result in the most efficient use of time and energy. Thus :

(a) The articulation of English words was not sought; the subject was required to produce only a distinct, well-formed and reproducible sound. It seemed redundant (during the early stages) to teach, e.g. "fuh" and "duh" sounds, and then to combine them to give an approximation of "food" when "fuh", in the relatively uncomplicated umwelt of an infant, would serve equally well as an unambiguous designator of the object-class food.

(b) The sounds taught were arbitrary and based on ease of articulation and tuition. This produced a bias towards unvoiced sounds.

(c) The sound produced was to designate a specific referent or class of referents.

(d) Sound object matching was arbitrary, but wherever possible attempted to follow the first phoneme of its English equivalent.

Autistic children are apt to vocalise spontaneously (Hewett, 1965; Lovaas, 1966) unlike the infant Orang-utan who is almost totally silent. Untrained vocalisations heard during the experiment can be divided into three types: (a) a peeping sound given when mildly disturbed, (b) a high-pitched scream of considerable volume, emitted when highly disturbed and (c) a grating inhalation which sometimes appeared immediately following a b-type scream. It will be noted that all such vocalisations were given when the infant was in some way emotionally upset. It was thought useful, therefore, to establish unformed, voluntary vocalisations in the infant prior to the physical imitation procedures. At very least, it was planned to teach breathing through the buccal (as opposed to nasal) orifice, so as to aid production of unvoiced sounds.

Training can be divided into seven stages (Table 5.2 overpage) beginning with the abortive Stage 1 in the 5th month. Prior to this the infant's comparative lack of psychological awareness would have made tuition extremely unproductive. Indeed,

TABLE 5.2

List of Stages and Phases

Stages and Phases	Age at Completion of Final Phase	Dates
STAGE 1: Shaping Method		3 Jan - 7 April
STAGE 2: Buccal Breathing (FoN)		18 Jan - 10 June
Phase (i) Intro & Experimentation		18 Jan - 9 Feb
(ii) FoN (aided)		14 Feb - 26 Feb
(iii) Transition (fading)		22 Feb - 27 Feb
(iv) FoN (unaided)		27 Feb - 9 Mar
(v) FoN plus "kuh"	7m.1w.6d.	9 Mar - 10 June
STAGE 3: Physical Imitation Training (h on H)		28 Mar - 17 June
Phase (i) Introduction		28 Mar - 15 Apr
(ii) h on H (aided)		15 Apr - 29 May
(iii) Transition		30 May - 7 June
(iv) h on H (unaided)	10m.1w.4d.	7 June - 17 June
STAGE 4: Physical Imitation plus Vocalisation		5 June - 7 July
Phase (i) his F on N (aided) plus "kuh"		5 June - 21 June
(ii) Transition (fading of physical prompt) plus "kuh"		21 June - 25 June
(iii) his F on N (unaided) plus "kuh"		25 June - 27 June
(iv) Fading of Visual Prompt during FoN, plus "kuh"		achieved concurrently between
(v) Fading of infant's FoN		
(vi) Transfer of Sound	10m.3w.5d.	26 June - 7 July
STAGE 5: Puh Vocalisation		7 July - 30 July
Phase (i) Pout added		7 July - 11 July
(ii) Transition A		11 July.
(iii) Pout (unaided)		11 July.
(iv) Pout and "puh"		12th July.
(v) FoN plus pout plus "puh" (unaided)		12 July - 18 July
(vi) Transition		18 July - 21 July
(vii) "Puh" (unaided)		21 July - 24 July
(viii) Retraining		24 July - 27 July
(ix) Fading		27 July - 29 July
(x) Unaided "puh"	12m.0w.2d.	30 July - Termn.
STAGE 6: Fuh Vocalisation		13 Aug - 21 Aug
Phase (i) Mouth Manipulation of lip to teeth		13 Aug - 14 Aug
(ii) Fading of mouth manipulation		15 Aug - 17 Aug
(iii) Lip to teeth (unaided)		18 Aug.
(iv) Lip to teeth (unaided) FoN & "fuh"		17 Aug - 21 Aug
(v) Fading of FoN		21 Aug.
(vi) "Fuh" (unaided)	12m.3w.4d.	21 Aug.
STAGE 7: Thuh Vocalisation		30 Sep - 2 Oct
Phase (i) Mouth manipulation of tongue to teeth		30 Sep - 1 Oct
(ii) Fading of mouth manipulation		1 Oct.
(iii) Unaided "thuh"	13m.0w.2d.	2 Oct.

according to Object Concept data (Chapter 3) the infant, at onset of training, was at substage III, and probably unable to cope with the symbolic representation required for imitation Piaget's theory holds that this is impossible before substages V and VI). With regard to the natural vocalisations of the wild Orang (kiss squeaks, grumphs, gorkums, lorks, raspberry, ahoor, barks, chomps, play grunts and various screams - MacKinnon, 1974), only the raspberry noise approximated any of the sounds eventually taught the infant, the "raspberry" being very close to the "Puh" sound.

CHRONOLOGICAL DESCRIPTION OF TRAINING

The training is considered chronologically with regard to the first trial of any one stage. When two stages run concurrently, training and results of the earlier stage are discussed first. Duration and overlap of the various stages and phases are condensed in Table 5.3; it is suggested that this summary be referred to often when following the sometimes complex procedures.

STAGE 1. UNFORMED VOCALISATIONS (3.1. - 7.4.74)

Training was essentially similar to that of Hayes (1951), the infant being seated on the teacher's knee during training. Food was offered the infant, then abruptly withdrawn, the teacher simultaneously voicing the request "Speak". Frustrated, the infant usually gave vent to a loud cry, at which point the food was quickly administered, together with the phrase "That's it!" By such means it was hoped Cody would come to associate vocalisation with the primary reinforcer Food, and the secondary reinforcers of social approval and contact comfort.

Training was given during feeding periods (approximately 8.30 a.m., 1.00 p.m., 5.00 p.m.). Standardisation was attempted wherever possible, the same objects being utilised each time at their usual locations in the room. The teacher and infant sat as in fig.5.2 so that the minimum of external stimulation impinged upon the infant's senses. Occasionally, because of illness, it was necessary to curtail or omit certain tuition sessions. A delicate balance had to be maintained with regard to feeding procedure as the

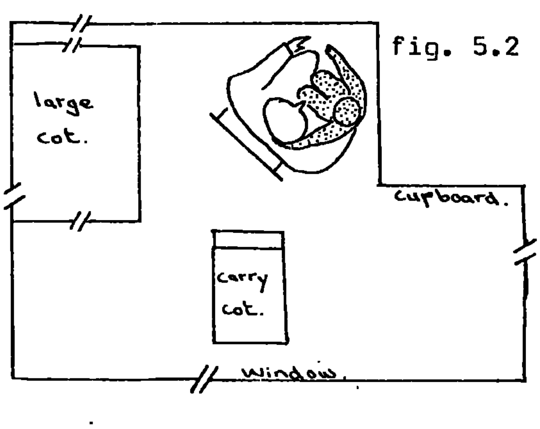


fig. 5.2

infant was still very susceptible to a variety of potentially fatal ailments. Further, the infant's weight often decreased appreciably during the teacher's periods of absence. These two considerations obviated a complete denial of food if no vocalisations were forthcoming.

Training proper began on January 3rd, 1974 (infant's age: 22 weeks 6 days) and was, as far as possible, continuous until April 7th. Breaks occurred during my absence from the experiment (on average 2 days/ 2 weeks) resulting in tuition on 80 of the 95 days that Stage 1 tuition was attempted (i.e. 84% of the time): Throughout this period, with one exception, there was no sign that the subject was capable of producing voluntary vocalisations.

The exception referred to above occurred during the 12th week of Stage 1 tuition. On one trial, instead of his usual screaming call, the infant uttered a quiet noise rather like a soft "uhh". He was strongly rewarded for this sound, but except for a single repetition the following day, the sound was never again voiced.

Severe illness (gastroenteritis) during the 14th week of Stage 1 caused cessation of tuition. As the response to Stage 1 training had been nil as far as overt responses were concerned, and as such heartening results were being obtained from the concurrent "finger on nose" experiment (Stage 2), Stage 1 was terminated, allowing more time to be given to subsequent training procedures.

STAGE 2. BUCCAL BREATHING (FINGER on NOSE - FoN) (18.1. - 10.6.74)

As buccal breathing had been of aid to Furness (1916) it was reasoned that such a voluntary capacity would be of great help in teaching this subject to produce sounds. Unlike Furness, what was looked for in the present subject was buccal breathing <u>without</u> external nasal occlusion. This required the subject to raise his velum and drive air out through the lips.

Tuition for Furness-type buccal breathing (fingers on nose) was divided into 4 phases: (i) Introduction and experimentation;

(ii) FoN (aided); (iii) Transition (fading); (iv) FoN (unaided); a fifth phase "FoN plus kuh" was added on 18th February, when vocalisation during phase (ii) training occurred spontaneously.

Coincident with the beginning of FoN training, a teaching booth was constructed. As a device similar to that of Hewes' was both of excessive cost and (because of the violent prolonged screaming that attended any enforced contact breaking) impractical for the Orang-utan subject, a booth of rather more modest design was constructed (fig. 5.3).

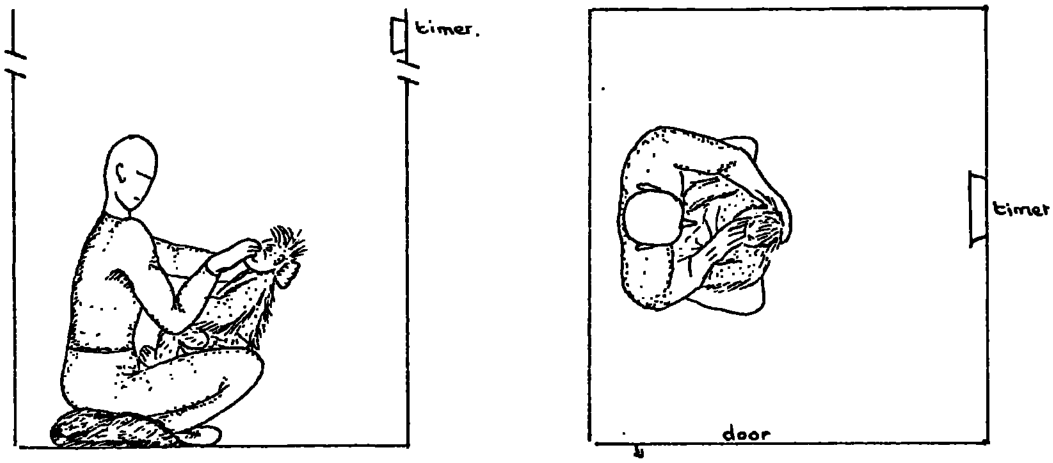


fig. 5.3

The apparatus was essentially a large box (6' x 5' x 5'), constructed of natural wood. As shown in fig. 5.3, the teacher, seated cross-legged, instructed the subject, who sat facing him, on his lap. This method proved very satisfactory for a variety of reasons (centring interest on the teacher; allowing ease of manipulation and control of unwanted movements; increasing the efficiency of "timeout" procedures; and allowing easy alteration of the booth for teaching further sounds.)

Phase 2(i) Introduction and Experimentation (18.1.74 - 9.2.74)

In the absence of any previously devised methods for initiating buccal breathing, all such attempts were introduced slowly and gently, so as to decrease the chances of the attachment of negative reinforcing properties to the procedure and to obviate negativism. These two were constant problems throughout all stages of tuition.

The phase began with experimentation to determine the best method of producing buccal breathing. The most obvious method, blocking the nose and therefore forcing mouth breathing or

asphyxiation failed when first tried, (18.1.74). From his violent reaction (wild head shakings, jaws clamped tightly together and gross bodily movements, hereafter referred to as "fighting") it was clear that, for Cody, the obvious human response of opening the mouth was lacking. This difficulty was overcome by initiating nose-blockage as shown in fig. 5.4 with the index and second fingers placed over the nose, and the third finger in the mouth.
This method allowed complete freedom of one hand for manipulations and administration of rewards, while the finger-in-mouth prevented closure of the oral cavity. It also appeared more acceptable to the infant himself.

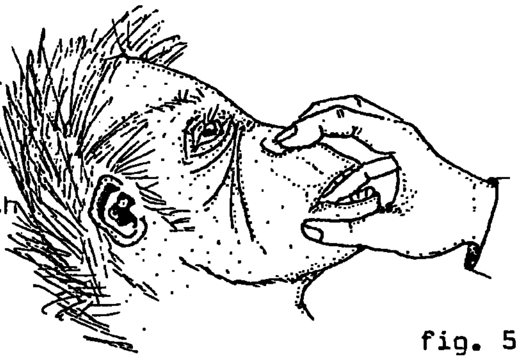


fig. 5.4

Following the discovery of what seemed the most efficacious technique for further teaching, a four-day rest period was given, and phase 2 (ii) begun.

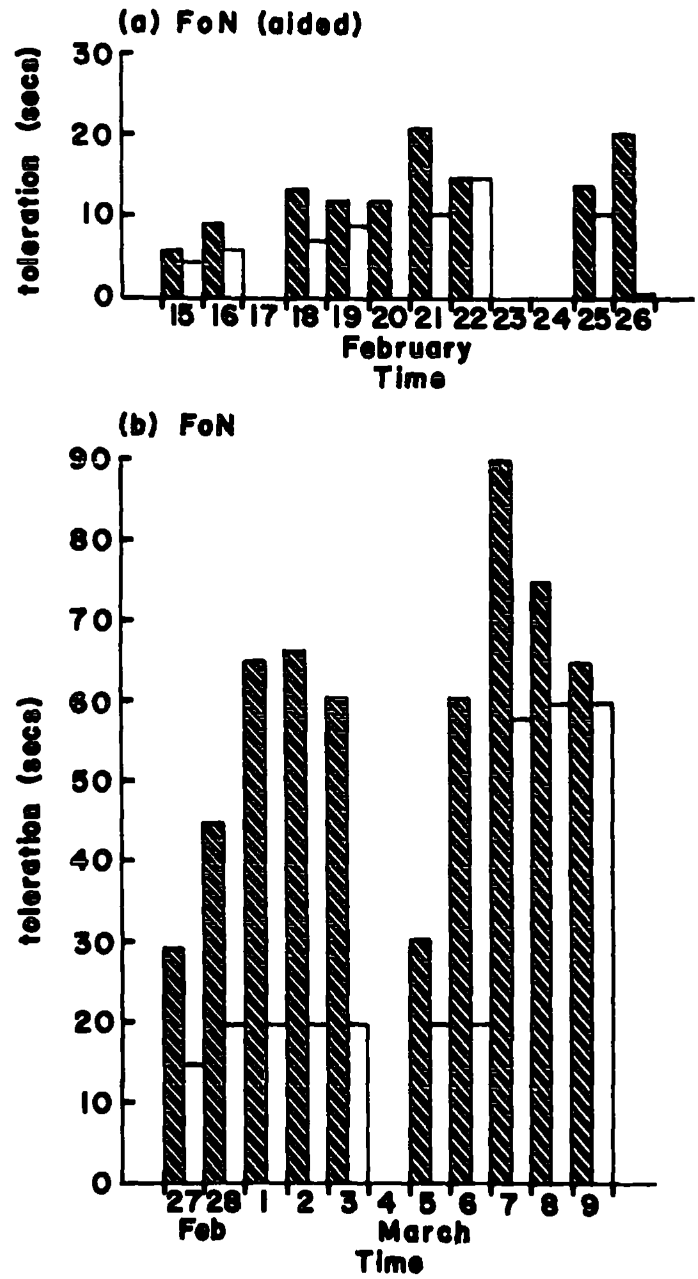
<u>Phase 2(ii). FoN (aided)</u> 14.2.74 - 26.2.74

This phase consisted of applying the previous phase's methodology and attempting to increase buccal breathing time with the ultimate target of extended toleration. The target for phase 2(ii) was arbitrarily set at 15 seconds mouth breathing, after which "fading" would be implemented.

Over the 12 days of this phase Cody's maximum toleration increased from 6 to 21 seconds. The increase was relatively steady despite one 2- and two 1-day breaks (maximum and minimum times shown in fig.5.5(a)). During training the infant did not respond consistently, however, being as likely to "fight" as to undergo such treatment with composure.

A second event of subsequent importance occurred during phase 2(ii). On both the third and tenth days spontaneous vocalisations were produced unlike any so far encountered, and resembling a guttural human "gruh" or "kuh". During the tenth day it was decided to reward this behaviour. This was done by slipping a small piece of chocolate into the infant's mouth.

FIG. 5.5
INCREASE IN MAXIMUM & MINIMUM TOLERATION TIMES AS A FUNCTION OF TIME.



Nasal occlusion was, however, maintained during administration of this "secondary" reward, and the primary reward given upon termination of occlusion.

Phase 2(iii) Transition (22.2. - 27.2.74)

This is of necessity a less well defined phase, requiring periods where no fading (i.e. slow removal of finger in mouth) was deemed useful. Fading was attempted twice on February 22nd after four FoN (aided) trials. Each time buccal breathing continued for a further three respiratory cycles. The infant then closed his mouth and began to alternately breathe and asphyxiate. Cody regressed on later days to simple mouth closure with no mouth opening, even though his face became suffused with blood. On these occasions nasal occlusion was terminated after 25 seconds. Five days after beginning phase 2(iii), sink-or-swim tactics were experimented with; mouth closure for a maximum of 40, as opposed to the previous 25 seconds without breathing, being allowed. On implementation, the infant "fought" madly, and only as the time approached 40 seconds did mouth breathing begin. Even then, only a single breath was taken and the closed-mouth cycle repeated. This procedure was repeated a total of four times, after which Cody breathed with relative ease through his mouth on five subsequent trials, and from this time on unaided mouth breathing was very much easier to train.

Phase 2(iv) FoN (27.2. - 9.3.74)

The advance required of this phase was an increase in toleration time of buccal breathing with voluntary mouth opening. The toleration target was of much longer duration than phase 2(ii) being set at 1 minute. The increase was necessary because, it was reasoned, the diverse lip and tongue manipulations envisaged for production of the various sounds would be extremely difficult to enforce within a time-scale of 15 seconds. One minute seemed a more reasonable duration.

Toleration times increased markedly during phase 2 (iv), (fig.5.5(b). The table is, however, a little misleading in that the maximum toleration time on the first four days were exceptional (achieved only once during 10 - 12 trials). The remaining trials were of 20 - 40 seconds each time, increasing as session number mounted. At the same time, the infant became increasingly blasé about phase 2(iv) training demands. Fighting was, nevertheless, still in evidence.

The infant achieved a 100% 1-minute toleration level on March 8th. March 9th showed a similar level of competency and phase 2 (v) was initiated.

Phase 2(v) FoN plus "kuh" (9.3. - 10.6.74)

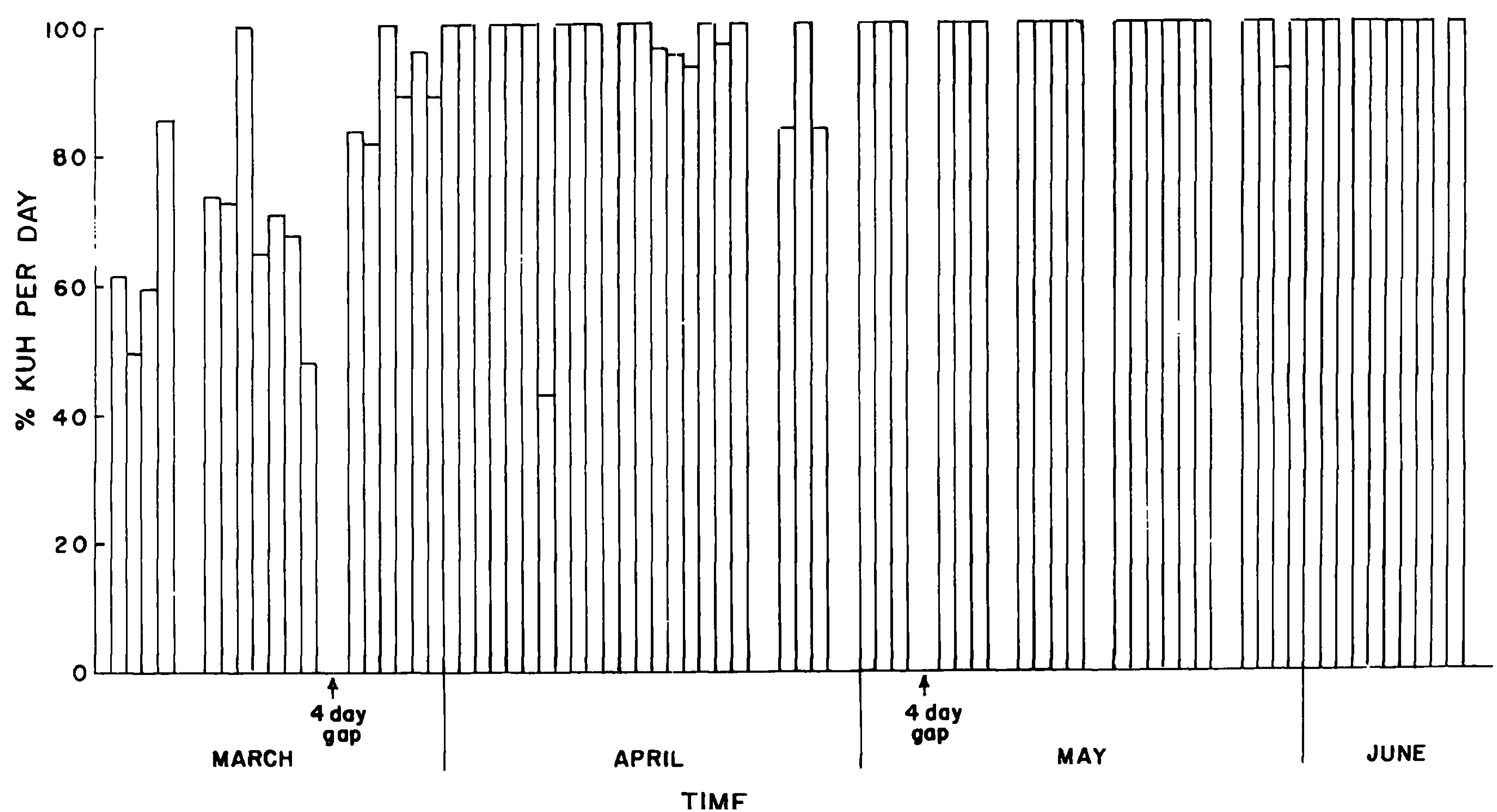
Although not mandatory, Cody continued to vocalise with a spontaneous "gruh/kuh" sound during phases 2 (iii) and 2 (iv). Secondary reward was probably responsible for the increased rate of vocalisation as, by March 6th, such utterances were far more common than at the beginning of phase 2 (iv).

During phase 2(v) a vocalisation of the "gruh/kuh" type was required during buccal breathing. The nose was closed either until the sound was produced or for a maximum of 1-minute 30 seconds. Upon either event, a food reward, verbal praise and petting were administered. During each trial the teacher modelled a "kuh" sound at 5 - 10 second intervals. The phrase "That's it!" was used consistently by the teacher following a correct response. Although not as averse as in previous phases, nasal occlusion and denial of ventral-ventral contact were both definitely disliked by the infant. As all restrictions were lifted when a vocalisation was produced it was hoped that Cody would, in time, come to associate early vocalisation with early release.

It is apparent from fig.5.6 that the infant very soon understood what was required of him, the % "kuh"/no "kuh" trials attaining 100% within ten days of phase 2 (v) commencement. After March 22nd, the level remained at 80% or above until May 1st, falling below this level on only one occasion (April 7th). This latter immediately preceded an attack of gastro-enteritis, almost certainly the reason for the infant's poor showing. From May 10th until termination, figures below 100% were seen but once (May 30th - 93%).

No less progress was made in other aspects of his vocalisations.

FIG. 5.6
% KUH PER DAY DURING PHASE 2(v).



The time taken for sound production to occur from the initiation of each trial decreased steadily over the weeks of training from a usual figure of 40 - 60 seconds until by March 16th, the majority of "kuh"-sounds were produced in less than 5 seconds (15 trials/session). Fighting also progressively decreased to negligible levels. This latter response is probably directly related to the former - less discomfort with increasing faster "kuh"-sounds reducing the need to fight to reduce the discomfort. It was still necessary to immobilise the infant's hands, however, the more so as Cody began attempts at wresting the nose-blocking hand from his face. To decrease these destructive outbursts to a manageable level, a "timeout from positive reinforcement" procedure was employed.

Rewarding appropriate responses, and placing inappropriate responses on extinction does usually result in extinction of the latter, but the process can be a long one. Baer (1962), Wolf, Risley and Mees (1964) have shown that removing the subject from the situation where he may have the opportunity to receive positive reinforcement decelerates incompatible behaviour.

From April 23rd, the infant was simply ignored, being set on the ground and denied eye and ventral-ventral contact. This position was maintained, in the first instance, for 15 seconds, then 30 seconds, etc., i.e. "timeout" duration was cumulative. Termination was contingent upon passage of time, and not, as in some studies (e.g. McReynolds, 1969) upon appropriate vocalisation emission. This procedure did not serve to greatly decrease undesirable behaviour, as Cody simply began playing by himself when ignored (McKinnon, 1974 , also mentions the great amount of time spent in auto-play in this species.). A new and much harsher "timeout" regime was introduced May 10th, with "timeout" functioning as a negative reinforcer. Here, Cody was held prone on the floor, his limbs pinioned by the teacher's hands. "Timeout" was again cumulative (15, 30, 45 seconds), termination being contingent upon passage of time. This procedure was far more effective, and in practice it was found that one "timeout" period (never more than two) was sufficient to restore attentive behaviour.

Lesser aids in training included the realisation that food plus ventral-ventral contact was a more efficient reward than food alone. Indeed, at certain times, Cody would by-pass proffered chocolate to achieve contact comfort. Placing the food reward in view while training was in progress also acted to increase motivation, though this technique was effective only after Object Concept Sub-Stage IV was attained (see Chapter 3 , page 34). Prior to this it seemed that "out of sight" was apparently also "out of mind".

The quality of "kuh"-sound production also improved during phase 2(v); gargling "grushs" and "klaahs" being gradually replaced by "kuh" or "keh" sounds. As confidence grew, Cody could (from April 10th) be "held" for a second, better "kuh", during a single trial. These holding trials (a form of successive approximation technique,(Wing, 1966) undoubtedly aided better pronunciation.

Fading of FoN (on seven separate occasions) produced ambiguous results. On April 12th and 13th, with nares 1/3 - 2/3 uncovered, Cody produced a soft and a loud "kuh" respectively. One day later, identical procedure resulted in failure, although on April 18th a good sound was recorded. During the next two fading sessions only a single nostril was closed. Cody produced 3 soft "kuhs", one failure and 4 normal "kuh"-sounds on these eight trials. That the infant could not yet produce sounds without aided nose closure was evident on April 10th, though from the way in which the mouth was opened and air expired in a sharp burst, it did seem that a "kuh"-attempt was being made. It is considered that, with appropriate training, unaided "kuhs" could very probably have been elicited by careful FoN fading. However, during phase 2(v), Stage 3 training (Physical Imitation) had been initiated. These later also promised to fulfil the target of unaided sounds, (and to do it by smaller, though longer, yet ultimately safer training increments). Phase 2(v) was therefore dispensed with.

STAGE 3. PHYSICAL IMITATION TRAINING (28.3. - 17.6.74)

Stage 3 training was designed to teach the infant to mimic certain physical movements. Hand on head (hoH) was chosen as the first model as it allowed the teaching of imitation movements per se, and was also quite similar to a nose-blocking movement which, it was hoped, would allow unaided "kuh"-sound production.

Training was divided into 4 phases: 3(i) Introduction; 3(ii) hoH (aided); 3(iii) Transition (fading); 3(iv) hoH (unaided). Session number (and trials/session) were gradually increased from 1 session/3 days to 4 sessions/day at termination. The training situation was as in Stage 2. During Stage 3 the teacher grasped the infant's left hand, and held out his own left hand until the infant was seen to fixate it. Then, with the request "Do this", the teacher's hand was moved through the required movement. Almost simultaneously, the infant's left hand was taken through a similar movement. The subject was thus prompted in three separate sensory modes: visual (teacher's modelling movement); auditory ("Do this"); physically (tactile/kinaesthetic impressions). If the infant broke visual or physical contact during this procedure, that trial was ignored and a further trial initiated. If such behaviour continued, a "timeout" period ensured. On completion of the required movement, the teacher cried "That's it!", simultaneously rewarding the subject with food, hugging and praise. During Stage 3, a short play period was also given between trials.

Phase 3(i) Introduction (28.3. - 15.4.74)

This was much less rigorous than any of the following phases. Four movements, (hand to nose, ear, head (vertex) and chin) were modelled and "imitated". The purpose was not to teach the infant any particular movement, merely to accustom him to the new experimental situation. Six sessions (46 trials) were given during the 17 days of phase 3(i). Cody, for the most part, accepted these trials passively. It was, however, evident that non-attention to the modelling movements would pose the greatest problem. The teacher, to catch the subject's attention had, on many occasions, to resort to striking the wall or his head with his modelling hand, or snapping his fingers.

Phase 3(ii) hoH (aided) (15.4. - 29.5.74)

For the first eight days these sessions were restricted to 5 trials/session, given between FoN trials. As predicted, inattention was a problem, and in addition, resistance to the guided movements seemed to increase during this period, being prevalent up to April 24th. Immediately after this, due to the teacher's ill-health, six days of tuition were lost. Work no sooner began again (May 1st - 3rd) than another four day break occurred for the same reason. Training resumed May 8th with no overt sign that the infant had understood what was required of him. Indeed, it was not until May 14th (infant's age: 41w 4d) that, on the last of twelve trials, Cody seemed to voluntarily take his arm through the last few cms. of the movement. The following two days confirmed that very slight aiding was occurring, In addition, whereas previously his fisted hand had been placed upon his head (obliging the teacher to open the hand forcibly) Cody now began to perform such a movement voluntarily.

Progress was extremely gradual, with the infant helping on more and more of the total movement. March 29th (14 days from initiation of 3(ii)) saw Cody performing the complete hand to head action although still held by the teacher's hand. Fading of the prompt was attempted from this date.

Phase 3(iii) Transition (30.5. - 7.6.74)

Fading was by releasing the hand progressively earlier in the imitatory movement. Response was rapid and on the evening session of the first day, Cody helped slightly on 9 of 15 trials. Aiding on 5 of 8 trials was seen the following day, and June 1st showed a further improvement, with helping on all but one of 19 trials; on three of these all that was necessary was a gentle touch on the elbow - this was termed slight prompting and can be defined as a push of no more than one inch against the elbow of the imitatory arm. June 1st also saw the first full physically unprompted hoH movements, as well as several "anticipatory" (before a prompt) imitatory actions. These latter were seemingly used as a "request" for milk, but were placed on extinction as it was desired that (at that point) Cody imitate the specific movements. Although "wrong" a "timeout" period was not made contingent upon anticipatory movements lest it led to negativism in the subject. In addition, it was hoped that, at some prior point in training, Cody should use his previously-imitated sounds without imitation and to severely negate this tendency might have jeopardised such aspirations.

Phase 3(iv) hoH (unaided) (7.6. - 17.6.74)

June 7th saw the reappearence of hand on head imitation to visual/auditory prompting alone (seen 6 of 22 trials). Progress was rapid, and a seven-day period of greater than 60% physically unprompted responses followed. It is interesting that on each occasion that the infant did not respond to visual/auditory prompting alone, a "slight prompt" was sufficient.

In practice, phases 3(iii) and 3(iv) tended to merge together and the infant never attained a complete 100% unprompted session. When hoH imitatory ability reached a level of 70% correct response, or more, it was evident that 100% hoH imitatory ability was possible with further training. As soon as it became evident that hoH capacity was possible, finger on nose imitation was initiated, and the former procedure taken up to an arbitrary level of achievement before being terminated.

STAGE 4. PHYSICAL IMITATION PLUS VOCALISATION (5.6. - 7.7.74)

Training for imitatory "finger on nose" was similar to the preceding hoH training, being an imitatory arm movement, directed towards the head, and given in an identical environment for similar food rewards. It did, however, differ in two respects; (i) there was very little introduction, as the infant already possessed considerable experience of the general teaching situation; (ii) a vocal response ("kuh") was required after the imitatory movement. This latter was not so difficult a matter as might be supposed as Phase 2(v) FoN tuition was still continuing at this time (see fig.5.2, page 203).

There were six phases in Stage 4 training:
4(i) his FoN (aided) plus "kuh"; 4(ii) Transition (fading of physical prompt) plus "kuh"; 4(iii) his FoN (unaided) plus "kuh"; 4(iv) Fading of visual prompt during 4(iii), i.e. vocal response

required to an auditory cue only; 4(v) Fading of infant's finger on nose (FoN) with vocalising; 4(vi) Transfer from talking booth to external environment.

The relative positions of teachers and subject were as in fig.5.3, with the exception that their relative positions (left to right) were reversed to aid discrimination of the two concomitant imitatory procedures (Stages 3 and 4). As in Stage 3, the teacher caught the infant's attention and, ordering "Do this", placed his index finger over the bridge of his nose simultaneously uttering a loud "kuh". The infant's hand was then moved so that his index finger was placed across his nostrils and held there until a "kuh"-sound was produced. His hand was then released and reward given. On days 1 - 5 of phase 4(i) as an introduction, the teaching trials were preceded by "normal" Stage 2(v) FoN trials (up to five).

<u>Phase 4(i) his FoN (aided) plus"kuh"</u> (5.6. - 21.6.74)

Training began with two sessions on June 5th, and surprisingly, on each trial a quiet "kuh"-sound was forthcoming. However, nasal self-occlusion was no more acceptable than instructor occlusion during the first days of phase 2(i). Much fighting occurred in consequence. Fortunately, this aversive reaction decreased with each session and by June 10th had all but disappeared. The "kuh"-sound, however, remained at a much quieter level than in preceding stages.

On June 10th also, it appeared that Cody produced a "kuh" <u>just before</u> his hand was pushed down across his nose. Two hypotheses presented themselves: (a) The infant could close off his nose internally, but the ability was not consistent; (b) Cody could not do <u>this</u>, and when closure did seem to occur it was due to an accumulation of factors, perhaps partial nose closure by facial (lip) contraction in the run-up to vocalisation, the remaining gap being closed by his fingers.

To resolve this question, the nose was purposely not fully occluded, up to half the orifice being exposed. On five of nine trials, an acceptable "kuh" was produced with the nostrils only partially closed. Further, on the remaining trials, despite

despite performing all the normal facial and respiratory contractions associated with sound production, the infant produced only a snuffling sound as air was expelled through the nose. Thus, it seemed that closure of the nasal chamber to expired air was possible, but not yet with consistency. This condition persisted and its authenticity further confirmed on June 13th when Cody produced a "kuh" with but a slight (accidental) prompt, despite the fact that the finger on nose movement terminated across the eyes.

An attempt to initiate "fading" (i.e. phase 4(ii)) was made June 17th (5 trials) but was unsuccessful. However, the following session of the same day saw a great improvement, Cody consistently helping the hand on nose action, and voluntarily opening his fingers to place them across his nose, though he still would not leave it in position. Seen the following day was a single instance of the infant pushing his head down onto my fist to produce a "kuh"-sound; this did not recur during the whole of the tuition period (cf. Viki, 1951). By June 20th (16 days from beginning Stage 4) only a very light hold on the infant's hand was necessary for Cody to complete the whole movement. On several occasions only a "slight prompt" was necessary, although slight holding down of the occluding finger was still required until a "kuh" was voiced. The "kuhs" themselves were not of the best but it was considered better to allow a slight degeneration while efforts were made to perfect the imitatory movements. In line with this, fading was begun the following day.

Phase 4(ii) Transition (21.6. - 25.6.74)

A second fading attempt by moving the guiding hand from index finger to wrist, showed limited success (3 of 17 trials). On these three occasions a well-formed "kuh"-sound was elicited. The same response was seen 20 times on a 22 trial session of June 22nd. Despite a two day absence, Cody responded on all 10 trials of his next session. On the last six trials of the following 11 trial session the teacher removed his hand as soon as the infant showed that he was moving it towards his face. On the first ten of these trials, Cody occluded the nose voluntarily and voiced a well-formed "kuh". However, the joint between finger and palm on the radial side of the palm was used. Trial 11 saw a similar movement, but no sound was emitted.

Phase 4(iii) his FoN (unaided) plus "kuh" (25.6. - 27.6.74)

During the next two sessions of June 25th Cody produced physically unprompted "kuh"-sounds on 80% and 100% of all trials (30 and 17 trials respectively). The six inappropriate responses all appear due to incorrect finger placement because of over-motivation for the food reward. However, incorrect placement of the finger cannot fully account for the non-production of "kuh", for on the final session (100% appropriate response) Cody also misplaced his hand relative to his nose. over motivation may not only have disorientated this movement, it may also have disrupted laryngeal vocalisation.

One occasion of anticipatory finger on nose plus "kuh" was seen, immediately upon taking up our positions in the booth.

Appropriate responses continued over June 26th and 27th. In addition, the infant voiced "kuh"-sounds with his hand brought only to chin level. Phase 4(iv) training was therefore initiated.

Although the remaining three phases were conceived as separate entities, in practice the subject achieved phases 4(iv), (v) and (vi) concurrently, and not wholly through the intricacies of training.

Phase 4(iv) Fading of Visual Prompt (26.6. - 17.7.74)

From the beginning, an auditory cue only was found to produce a correct response. Spontaneous "kuh"-sound production (with or without hand to face) was also recorded, the only cue being the presence of a desirable object.

Phase 4(v) Fading of hFoN when Vocalising (26.6. - 7.7.74).

As mentioned, Cody began to "fade" the finger on nose movement himself, although his hand did seem impelled to move some or all of the distance towards his face. Hand to nose gradually declined until by July 7th (12 days from beginning of Stage 4), 100% "kuh"-sound production without finger across nose was recorded. This level was maintained until termination of the "language" experiment.

Phase 4(vi) - Transfer (26.6. - 7.7.74)

Transfer to various objects and situations was for the most part spontaneous (see usage). Within six days of the infant producing a "kuh"-sound outside the experimental situation, e.g. Piagetian testing, using milk as a lure, at least one session each day took place outside the booth. In all cases Cody performed at his normal level of competency, even when, e.g. three persons, two rare visitors and one a complete stranger, were present during a "kuh"-session.

Cody could now produce a well-formed distinct "kuh" during feeding and spontaneously; formal training was therefore terminated. Except in the feeding period (and when training other sounds) no restriction was placed on the infant's use of "kuh" it being considered of interest to determine to what uses he might bend his "word".

STAGE 5. SECOND VOCALISATION -"PUH" (7.7. - 30.7.74)

It was thought advisable that the second sound to be trained should differ as much as possible from the first, within the limits of ease of training, so as to produce easy discrimination between the two sounds. That chosen as suitable was the sound "puh".

This "puh"-sound differed from the first in several ways; it was a "stop" sound produced by closing off the lips as air was expelled, as opposed to being sounded from the throat; it was unvoiced and therefore required no involvement of the larynx, the latter did; the formative stages of "puh" could be visually modelled, this was not the case for the "kuh"-sound; pouting was already present in the infant's behavioural repertoire. Thus, no innovative motor patterns required training.

As the talking booth had proved most useful in shielding the subject from unwanted stimulation it was decided to utilise this facility, but to alter it so as to make it "different" yet maintain its desirable aspects. To this end the door of the booth was made reversible and one side painted a bright, golden yellow. During "puh" training this coloured side faced inwards, and the infant and teacher sat so that the teacher was framed by a yellow-hued backdrop.

The teacher was also made a discrepant stimulus during "puh"-training. A mountaineer's cagoul, hooded, reaching three inches past the knee, and of the approximate colour of the booth door's painted side, was worn during the first days of training.

It was hoped that all such precautions would aid the infant in cognising that the training to be given was different from that to which he was accustomed, i.e., it should be obvious that some response other than "kuh" was necessary. Training began July 7th.

The training schedule envisaged, in general, a replication of the hoH and FoN procedures. A 6-phase time form was planned as follows:

(i) Pout (aided) - Mouth manipulation would be used and the infant required to replicate the teacher's pout model.

(ii) Transition (a) - Fading of mouth and lip manipulation.

(iii) Pout (unaided)

(iv) Pout plus "puh" (aided) - After pouting (unaided), the subject's lips would be closed off by the teacher as he breathed out and a physically-prompted "puh"-sound produced.

(v) Transition (b) - The physical lip-closing prompt would be slowly faded resulting in physically unprompted "puh" production.

(vi) "Puh" (unaided) - The infant would be required to produce this sound during each trial, and later to use it appropriately in the external environment.

Two events spoiled an unhindered progress, (a) Cody's inability/unwillingness to expel air through his mouth, and (b) complications arising from the previously-learned "kuh"-sound. To counter the first problem, a finger on nose (FoN) phase was interpolated after phase (iv), and the transition phase (now phase (vi)) was extended to include fading of both finger on lips <u>and</u> finger on nose. The second problem was overcome only by retraining the aided "puh"-sound, and a subsequent fading phase (phases (viii) and (ix) respectively.)

<u>Phase 5(i) Pout (aided)</u> (7.7. - 11.7.74)

This began with one session per day. Reward, in the first instance, was novel, - one grape per correct response. This again served to enhance "kuh"/"puh" differentiation. Normal food was given from 9.7.74 and during the final period of the experiment (after transfer) no food.

Training consisted of manipulating the infant's lips into a funnel-shaped pout, the teacher first requesting "do this" and modelling the mouth position himself.

During the first session of Stage 5 the infant produced many "kuh"-sounds, while manipulation for a pout was in progress. These were placed on extinction (not rewarded). The infant was, at best, passive, during this period. During the following 18 days required for mastery of this sound, Cody received on average 3.39 training sessions of 16.1 trials per session (54.9 trials/day).

Within the first day (4 sessions) the infant had mastered the pout response, although during sessions 1 and 2 "kuh"-sound production was extremely common. Sessions 3 and 4 evinced no ""kuh"-sounds, and the infant began slowly to aid the pouting movement, culminating in T.9 and 10 of session 4 with two pouts when the teacher's fingers barely touched the lips.

Unfortunately, this rapid progress produced complications in the infant's first sound. The "kuh" session following "puh"-session 3 was completely destitute of any "kuh"-sounds.

Not until the next "kuh"-session did Cody (after several seconds of open-mouthed silence) produce a quiet "kuh"-sound, and following this his usual, loud "kuh". This pattern was to be repeated (and more seriously) later in Stage 5.

Phase 5(ii) Transition (a) and 5(iii) Pout (unaided)

These two phases were achieved within one day. By the second of 5 sessions (July 11th) the infant was pouting without physical prompting on 9 of 15 trials (60%) and by the third session on 76% of 21 trials. Phase 5(ii) was terminated and phase 5(iii) initiated during the fourth and fifth sessions, these being 100% physically unprompted (30 trials).

Phase 5(iv) Pout plus "puh" (12.7.74)

During the first session of this phase it became apparent that the infant was in no way synchronising lip closure with the expulsion of air. Indeed, mouth breathing was not observed at this time. Without such synchrony, the sound could never reach the degree of loudness required. The Pout and "puh" phase was therefore terminated, and a FoN phase (phase (v) inserted, beginning July 12th.

Phase 5(v) FoN plus and "puh" (aided) (12.7. - 18.7.74)

Here, after modelling the teacher's right hand was used as previously to produce a pout, the index finger of the left hand then occluding the nose. As the infant expired his lips were brought together briefly with the right hand, resulting in a pressure build up subsequently released as a "puh". It was interesting that, at this point, Cody seemed to regress somewhat to his condition prior to Stage 5, it being necessary to again mould the pout movement manually. "Kuh"-sounds were produced during the first two sessions of phase 5(v) (compare phase 5(i)). However, by the fourth session unprompted pouts with FoN were recorded during 73.5% of 15 trials. On 7 occasions lip-closure was initiated and, although difficult to judge the respiratory cycle, this produced 5 acceptable "puh"-sounds. A similar level was maintained throughout the following 3 days and July 16th saw Cody pouting on 97% of 59 trials. At the same time, the infant occasionally blew out air through his pouted lips, thereby increasing the quality of "puh"-sound produced. This tendency increased during the following days, up to July 18th.

Phase 5 (vi) Transition (18.7. - 21.7.74)

An accidental misplacement of the teacher's fingers on T.19 of the third session of July 18th demonstrated that Cody could expel air through his lips without nasal occlusion; a subsequent unoccluded trial confirmed this, and transition from FoN to unaided mouth-breathing was begun. The "puhs" produced by unaided buccal breathing, although still produced by aided lip-closing, were, nevertheless, loud and clear.

July 20th saw further progress. The infant produced a "puh"-sound (very like a "Bronx cheer") on the third of the day's 5 sessions and by the final session, 10 of 29 trials were "puh"-sounds with unaided mouth-breathing (though aided lip closure).

Phase 5 (vii) "Puh" (Unaided) (21.7. - 24.7.74)

100% unaided "puh"-production was achieved on the final session of July 21st. Prior to this the infant had shown gradual improvement. The sounds themselves were extended vibrations of the lips, more reminiscent of a derisory "raspberry" than a concise "puh". However, it was considered of greater import to consolidate the sound than to insist prematurely on the niceties of pronunciation.

An unfortunate concommitant of this progress was the immediate and complete loss of Cody's ability to voluntarily vocalise "kuh" (see Usage section below).

So as to give the "kuh"-sound a greater possibility of re-establishment, the order of "kuh" and "puh" training sessions (previously "puh" first, "kuh" following approximately 15 minutes later) was reversed from July 24th. The procedure was successful eith regard to the "kuh"-sound, but "puh" now became extremely difficult to elicit. It became clear that re-establishment of prompting, and its gradual fading held the greatest possibility of producing consistent, voluntary "puh"-sounds. Subsequent sessions showed the finger on nose procedure to be unnecessary, but lip closure was still necessary on approximately 80% of 46 trials.

Because of the large number of "puh"-trials given during

July 24th, "kuh" production decreased markedly during "kuh" tuition, although not to the extent previously experienced.

Phase 5 (viii) (24.7. - 27.7.74)

1 "kuh" + 3 "puh"-sounds were produced during a morning play period. With the training situation, however, only one trial in 14 elicited a voluntary, unaided "puh"-sound during the best session of the day.

Lip prompting continued, with a slight increase in unaided "puhs" (30%, session 3, July 26th) until July 27th when fading of this prompt began.

Phase 5 (ix) Fading (of Finger on Lips) (27.7. - 29.7.74)

It was found possible to elicit an identical "puh"-sound touching one finger to Cody's upper lip. The following day (July 28th - the infant 1 year old precisely) unaided "puh"-sounds were produced on 5 of 15 trials, the remaining trials being "puh"-sounds with the new "faded" lip-prompt.

Attempts at complete fading on July 29th resulted in acceptable "puh"-sounds on a percentage varying from 25% on session 1 to 50% during the final session. The failures were due entirely to the infant's inability to close off the lips voluntarily at the required moment. In the case of an inappropriate response, lip-prompting was initiated immediately afterward, reward being contingent upon "puh"-production. Thus the subject had to make two efforts at vocalisation to obtain one reward when an inappropriate response was given. As only one effort was required for an appropriate response it was hoped that the infant would be motivated to perform more efficiently by this means.

Phase 5 (x) (30.7.74 to termination)

100% appropriate response was obtained in all sessions of the first day (4 in number, total trials: 68). This figure was maintained throughout the experiment.

Cody was now at the point he had achieved during phase 5(vii) on July 21st. And, as on that date, "kuh" vocalisations were very difficult to elicit. However, the problem was by no means as serious as the initial "kuh"-loss and had all but cleared by the following day.

After a further 9 days training and consolidation, transfer to the external environment was begun. The "puh"-sound was now required of the infant before he was picked up. The sound, it was hoped, would thereby come to signify a desire for close contact with the "parent".

STAGE 6. THIRD VOCALISATION - "FUH" (13.8. - 21.8.74)

Following a further 5-day consolidation period for the use of the "puh"-sound, training began for a third sound. Considering the relatively rapid learning of the "puh"-sound, a second unvoiced sound was thought most amenable to tuition. This third sound should neither require overly complex mouth movements nor be difficult to visually model. The sound "fuh" was chosen as fulfilling both requirements.

Tuition was given in the talking booth and training procedures followed a similar pattern to those performed previously for "puh". No introductory phase was given. Reward during the first three days of Stage 6 was highly-desired fudge-toffee, only introduced to the infant for Stage 6 trials.

Phase structure was as shown below:

Phase 6 (i) Mouth Manipulation - The bottom lip was manipulated by the teacher so that it was positioned under the infant's upper dental arcade (oral) expiration would then result in a "fuh").

Phase 6(ii) Fading - of teacher's lip manipulation.

Phase 6(iii) Unaided lip to teeth movement.

Phase 6(iv) Unaided lip to teeth movement, FoN and "fuh".

Phase 6 (v) Fading - of FoN.

Phase 6(vi) Unaided "fuh" vocalisation.

Phase 6(i) Mouth Manipulation (13.8. - 14.8.74)

Lip manipulation was employed, and reward made contingent upon a bottom lip under upper teeth position, hereafter referred to as "lip to teeth".

No help was given during the first session of phase 6(i) (31 trials). One "kuh" and 4 "puhs" were given during this session. By Session 2 Cody assumed the correct mouth position on 46% of 11 trials, and on the third and last session of the second day (August 14th) aiding of the lip to teeth mouth position was noted and Phase 6(ii) began.

Phase 6(ii) Fading (15.8. - 17.8.74)

Fading was increasingly successful, and resulted (August 17th) in a quiet "fuh"-sound on 1 trial. FoN trials were then instituted (see Phase 6(iv)).

Phase 6(iii) Unaided Lip to Teeth Movement (18.8.74)

100% competency in this action was achieved from its first trial and was maintained at this level until termination. Anticipatory lip to teeth movements were placed on extinction.

Phase 6(iv) Lip to Teeth (unaided), FoN and "fuh" (17.8. - 21.8.74)

This phase was initiated briefly during August 17th. A rapid improvement was seen, with 100% "fuh"-sound emission with FoN during August 18th and > 80% appropriate response following a 2-day break. Inappropriate responses were due to escape of air from the junction of upper and lower lips.

Phase 6(v) Fading - of FoN (21.8.74)

On the second session of August 21st fading (one nostril occluded) was attempted. Although notably quieter, "fuh"-production was not prevented. Subsequent sessions demonstrated the redundancy of fading and Phase 6(vi) began.

Phase 6(vi) Unaided "Fuh" (21.8.74)

On the last session of August 21st, unaided "fuh"-sounds were emitted on the first 12 of 13 trials. The infant demonstrated clear competency in producing a "fuh"-sound from this time on. However, several minor problems arose, as detailed below.

"Kuh" production suffered at the time of attainment of the new sound (see page 244). In addition, in the first few days following "fuh"-competency, the infant would sometimes seemingly forget the correct response, and attempt various strategies to reinstate his reward. The clearest example of this was given the day following attainment of Phase 6(vi). During the first four trials of Session 3 (15 Ts) Cody produced, with no prompting, the following attempts:

T 1 lips to correct mouth position without expelling air

T 2 lips to correct mouth position and say "kuh".

T 3 lips to incorrect mouth position (teeth clenched, not over bottom lip), expel air and emit "shoosh" sound.

T 4 blurting

T 5 - 15 "puh"-sound

Transfer of the "fuh"-sound to a specific referent began August 22nd. It was decided that "fuh" should be requested each time solid nourishment was given (porridge, fresh fruit slices, etc.), and "kuh" each time milk and liquid sustenance offered. "Puh" remained obligatory for contact comfort.

Transfer of the "fuh"-sound to the external environment was completed within two days beginning August 26th. During Day 1 the teacher's cagoul was placed on the teacher's lap - "fuh"-production was unaffected. On the following day, the cagoul was omitted completely with the same results. Full transition was achieved during the test session with 66% correct response outside his cage, in the Zoo offices. By August 28th Cody had achieved his usual 90 - 100% level of "fuh"-production.

Between termination of Stage 6 and the commencement of Stage 7 an unavoidable 26 day break in tuition occurred (August 30th - September 24th). During this time the Zoo staff kindly agreed to request the appropriate vocalisation before contact, milk or food was allowed, and to record the infant's responses. Their results indicate that on each day of the teacher's absence, Cody produced on average 35 "kuhs", 44 "fuhs" and 28 "puhs". Per session the average of "kuh", "fuh" and "puh" emission was 11.6, 14.6, and 9.3 respectively.

STAGE 7 - FOURTH VOCALISATION - "THUH" (30.9. - 2.10.74)

With three sounds already learnt, it became increasingly difficult to conceive of novel classes of objects or demands upon which a further sound could be transferred. Cody possessed sounds for food, drink and contact, and these, it seemed, comprised his raison d'être. Two alternatives presented themselves, (a) a class of objects for which a single sound now served could be sub-divided, e.g. "puh" as a contact-demand sound and the fourth sound as a request for his door to be opened; (b) other objects and services could be chosen for production of the new sound.

Course (b) was chosen, primarily because it was realised that one further service - brushing - remained to be exploited. The infant revelled in brushing sessions and would remain limp and uncaring during such a procedure for periods of up to 30 minutes.

The sound chosen was "thuh" (as in "thumb"). It possessed all the advantages of "puh" and "fuh", although the necessity for tongue manipulation suggested it might prove somewhat more difficult to train.

Training began on September 30th, having allowed four days for the infant to become accustomed to his new quarters in Sunderland. A new talking booth was constructed for "thuh" tuition. The infant's cot and the original talking booth door formed two sides of the booth, and the walls of the room (plain white) completed the remainder. The yellow side of the booth door faced inwards during teaching of a new sound and the teacher wore the yellow cagoul.

Tuition was divided into 6 Phases.

Phase 7 (i) Mouth manipulation - the infant's tongue and jaws manipulated to assume the positions shown in fig. 5.5. This termed "tongue to teeth".

Phase 7 (ii) Fading - of mouth manipulation.

Phase 7(iii) Unaided tongue to teeth position.

Phase 7 (iv) FoN with tongue to teeth position and "thuh" production.

Phase 7 (v) Fading of FoN.

Phase 7 (vi) Unaided "thuh".

It became apparent during the early phases of Stage 7 that it was not necessary to pursue FoN procedures. Further, Phase 7(iii) did not appear as the infant moved immediately from Phase 7(ii) to unaided "thuh"-sound production. Accordingly, Phases 7(iii), (iv) and (v) were omitted. Phase 7(vi) in the above format became Phase 7(iii).

Phase 7(i) Mouth Manipulation (30.9. - 1.10.74)

The infant produced many "fuhs" and "kuhs" during this initial period. However, within the first session, 10 approximations to the sound "thuh" were elicited and rewarded. Thus, the infant was, at this early stage, expelling air through his mouth without nasal occlusion, and as soon as manipulation achieved the correct mouth-form, a "thuh"-sound was elicited.

Cody seemed to find it much easier to place his tongue behind his teeth than between them (see fig.5.5 (a) & (b) below.) The sound emitted was virtually indistinguishable from a normally-produced "thuh"-sound. It was termed a "near-thuh" ("n-thuh") and its production was rewarded.

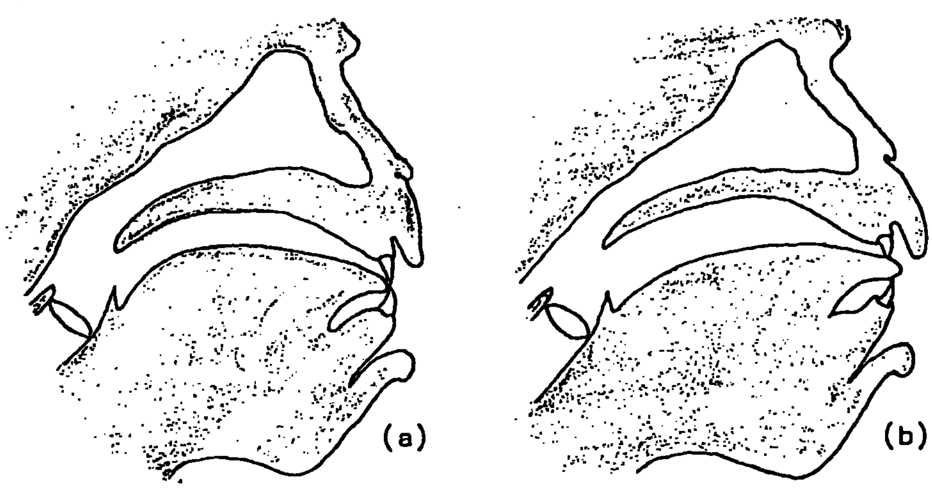


fig. 5.5

By the second day (1st Session) much less mouth-manipulation was necessary to produce the correct mouth-form. On 3 trials it was necessary only to touch the infant's lips for this to occur, and a "thuh"-sound to be produced. Fading (Phase 7(ii)) was begun.

Phase 7(ii) Fading (1.10.74)

Fading was accomplished within three sessions of October 1st (the second day of Stage 7). The only physical prompt given was touching the infant's bottom lip which proved sufficient to elicit "thuh" or "n-thuh" production. By the fourth session the infant was producing a 60% correct response with auditory and visual prompting alone.

As on the acquisition of other novel sounds "kuh", "puh" and "thuh" production once again suffered (see Usage)

Phase 7(iii) Unaided "thuh" (2.10.74)

From the 60% unprompted level of October 1st, Cody progressed rapidly to 100% competency during the final 2 (of 3) sessions of October 2nd.

Following these results, attempts were made to transfer the sound to a request for brushing.

LEARNING COMPETENCY

Table 5.2 lists the Stages referred to above, their Phases, dates of commencement and termination, and the duration of each Stage. Fig. 5.10 details graphically the total training time (omitting Stage 1) for each Stage. Because each Stage is concerned with the achievement of a particular ability it is difficult to compare Stages. However, it could be argued that Stages 2 to 4 show increasing difficulty for the infant. Stage 2 requires the single action of opening the mouth, together with buccal breathing and, (latterly), "kuh" vocalisation. Stage 3 requires imitatory movements demanding a greater degree of physical dexterity. Stage 4 demands all attributes of the preceding two periods. The remaining Stages may be rated as offering at least as complex a challenge to the infant as Stage 4. Hence it is of interest to compare their times to achievement, (fig. 5.10).

A rapid, consistent and continuing decrease in acquisition time is at once noticeable in chronologically later Stages. When charted as a percentage of total training time a similar

FIG. 5.10
COMPARISON OF TIME TO COMPLETION OF THE STAGES 2-7.

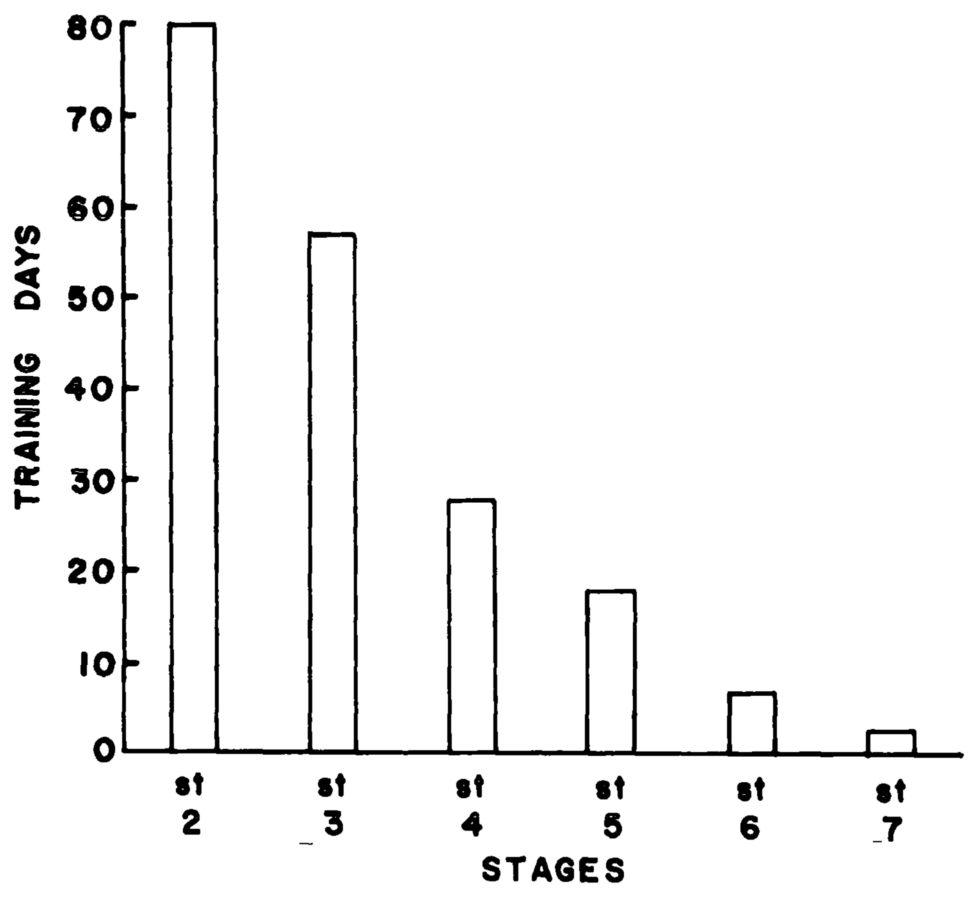


FIG. 5.11
COMPARISON OF PHASES 3 ii–iv WITH PHASES 4 i–iii.

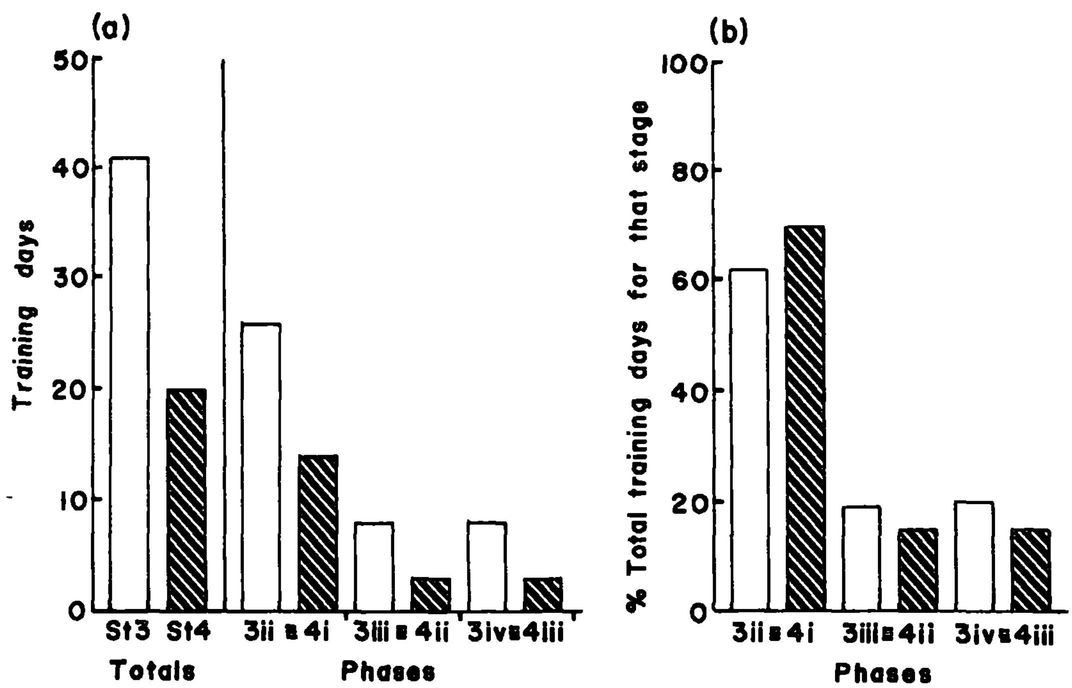
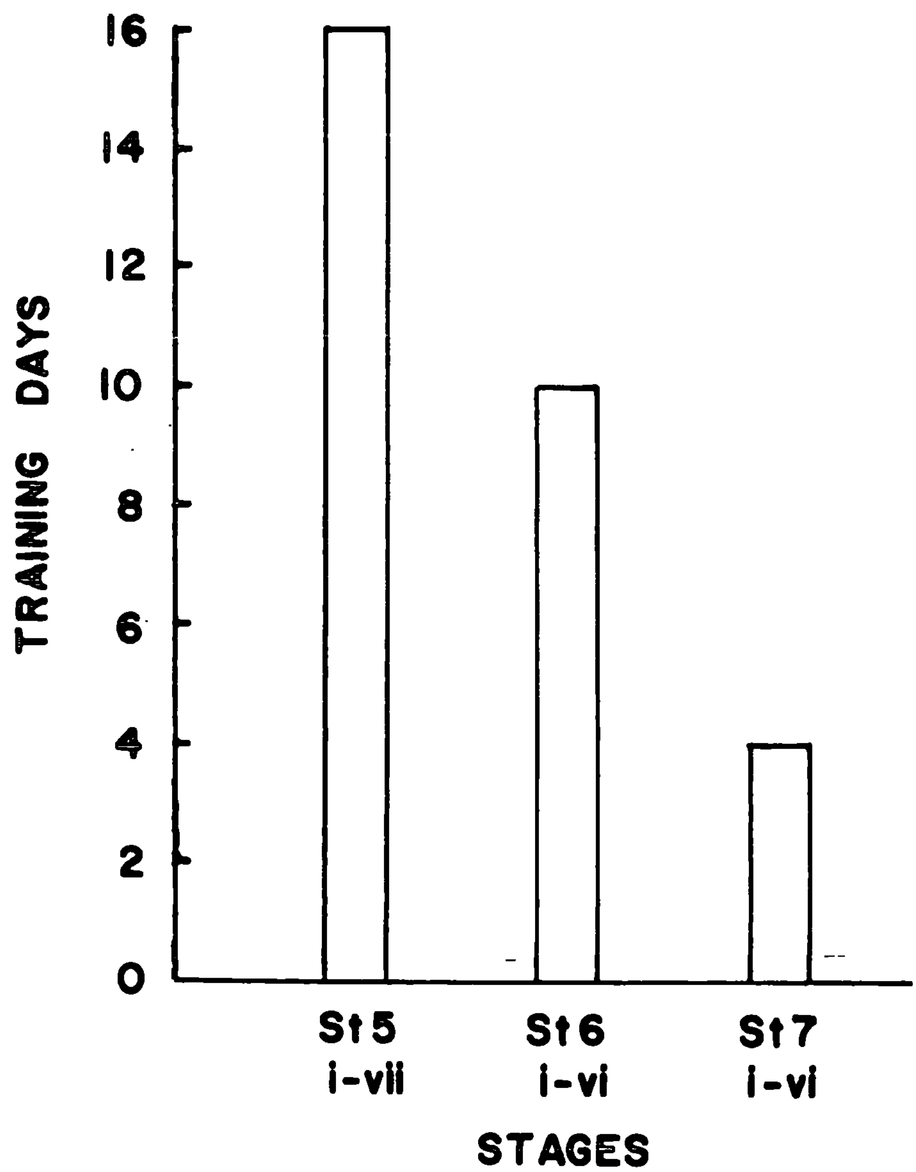


FIG. 5.12
COMPARISON OF St 5, i-vii, St 6, i-vi & St 7, i-vi.



trend results, indicative of increasing ease of mastery as each succeeding Stage is attained.

Valid comparisons can also be made between certain Phases of the different Stages described above. These again show a consistent decrease in times to mastery of comparable elements.

Time taken to achieve hand on head imitation (omitting the introduction period) is compared with that taken to reach finger on nose mastery in fig.5.11. For purposes of analysis Phase 3(ii), 3(iii) and 3(iv) are considered to correspond with Phases 4(i), 4(ii) and 4(iii) respectively, and the times charted. In addition, the percentage of training days during which tuition was in progress for each Phase has been determined and the percentage of the total tuition time of that period (either Phases 3(ii) - (iv), or Phases 4(i) - (iii) calculated (fig. 5.11(b)). As is evident (fig.5.11(a)) Phases 4(i) - (iii) are completed in approximately half the time of Phases 3(ii) - (iv), the relation holding true for each comparable Phase in the two Stages. Less evident is the similar pattern seen when comparing the percentage <u>within</u> Stages. Phases 3(ii) and 4(i) each comprise 60 - 70% of the training days of the total section under analysis in Stage 3 and 4. Similarly, Phases 3(iii) and 4(ii), and Phases 3(iv) and 4(iii) lie between 15 and 19%.

With regard to Stages 5, 6 and 7, it is possible to directly compare large sections of these periods. If time until first unaided "puh" is taken as time to mastery of the "puh" sound, (omitting the abortive Phase 5(iv) and ignoring the following complications with the "kuh"-sound - Phase 5(viii)-(x) - see below, appropriate usage) them comparison between Stage 5(i) to (vii) and the total Phases of Stages 6 and 7 is possible. This has been done in fig. 5.12 As is evident, a steady fall in "time to completion" is seen with Stage increase, i.e. the same trend as was seen in Stage 3 and Stage 4 comparisons above.

USAGE

Usage can be most usefully analysed by dividing the sound emissions into Appropriate and inappropriate, and Novel emmissions, i.e. emissions in novel situations.

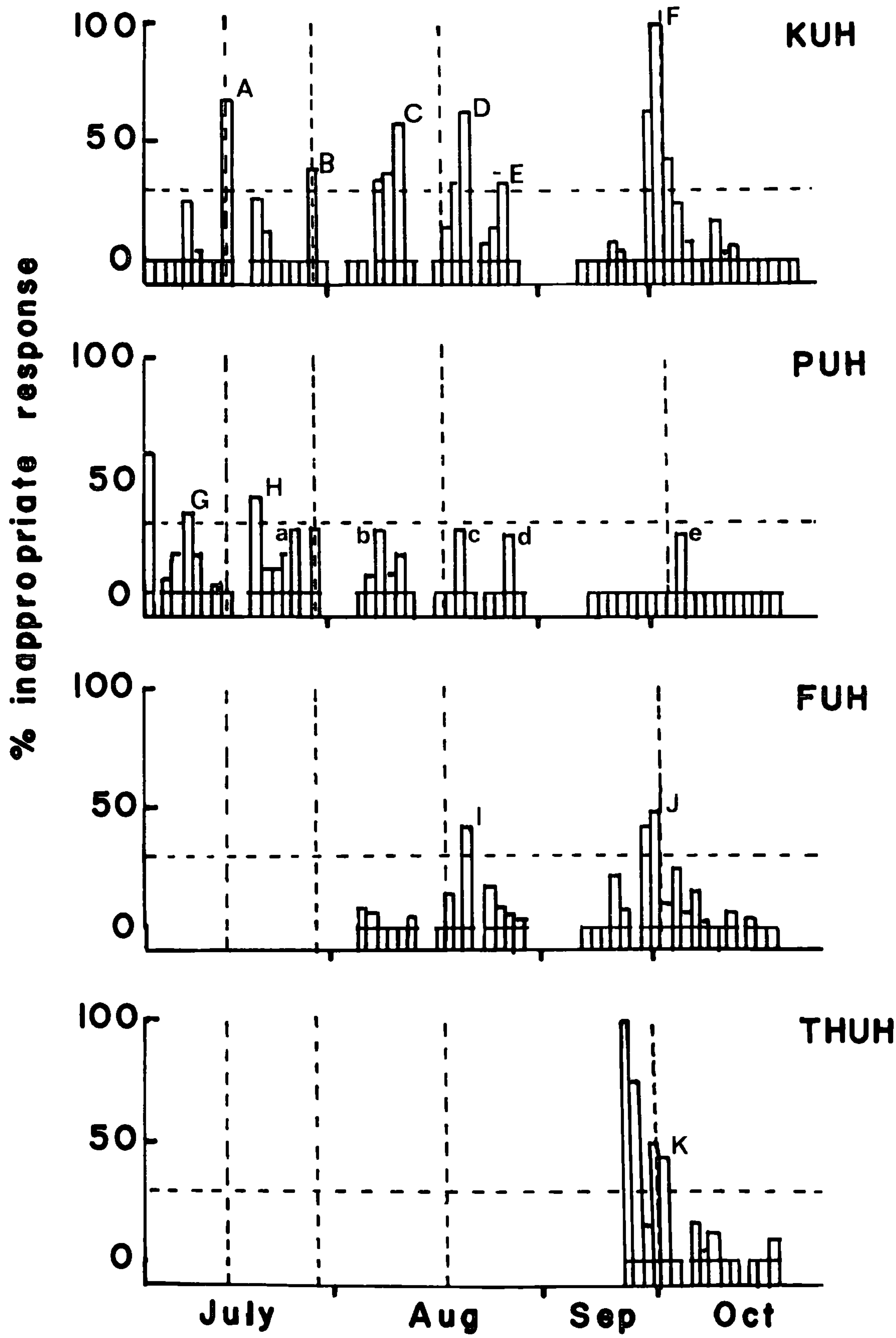
Appropriate and Inappropriate Emissions

An appropriate emission was one which occurred during an event for which the teacher had trained the infant. As an ongoing part of the experiment, each time the infant mastered a new sound it was transferred to a definite object- or activity-class. The infant was then required to match vocalisation with object/activity. As the sounds were learned in series and not in parallel, it was necessary that one word should originally "stand for" all desired objects and activities, and that sub-division of the referents of this "magic word" should occur as more sounds were learned. The sounds, and their arbitrary meaning at various stages are shown below.

Table 5.3

Date	Sound	
up to July 7th	Kuh	All desired objects/activities.
July 7th to Aug. 15th	Puh	All desired objects/activities <u>when cagoul worn</u>.
	Kuh	All desired objects/activities, without cagoul.
Aug. 15th to 22nd	Puh	Contact comfort.
	Kuh	Contact comfort; all desired objects/activities, without cagoul.
	Fuh	All desired objects/activities <u>when cagoul worn</u>.
Aug. 22nd to Sept. 30th	Puh	Contact comfort.
	Kuh	All desired objects/activities, without cagoul.
	Fuh	All desired objects/activities <u>when</u> cagoul worn.
Sept.30th to Oct. 2nd	Puh	Contact comfort.
	Kuh	Milk and other beverages in mug.
	Fuh	All pan and solid food, without cagoul.
	Thuh	All food and milk, <u>when cagoul worn</u>.
Oct. 2nd	Puh	Contact comfort.
	Kuh	Milk and other beverages in mug.
	Fuh	All pan and solid food.
	Thuh	Brushing continuation.

FIG. 5.13
CUMULATIVE % INAPPROPRIATE RESPONSE PER DAY.



At each point in time situations were engineered that required the production of a specific sound, (e.g. feeding periods (eventually) required a "puh" from Cody for him to be lifted up and carried to the feeding place, a "fuh" for solid food, and a "kuh" when milk was offered.) Inappropriate responses were noted and are shown in fig.5.13, 30% inappropriate response (i.e. 70% appropriate response) was taken as the limit of competency.

As is evident from fig.5.13, inappropriate emissions were held below the 30% level on 47 of the 56 training days covered by the graph (79% for "kuh", if take graph from beginning of "puh" tuition, July 7th.) on 46 of 53 for the "puh"-sound (96.5 %), on 30 of 33 for "fuh" (91.9%) and on 10 of 14 (61.5%) for the "thuh"-sound.

Several peaks of inappropriate response remain above the 30% level. Those occurring at the initiation of training procedures of any new sound are ignored for purposes of this analysis as indicative only of the strangeness of the situation. Remaining points above the 30% level are :

(i) 6 peaks in "kuh" training (peaks A,B,C,D,E & F)
(ii) 2 peaks in "puh"-sound tuition (G & H)
(iii) 2 peaks in "fuh" tuition (I & J)
(iv) 1 peak in "thuh" training (K)

In addition, the "puh" section of the graph shows several minor peaks (a - e) which, while below the 30% level are thought to be significant owing to the usual zero rating of this sound.

The six major and five minor peaks of inappropriate emission show a marked temporal correspondence. It was hypothesised that certain events occurred during the period of training which produced serious upsets in appropriate emission. The events may have been overt (a new training regime, happenings outside the training situation (e.g. injury, shock, etc.) absences of "parent", new food) or covert (e.g. the realigning of the infant's psychological structure because of input or developmental factors) or they may be a synthesis of both. The diaries were consulted for notable occurrences coinciding with these peaks of inappropriate emission.

No consistent traumatic or anomalous events outside the training procedure were found to correspond with peaking. Within the experimental tuition situation changes of food or meal times were not deemed causative agents. Two events did, however, provide a good fit with the peaking data. These were :

(a) The achievement of unaided production of a new sound.

(b) Transfer of a sound to a new or narrower referent.

(a) The achievement of unaided production of a new sound. When the dates of unaided production of the sounds "puh" (two marked, as the sound required relearning) "fuh" and "thuh" are marked (vertical broken lines), 4 of the 6 "kuh" peaks are seen to fall either on (A,B & F) or within one day (peak D) of their occurrence.

Similarly, unaided "fuh"-sound mastery falls within one day of an increase to within 2% of the 30% criterion level in "puh" emission (minor peak c), highly suggestive of a causal link. Mastery of "thuh" production also demonstrates a major "fuh"-peak (J) and a minor peak on "puh" (e).

Thus, of the 11 major and five minor peaks which deviate from an acceptable level of appropriate response, 5 major (A,B,D & F in the "kuh"-line, J in the "fuh"-line), and two minor (c & e in the "puh"-line) seem to be accounted for by some aspect of mastery of a new sound.

Nor is this all. Just as a new sound produces repercussions on the previously-established "vocabulary", the ability to produce the new sound voluntarily also seems to affect its own production immediately thereafter. Thus, major peaks H, I & K occur within one training day of mastery of the respective sounds, as does the minor peak (a) when relearning the "puh"-sound.

(b) Transfer of a sound to a narrower referent. Table 5.3 details the redefinition of sounds already learned from the simpler sound-for-everything to a situation where reward was made contingent upon the production of a specific sound for a more narrowly defined referent. The four dates corresponding to this training demand are: August 15th ("puh" for contact comfort, partly transferred as "kuh" also serves); August 22nd ("puh" for contact comfort); September 30th ("fuh" for solid food, "kuh" for milk); and October 2nd ("thuh" for brushing continuation). These dates marry well with peak inappropriate dates. Thus, August 15th with major peak C and minor peak b; August 22nd with major peak D, minor peak c; September 30th with major peak F and October 2nd with major peaks J and K.

The two remaining major peaks (G & E) and the singleton minor peak (d) are somewhat conjectural. At no time during the date in question or the previous three days was any great emphasis placed upon the sounds which formed the bulk of the inappropriate response. Indeed, on occasion, more weighting was given to the sound against which errors were made.

Error Sounds

The error-sounds of inappropriate emissions are themselves of interest. At what percentage did each sound occur during peak inappropriate responses, and is there any pattern in these figures? Fig. 5.14 demonstrates the percentage occurrence of each sound type at each peak, graphically.

It is notable that only sounds previously learned figure as inappropriate responses in the table, i.e. there is no attempt to produce the "emotional" inborn cries of which the infant was capable(pg 203). When the dates of occurrence of unaided mastery of each sound are also tabulated, it can be seen that for the relevant peaks (A,B,C,D, E,F, a,b,c,d,e & J) the infant produces more errors using the previously-learnt sound than using those sounds learned at an earlier stage of tuition.

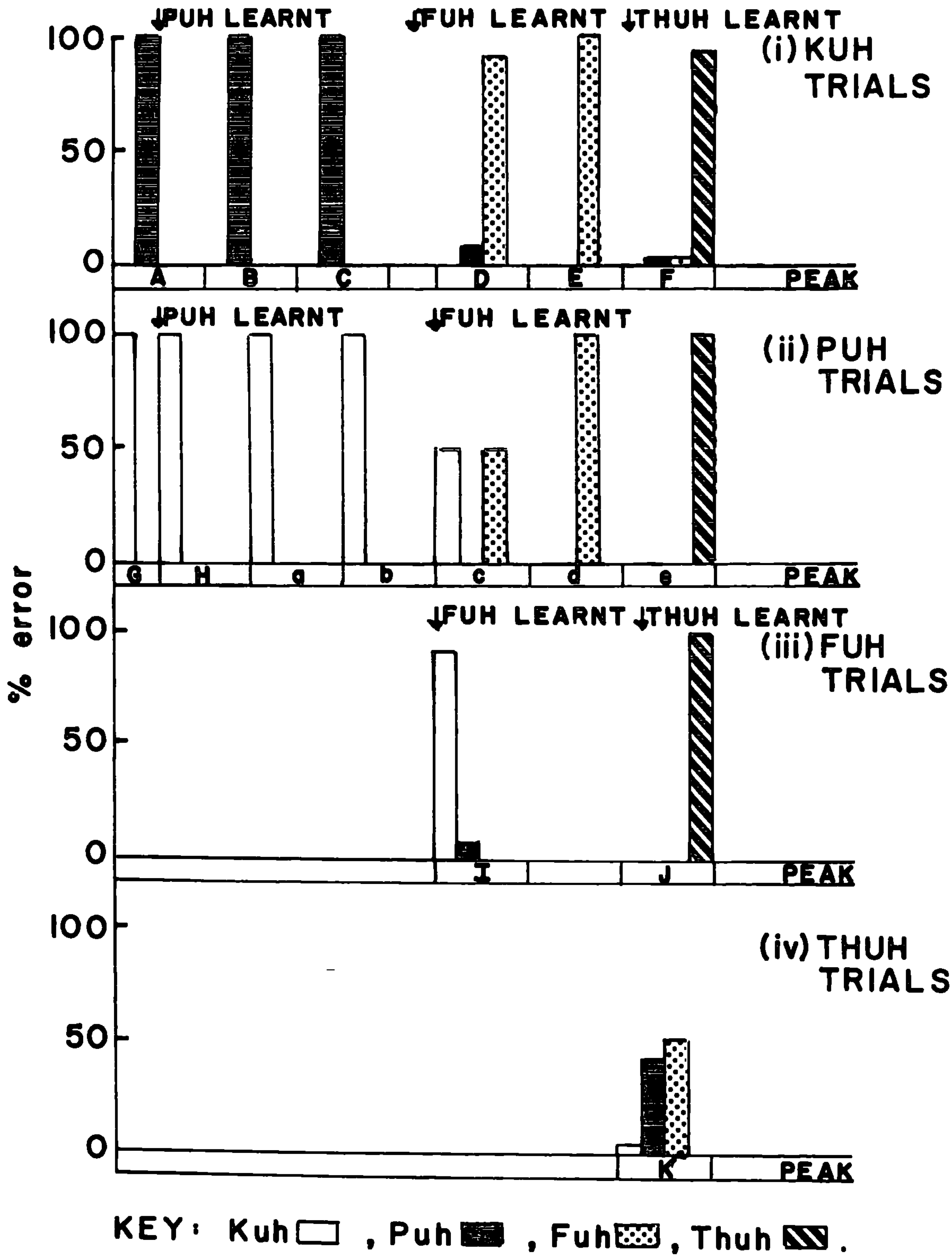
When only two sounds are known to the infant, the error-sound is obvious. However, when the third sound ("fuh") is available in the infant's vocabulary, there is then a choice of error-sounds ("kuh" or "fuh", "puh" or "kuh", or "puh" or "fuh"). Considering the "kuh" trials, (fig.5.14(i)) it can be seen that following the monopolistic position of "puh" during the early stages, the "fuh"-sound immediately takes on the role of primary error-sound during peak D (immediately following "fuh"-mastery) and attains complete monopoly at peak E. However, upon achieving voluntary "thuh"-production "fuh"-errors fall to the equally low level of the "puh"-sound (2.55% of the total error on peak F) and "thuh"-errors supercede.

Similarly, with "puh"-trials (Fig.5.14 (ii), the first peak following "fuh"-mastery shows a 50-50 split between the two choices ("kuh" and "fuh") but "fuh" then takes over, and the error of peak d is "fuh". Following "thuh"-learning "thuh" replaces "fuh" as source of error.

The same is true for "fuh"-trials after "thuh" is mastered; errors on "fuh"-trials (previously "kuh" and "puh") are usurped and "thuh"-errors predominate at the 100% level.

"Thuh"-sounds cannot be compared on these grounds as no newer sound was taught; however, it is interesting that errors during

FIG. 5.14
% OF EACH ERROR SOUND DURING PEAK INAPPROPRIATE EMISSIONS.



inappropriate response peak K seem to reflect the order of sound-tuition, with "kuh" possessing the lowest percentage occurrence, "fuh" the highest, and "puh" occupying a mid-position. A similar trend is not seen, however, at the time of "fuh"-mastery, (peak I).

Novel Emissions

Novel emissions are defined as those uttered outside the teacher-engineered situations and normal training demands, i.e. "kuh" for milk, "fuh" for food, "puh" for contact comfort and "thuh" for brushing. Emissions so defined are in excess of 175 sounds during the period June 28th (when novel usage began) to October 15th (termination of the experiment, see Table 5.4. Emissions may be subdivided on the grounds of context into three categories.

Category 1 - Phenomenological "Requests" - sounds produced by the infant when a non-training object in a novel situation was denied him, without the teacher or a second person being involved in the request (so-called "magic words").

Category 2 - Spontaneous Emissions - sounds voiced by the infant for no apparent reason whilst sitting quietly or moving around the cage.

Category 3 - Novel "Requests" - sounds produced when a non-training object in a novel situation was denied the infant, with the involvement of the teacher or a second person.

Type, number and context of each novel utterance recorded whilst with the infant is shown in Table 5.4.The number and occurrence of Category 1, 2 and 3 sounds are graphed respectively in fig.5.15(b), (c) and (d).

Emissions: The data shown in fig.5.15(b), (c) and (d), and reveal phenomenological requests to be uttered a far greater number of times (78) than novel emissions (46) with spontaneous sounds (56) occupying a middle position.

Emissions per day. The total time that novel emissions took place can be divided into four periods, each corresponding to the learning of a new sound. These periods are not equal in length, but by dividing the number of emissions by the number of days in that period, the number of emissions per day can be calculated, and the figure for each period is then directly comparable.

When this is done (fig. 5.16) average emissions per day are

FIG. 5.15
NOVEL SOUNDS EMITTED.

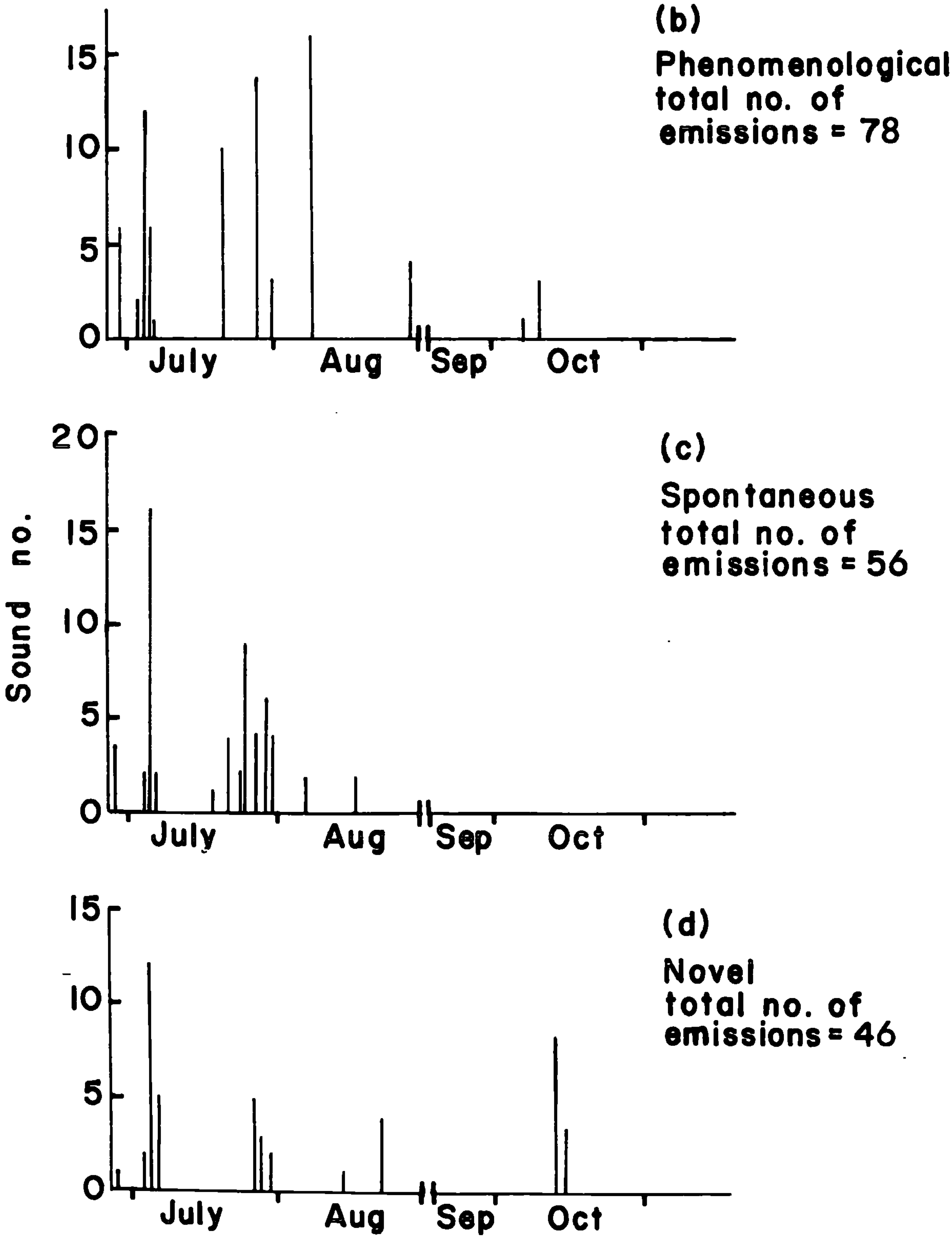


FIG. 5.16
EMISSIONS PER DAY.

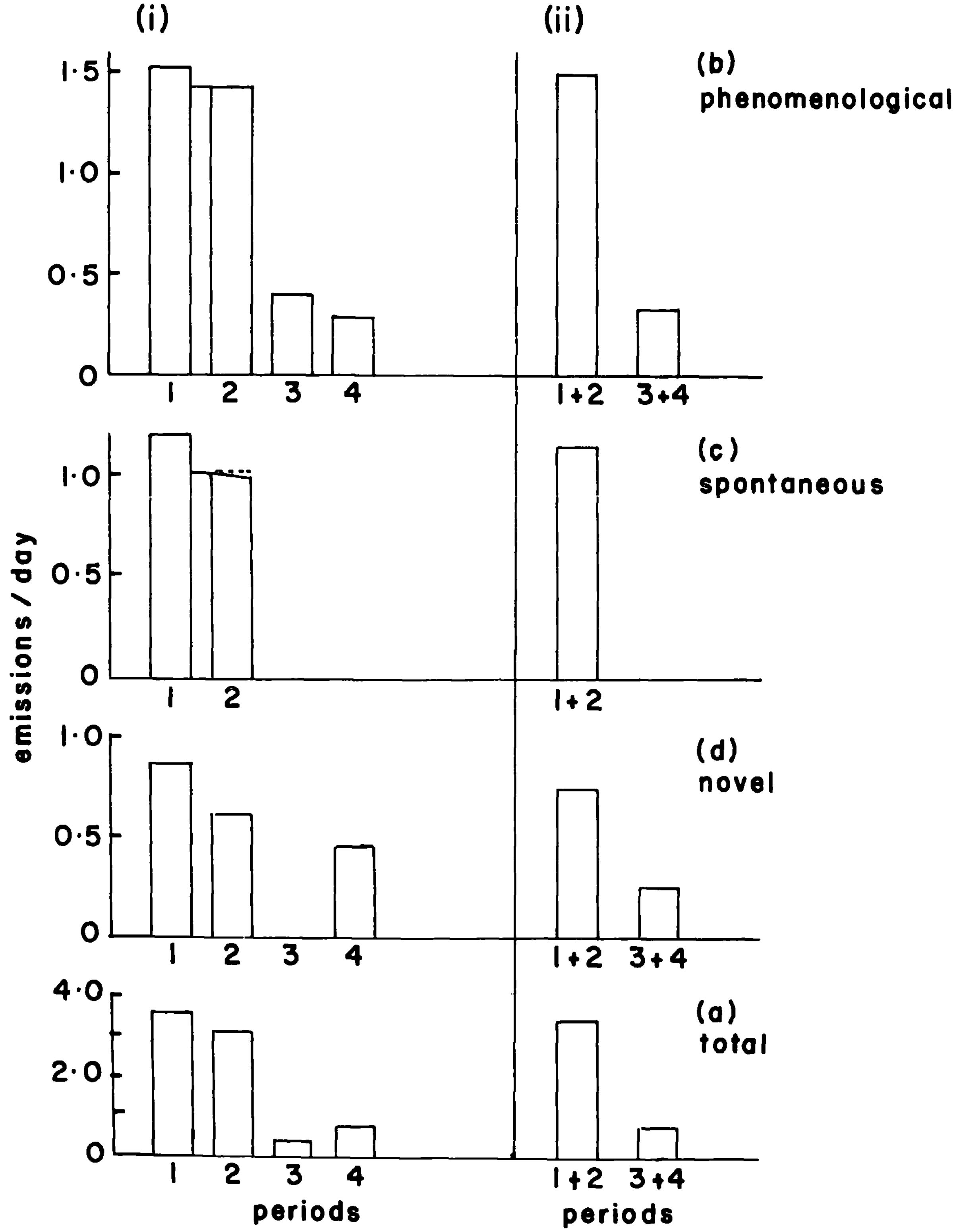


Table 5.4(a)

Phenomenological Sounds	
DATE	SITUATION
28th June	Support Test: 5 hah + 1 kuh, on 6 trials, as moving bottle to support
3rd July	Long Toy Test: kuh on 2 tests; Trial 1, as desired object moved away from him; Trial 2, as object shown to him.
4th July	(i) Gessel Test: 2 kuhs as I move bell away from him. (ii) Cover Test: 10 kuhs on 9 tests. Gives kuhs when I hide object and also just after he's uncovered it as if he has to say kuh before he can grasp it."
5th July	Support Test: kuh on 6 tests after Cody shown object
7th July	String Test: kuh on 1 test.
20th July	Support Test: 10 puhs on 17 tests.
26th July	(i) 1 kuh when Cody tries and fails to grasp at clock on cupboard. (ii) Support Test. 13 kuhs in 13 separate tests.
31st July	1 kuh + 2 puhs after trying to pull down wood tray.
8th August	Stick Test: kuh on 4 tests; kuh + immediate puh on 2 tests; puh on 8 tests.
28th August	Long Toy Test: fuh on 4 tests.
7th October	1 puh after pulling vainly at base of door to open it.
10th October	Puh when sitting back after trying to grasp door handle and failing. Waits for a moment, looking at door. Says puh, waits then (still looking at door) says "thuh".

Table 5.4(b)

Spontaneous Sounds	
DATE	SITUATION
28th June	3 kuhs while playing.
5th July	2 kuhs when on floor.
6th July	5 kuhs twice "for no apparent reason than that he's practising it". 11 kuhs in 25 mins. "Not directed at any specific target or is it a generalised recognition work?"
7th July	1 kuh when looking out of window at people. 1 kuh : Cody biting wall, turns to me, says kuh, then returns to biting wall.
8th July	1 kuh in cot.
21st July	4 puhs in cot.
24th July	2 puhs during observation period.
25th July	3 puhs, 5 kuhs when lying on back relaxing in cot. 1 puh during observation period.
28th July	2 puhs, while playing by himself. Later 2 kuhs ditto
30th July	2 puhs, while playing by himself. Later 4 kuhs ditto.
31st July	1 puh, during observation period. 3 puhs as crawling about.
6th August	2 puhs, during observation period.
17th August	2 puhs long and slow, while climbing about.

Table 5.4(c)

Novel Request Sounds	
DATE	SITUATION
28th June	1 kuh when trying to rise as nappy is changed.
4th July	1 kuh. After putting out jug, Cody says "kuh" to it. 1 kuh. I stop Cody crawling away; he says "kuh".
5th July	7 kuhs, when trying to rise as nappy is changed (2 nappy changings in different locations). 5 kuhs, when I stop brushing him.
6th July	5 kuhs, when I stop brushing him.
26th July	3 kuhs, then 2 puhs, when trying to rise as nappy is changed, (in two different locations).
27th July	(i) 1 kuh, when wanting to be picked up (ii) 2 puhs, when trying to rise as nappy is changed.
29th July	2 puhs, when wanting to be picked up
14th August	1 kuh, during timeout period of fuh tuition, as if it will get him released.
22nd August	2 puhs, when watch taken from him. Later 2 kuhs, ditto.
13th October	(i) 1 fuh, 1 kuh, 1 puh, 1 fuh, 1 fuh, 1 thuh. Cody sees my wife Liz eating meat. Crawls over and says fuh. Liz ignores. Cody says kuh, puh, fuh, gets annoyed and bites at Liz. Stands up and says 1 fuh, 1 thuh. Liz asks then for a fuh, Cody obliges and he gets piece of meat. (ii) 2 thuhs, Cody slapped for biting, I turn away from him. Cody says thuh, runs round to face me, climbs on knee, looks straight in eye and says thuh, as if it will stop my anger.
15th October	2 kuhs, 1 puh. Cody refuses last teaspoon of solid food, says kuh (word for milk) then a puh. I put him down and he makes straight for his milk cup. Asking for milk?

seen to fall steadily with each successive period in all but one category, novel requests. Emissions in this latter case were produced at a relatively high level during period 4, in sharp contrast to the zero rating of period 3. This result affects total average emissions per day, resulting in the increase seen in period 4. More definite is the finding that a greater number of novel emissions took place during the periods 1 & 2 as opposed to periods 3 & 4 (fig.5.16(i)&(ii). This is true for all categories. When the periods are summed in this fashion (fig.5.16(ii)) the discrepancy becomes even more obvious. On no occasion do periods 3 and 4 comprise more than 25% of the total emissions of any one category (novel emissions) and in the case of spontaneous emissions, vocalisation occurred solely in the first two periods.

Occasions. Emissions per day and number of emissions are not necessarily the best measures for all aspects of novel vocalisation. Simple numerical superiority conveys something of the infant's use of his sounds, but the number of contexts in which vocalisations were made adds another facet. An example may make this clearer, contrasting number of emissions with number of occasions.

July 6th	5 "kuh", each time I stop brushing;	5 emissions, 1 context
July 7th	1 "kuh" while standing watching people; 1 "kuh" after biting wall; 1 "kuh" during ring and string experiment;	3 emissions 3 contexts

Thus, the number of separate occasions when the infant produces sounds is considered more important in this regard than the actual number of sounds produced.

When analysis is conducted in this fashion, the disparity between the three categories decreases, and their relative positions change, with spontaneous vocalisations numbering 19, phenomenological, 15, and novel requests occurring 18 times (fig.5.17).

When the number of occasions per day during each period are computed (as was done with emissions, p234) several points emerge (fig.5.18).

It is clear that, as with emissions, certain periods are characterised by far greater numbers of novel emission than are others. The pattern of the total occasions histogram is similar to that of the total emissions, but there appears to be a reversal of relative positions with regard to periods 1 and 2. This pattern corresponds with no single category of emission occasion.

FIG. 5.17
NOVEL USAGE OCCASIONS.

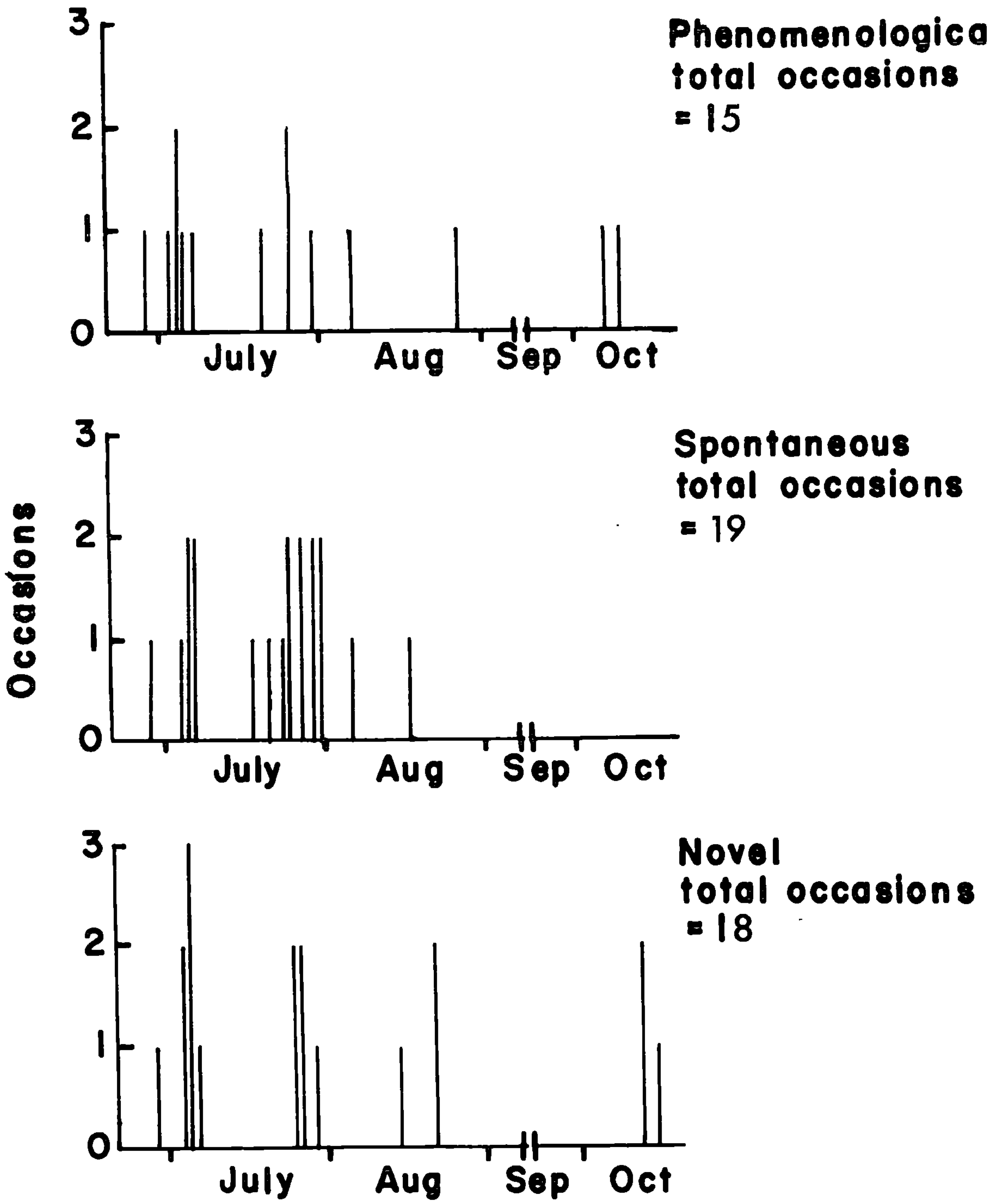
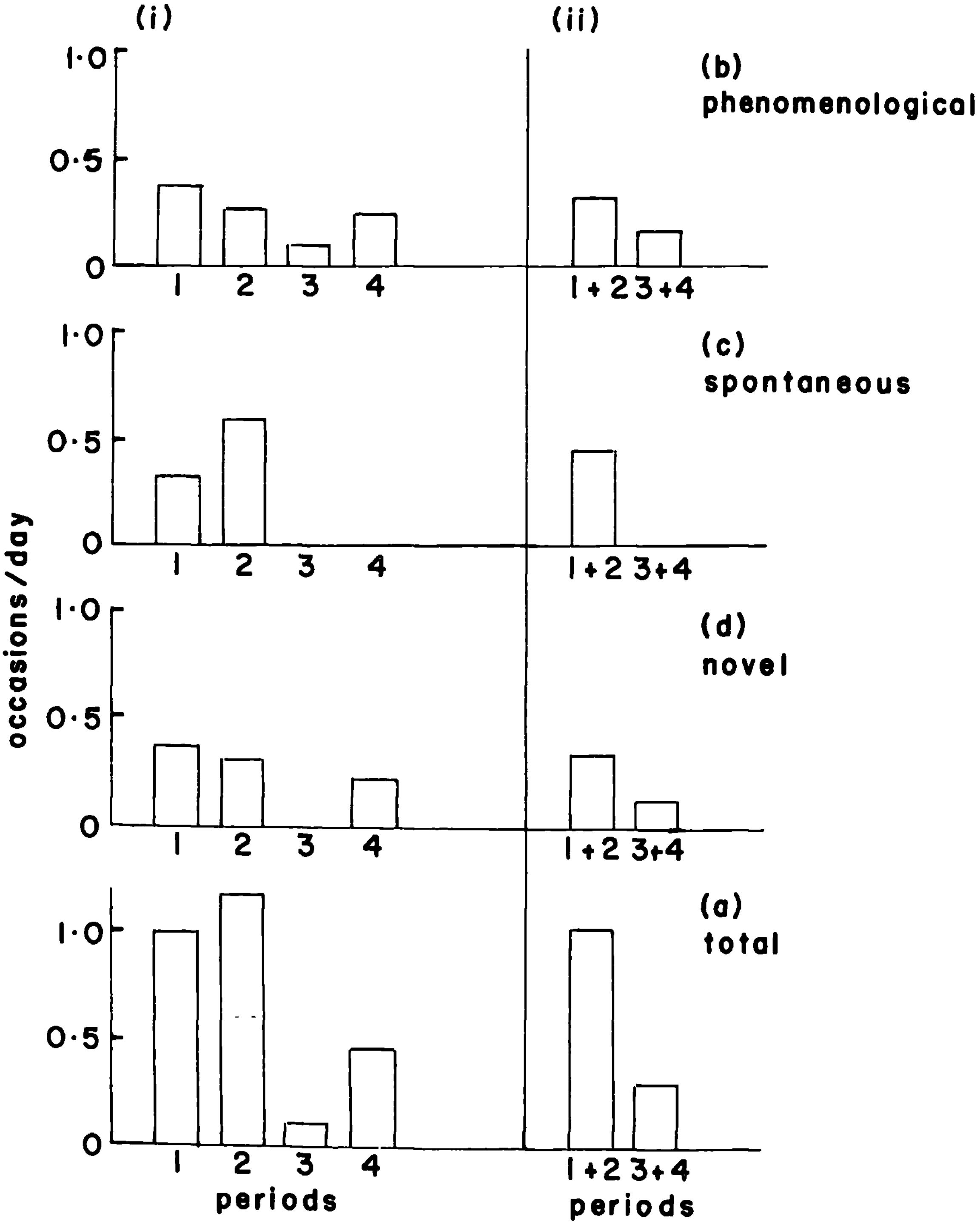


FIG. 5.18
OCCASIONS PER DAY.



On comparing average occasions for each category during the same period, a marked correspondence between periods 1, 2, 3 and 4 is seen for the phenomenological and novel request categories. The figures for each period are .37, .27, .1 and .2 for category 1 (phenomenological requests) and .37, .21, 0 and .23 for novel requests. No such similarity exists for category 2 except perhaps in period 1 (.33 as opposed to .37 for categories 1 and 3).

As with emissions, there is a much larger proportion of occasions when vocalisations occured during the first two periods of each category. The average for each two-period grouping is shown in fig.5.18(ii). The discrepancy beween periods 1 and 2, and 3 and 4 is not so great as in emissions, the latter varying between 0% and 35% of total occasions in any category, and, <u>in toto</u>, 21.5%.

The first point of interest in these results is that the number of novel vocalisations (both emissions and occasions) decreased with time. It is not known for certain why this should occur, but it seems possible that the infant gradually realised that the sounds he had been taught signified something, and that there was no advantage in producing them at random. This possibility finds support when one considers the rate of decrease in the separate categories. Spontaneous sounds decrease the most rapidly of the three categories (fig. 5.16(c), fig. 5.18(c)). The spontaneous sound category is just the one we would expect to decrease if the infant were beginning to use his sounds as " verbal signs ", i.e. to indicate specific object-/activity-classes. As Table 5.4 shows, the spontaneous sounds <u>were</u> random, whereas the remaining categories were emitted by the infant as a " demand" or "request" (albeit magical or novel) for some object or activity. In other words, random sounds (spontaneous sounds) were dropped, whereas those novel vocalisations for goods and services were not entirely eliminated. It is of interest to note that,per day, the number of occasions when Cody voiced novel request and phenomenological sounds increased in period 4, as opposed to the number voiced in period 3 (fig.5.18(i), (b) and (d)), as did novel request emissions per day (fig.5.16(i)(d)). This would seem to indicate that, although Cody did not, after period 2, produce sounds for no reason, he would still " try his luck " when presented with a situation in which he desired some object/activity, but had not yet the verbal-sign to secure the object of his desires. It may thus be wrong to call these sounds errors. Cody appears to have been aware that his verbal-signs signified something, and to have responded to new situations with the only verbal signs at his disposal.

DISCUSSION

LEARNING

Cody's learning of the different training stages at a faster rate with each increasing stage (fig..5.10) is very reminiscent of Learning Set (Harlow, 1949), i.e., as training proceeds the infant learns to learn what is required of him. This hypothesis is strengthened when comparison is made of the phases within various stages; here each phase is of shorter duration than the correspondingly earlier phase. This finding also suggests that had further work been possible with the subject the sound-gains may have been commensurately greater for any given time period.

USAGE

The data show that the infant produced a sound corresponding to that "indicating" the object/activity he required at greater than a 70% level (more often 80%) throughout the period following initial tuition and training in the sound. It is important to realise that these vocalisations were NOT produced in a standardised training environment (i.e. not in the talking box) once mastery had been achieved. Once tuition was complete, the infant was required to produce his sounds in a variety of situations, and he achieved this at a greater than 70% competency level (except where otherwise indicated, and for the reasons stated). In all, Cody requested food, milk, and contact-comfort with the appropriate sound in no less than 14 different rooms in 7 locations.

Neither was the infant person-bound; appropriate sounds were elicited by at least three different keepers while the teacher was out of sight but within auditory range, and by the teacher's wife, mother and sister in the teacher's absence. Neither was object-limitation seen, in that the subject would produce the "fuh"-sound equally well for fruit (usually apple or pear), for vegetables, biscuits, meat and toffee; "kuh" for milk or other liquid in a variety of cups (more than three), or for his bottle (maxi or mini) and "puh" for contact-comfort to three keepers and the teacher's mother. It seems, therefore, that the infant possessed a class-concept (Rosenstein, 1961) with regard to the three sounds taught. "Thuh" was not tested for a sufficiently long period to allow such a conclusion.

This ability was not apparently shared by Viki, who was extremely stimulus and situation bound, (Lenneberg, 1967). Hayes (1970) also makes telling comments on Viki's capacity.

"At the age of 30 months (she)....... used only 3 words and these not always appropriately. In fact, some days she either refused or was unable to say anything". By virtue of the chosen experimental set-up, Rumbaugh's subject, Lana (Rumbaugh, 1974) is likewise stimulus and situation bound, as is Sarah (Premack, 1969). It is the Gardner's chimpanzee, Washoe, with whom Cody is most similar in this respect. Washoe is reported (Gardner and Gardner, 1969) as producing her signs spontaneously, signing with a variety of persons (and when alone) and possessing the ability to generalise from specific object-sign combination taught to the object-class from which the teaching object had been taken.

For himself, Cody very rarely used his sounds to request some object presently out of sight, nor did he use one sound so as to put himself in a position to emit a second sound. This is considered due, in part, to the immaturity of the subject, who was 15 months at termination of the experiment. Exceptions to this state were few, but did, nevertheless, occur, the protocol given below falling within the last week of the experiment, and suggestive of a developmental, rather than an absolute limitation on ability (see also Table 5.4). Thus, during the 15th October, the infant twice refused the last of his pan-food, voicing "kuh" each time. When placed on the floor, he immediately made his way to where the milk bottle was located. Later, after termination of the experiment, but before Cody had been left to return to a more natural state with a second infant Orang, the infant came across to the teacher when he offered pan-food, voicing two "puhs". The teacher replied "No, fuh" on two separate occasions (the correct sound for pan-food) but the infant replied each time with a "puh", attempting at the same time to climb up the teacher. When allowed to do so, and settled on the teacher's right hip, he turned and, without being prompted, uttered a good "fuh"-sound with his eyes directed towards the food.

COMPARISON WITH "LANGUAGE" ACQUISITION IN PRIMATES

When rate of sound acquisition is considered, it is found that Cody mastered sounds at a much faster rate than Viki, the infant chimpanzee for which we have most data in regard to sound acquisition.

The first sound was learned at ten months (5 months after initiation of training) and approximately the time taken to teach Cody his first sound, (Hayes, 1970). However, Viki's second sound did not appear until 14½ months of age (Cody: 12 months), the third sound being achieved at 23 months (Cody: 12 months 3 weeks). Cody's rate of acquisition is far more comparable with Furness' Orang-utan subject which took 11 months to learn 4 sounds. Such a result may reflect a difference in the relative efficacy of the training methods administered to the subjects, or a natural propensity in the Orang-utan for voluntary vocal production. I am inclined to favour the former hypothesis. There are several reasons for this bias.

Phylogenetically the chimpanzee is closer to man than is the Orang-utan (Young, 1971) and might therefore be thought to possess more points of similarity than does its Asian cousin. This in itself is, of course, not a strong argument. Wolves, for example (Banks, Pimlott & Gunsburg, 1967) because of their similarity in hunting technique, are far closer to man in many aspects of social behaviour than are the Lorisidae, although these latter are phylogenetically much closer. However, the chimpanzee is a social creature (Goodall, 1963, 1965) much more so than the Orang-utan (Harrison, 1961; Mackinnon, 1971; Davenport, 1967), and it is thought likely that a much greater selection pressure towards communicatory competence would be seen in Pan than in Pongo. (This may indeed be the case but the work of Gardner and Gardner (1971) and Fouts (1974, 1975) has shown that such communicatory skill may well have been channelled into gestural rather than vocal communication). However, both chimpanzee larynx and facial musculature are more like man than are the Orang-utan's, and the buccal manipulations of human language might be supposed easier for the chimpanzee than for its Asian relative (see Introduction). In addition, Kortlandt(1965) has drawn attention to the early babbling of the chimpanzee infant (confirmed by Hayes, 1952), and speculates that it disappears early after its appearance because of the selective disadvantage of such self-advertisement to predators. No such babbling was heard in the Orang-utan subject here discussed. Further, Viki-type "language" instruction, when used on human subjects, is equally inefficient (Lovaas, 1966). The evidence reviewed above does seem, therefore, to support the argument that the chimpanzee may produce as good a vocal showing as the Orang-utan should similar operant techniques be utilised.

As a general rule, the acquisition of sounds in this Orang-utan subject seems to follow the pattern: a time of passivity or non-cooperation; unsureness and partial cooperation in the production of a sound; success at sound production; unsureness as to the correct context for sound production; and success at sound production in the appropriate context. Once achieved, the sounds were emitted (with the exception of periodically "confused periods" - see below) at an acceptable level of correctness until termination of the experiment.

An exception to this pattern was the "puh" sound, where, upon mastery, "kuh" was lost; when "kuh" was retrained, "puh" was lost completely and immediately, and had to be partially retrained. It is considered that the most plausible explanation for this anomalous behaviour is that the acquisition of the second sound occasioned the first challenge to the infant's omnipotent "magic spell" - "kuh". Until this time "kuh" had been, as it were, the giver-of-all-good-things. Whatever object or activity the infant required would be supplied on production of this sound, and the infant had become accustomed to this happy state of affairs. The second sound is thought to have initiated a conflict within the subject - "kuh" was no longer the giver-of-all-things and, because of the preponderance of "puh":"kuh" trials at the time of "puh" acquisition, "kuh" was dropped in favour of "puh" as Cody's "panacea". Training was then initiated to reinstate "kuh", whereupon "puh" dropped out and had to be retrained. In short, it required a period of several days to inclucate in the infant the realisation that <u>both</u> "kuh" and "puh" were required <u>on specific occasions</u>. Subsequently, following mastery of a third sound, Cody was not unversed in the ways of redefinition of sounds for a more specific referent, and the addition of further sounds did not cause total loss of any sound for periods greater than one session. During this latter period, however, the "magic word" phenomenon, (using the most recently learned sound) was still evident. It would be of great interest to know if such conflict occurs among human infants, either during the period before the acquisition of approximations to adult words (Halliday, 1973) or at the so-called "holophrastic stage". The same query may be advanced with regard to the conclusions of the following two paragraphs.

The finding that, when one sound was newly learned it took over from the preceding sounds (albeit briefly) as a "magic word" was depicted graphically in fig. 5.14. It appears that the learning of a new sound produces, initially, its use as a "magic" sound, and, concurrently or very soon thereafter, a reappraisal of all sounds known to the infant, until a new status quo is achieved.

Redefinition of sounds already learned to a more specific referent, as occurred on August 15th and 22nd, September 30th and October 2nd, can also be seen as an event likely to require reappraisal of such sounds as are presently possessed. It is just this event that seems to contribute to, or be solely responsible for, peaking of inappropriate response on the four dates mentioned (see fig. 5.13) and for confusion in sound-class matching.

When Cody's linguistic development is compared with that of a normal human infant of the same age, a great fall-off in the former's abilities is seen. Halliday (1973), researching language acquisition prior to the mastery of approximations to words in adult usage, found that he could divide all such utterances into six categories: Instrumental, Regulatory, Interactional, Personal, Heuristic, Imaginative. Of these the first four appeared during $9\frac{1}{2}$ - 10 months of age, and these, plus the fifth and sixth categories by the 22nd.month.

Cody, by comparison, seems to have possessed primarily the Instrumental mode, i.e. "give me" (with the sound signifying which object/activity was desired). A speculative regulatory (command) role might possibly be given to the infant's use of the "thuh" sound ("do brushing again") but it is thought more likely that the sound was used simply as a fourth command ("more brush"). Interactional emissions were heard, but only rarely. To quote from Diary 13 (October, infant's age 15 months) verbatim:

"Cody bites me hard - I slap, then turn my back on him. He says "thuh", runs round to face me, climbs on my knee and, looking straight up at me (at my face) says "thuh" as if this would appease me and assuage my anger".

During the whole experimental period no sound was heard produced in a personal, heuristic or imaginative context. It seems, therefore, that Cody's "linguistic ability" during the duration of training consisted of two, perhaps three, of the four functions seen in a human child of approximately the same age. It is notable that of the functions observed, only one, (Instrumental emissions) had been trained, the other(s) being the infant's own creation. This is not to say that the subject possessed language, which even accepting the loosest functional definition would require the capacity to recognise and use new words, to understand and generate sentences, and by means of language to learn more about a language. However, it is unlikely that Halliday's subject, Michael, or Lock's "children" would also fulfil such criteria at a similar age. From this viewpoint, Cody's achievements become far more similar to the human condition. And while such comparability is extremely unliekly to persist, it is also extremely improbable that Cody had yet reached his limiting point as far as language development was concerned.

GLOTTOGENESIS

The evolution of language is a long-standing problem, the main points of which have been lucidly reviewed by Hewes (1973). Of all twelve major theories, this author chooses a gestural origin for language, basing his conclusions, in part, on the findings of Gardner and Gardner (op.cit) and Premack.

Lock (1977) also seems to incline to this view, combining gesture with vocal signals. The human child does appear to be placing an essentially emotional sound (crying) under voluntary control when he cries and raises his hand to be picked up. The Orang-utan of this study also resorted to this ploy, hand raising while crying appearing at the age of four months, and for the same reason. Later, the "puh" sound plus arm-raising was used to "ask for" contact-comfort. It is interesting to note that the Orang-utan does not appear capable of making the transition from crying to an arbitrary sound produced voluntarily. However, training (as was the case for "puh") can achieve such an end.

The human infant may voluntarily use a sound to communicate to another its needs, but what of the creatures wherein language might reasonably be thought to have its beginnings, Dart's "Southern Ape", the Australopithecines? Were these hominids whose brain size approximated that of the present-day Great Apes able to equal or better the capacities of Lock's children? Although not directly on the evolutionary line to Man, it has been speculated that language arose in Australopithecus, and, presumably, in the genus Homo also, by "singing" (Livingstone, 1973). Language is said to a mutation, and have arisen with the chance conjunction of babbling in hominid babies and a brain that can represent symbolically (Carini, 1970). Haldane (1955) suggested that the naming of objects and persons was the function of human vocalisation that led to the development of language and symbolling. The nub of the problem, therefore, seems to be the question "at what level of neuronal complexity can a primate begin to use voluntary vocalisations to signify to another an object or an action?". No matter how skilled in gestures, voluntary vocalisation is the _sine qua non_ of Man's primary communication system, vocal language. The work described in this chapter would seem to show that, given a neural matrix of equal complexity to the fifteen month Orang-utan infant (and sufficient training) it is possible for the association of a specific sound to a specific object to be formed. This may be regarded as a form of proto-naming. It is unlikely that such an ability (given the necessary environmental and selective pressures) would have been beyond the Australopithecines, whose brain volume was comparable to that of an adult Orang-utan.

It is, perhaps, an opportune time to say a few favourable words for a multi-theoretical approach to language evolution. Why any one theory must account _in toto_ for glottogenesis seems obsucre. It appears far more likely that various skills and abilities acted in concert to initiate the communication which led ultimately to the vocal system we know today as language. To divorce vocal language from gesture in this context is both artificial and unnecessary; there is a place for each. In the behaviour of Lock's subjects, with their integration of gesture, emotional and referential sounds, we may see a pale shadow of the prcesses which shaped the intitial stages of glottogenesis. These abilities do not seem, moreover, to be the unique province of Homo sapiens. The work reported here demonstrates that, albeit in a restricted form, they are within the bounds of competence of an infant Orang-utan. Thus, given "some millions of years under suitable environmental conditions" (Hewes, 1973) vocal, as well as gestural competence could well have developed in parallel, within the genus _Australopithecus_.

CONCLUSIONS

Ape "Languages"

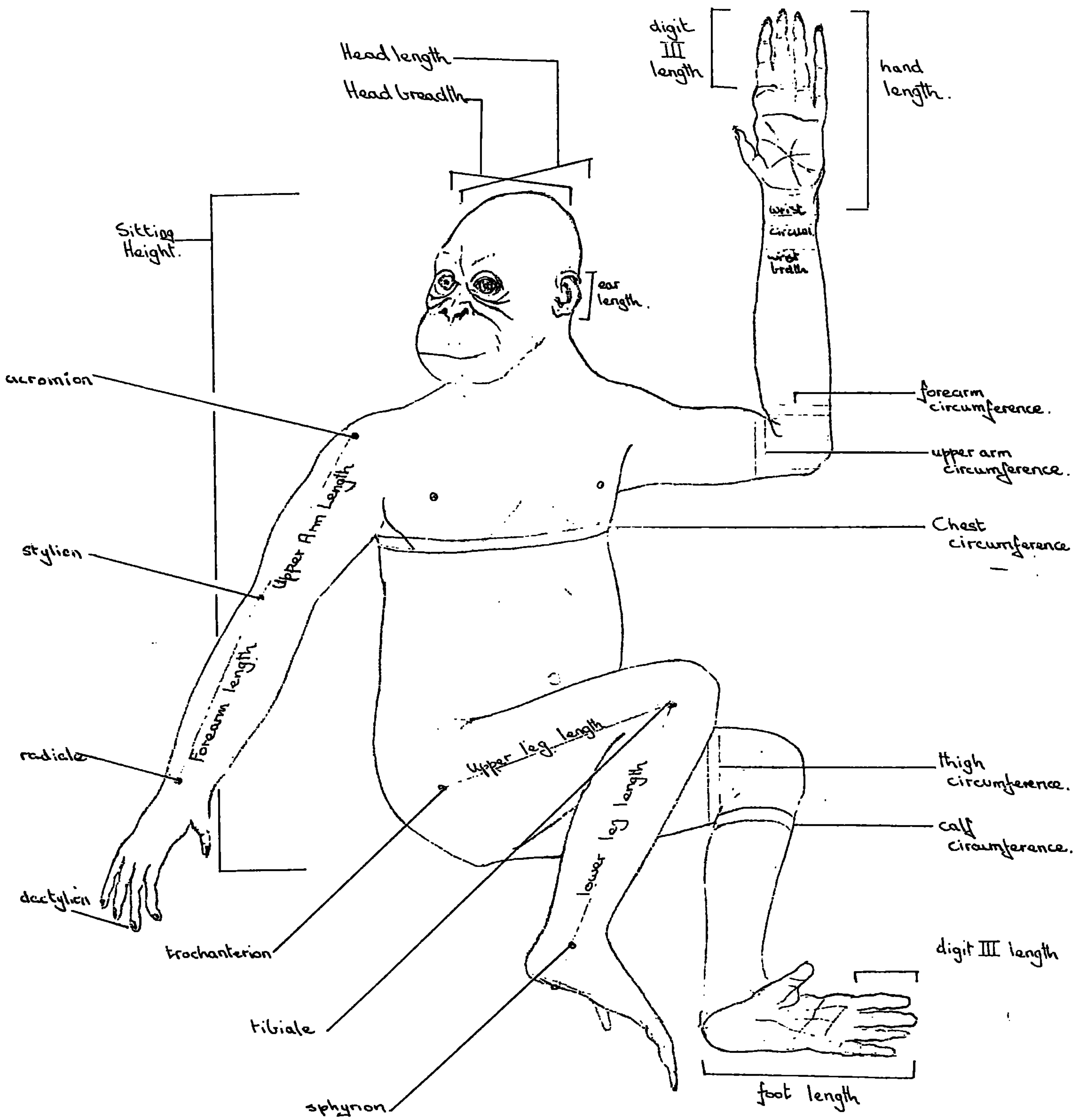
It has been conclusively demonstrated that no ape will ever perform human vocal language (Lieberman, 1974; Lieberman, Klatt and Wilson, 1969). Even given the necessary neural apparatus, and laryngeal musculature, it is simply impossible for the ape to produce the required articulatory configurations and manoeuvres of the supralaryngeal vocal tract necessary for the speech encoding which is essential to human vocal language. In addition, the "calibrating vowels" (i), (u) and (a) are not present in the (chimpanzee) phonetic repertoire, making speech decoding difficult, if not impossible. But there is, perhaps, too great an emphasis on "language" being considered exclusively as Human vocal language. Other symbolic systems such as sign language (ASL) do seem to allow the chimpanzee (and, latterly, the Gorilla "Koko", (Usher, 1978)) to attain a high level of information transfer. Whether this is termed language or not is simply a matter of definition - ASL is certainly used as the primary method of communication by many thousands of deaf humans in the U.S.A. who would no doubt be rather annoyed to be told that they do not possess a language.

ASL is a slower method of communicatory exchange than human vocal language, yet for many workers in this field it is a language. It should equally be possible to devise a fairly complex vocal "sign" language for use by apes. Indeed from the protocols and results described, Cody may be legitimately regarded as being at the initial training stages of such a system. It should be noted that Cody did prove capable of learning vocal responses, of using such responses appropriately, and of generalising their use. But Cody went beyond this learning task. The infant used his sounds in novel ways (phenomenological and novel requests) as well as seemingly playing with his sounds during his free time (spontaneous sounds). His abilities, especially with regard to his novel usage of sound, <u>and</u> his apparent ability to work at a high level of competency regardless of situation, person, or change of object within a particular object-class, are each highly suggestive of potentially more advanced capacities.

In the light of the domonstrated capacity of the infant to learn new sounds at an increasingly faster rate (and especially if training schedules such as those recommended above were to be implemented) it is considered that a "vocabulary" of sounds and their referents larger than that mastered by the infant would have been possible, given additional time to continue the research. As it is, further work (perhaps using the more socially-minded Chimpanzee as well as the Orang-utan) continuing to the 24 or 36 month level, would greatly advance our understanding of the true limits of this capacity in these species.

APPENDIX: ANTHROPOMETRIC MEASUREMENTS.

Data was collected at two week intervals over the course of the experiment. Apparatus used was metal anthropometric calipers and steel tape. Nineteen measurements were taken using the standard landmarks (found by palpation) as shown in fig A.1. overpage .· All figures in the table are in cms.



Head length
Head breadth
digit III length
hand length.
Sitting Height.
ear length.
wrist
acromion
Upper Arm Length
stylion
Forearm length
radiale
dactylion
forearm circumference.
upper arm circumference.
Chest circumference
upper leg length
lower leg length
trochanterion
tibiale
sphyrion
thigh circumference.
calf circumference.
digit III length
foot length

Measurement	DATE 12.9.73	26.9.73	10.10.73	24.10.73	7.11.73
1. Sitting Height	27.45	31.0	33.6	35.0	35.6
2. Wrist breadth	3.0	3.3	3.4	3.6	3.55
3. Wrist Circumference	9.7	9.9	10.5	10.6	10.8
4. Forearm Circumference		13.2	14.0	14.7	14.9
5. Upper arm circumference		10.9	11.4	12.0	11.8
6. Chest circumference	31.3	33.4	35.0	35.5	37.0
7. Head length	9.9	10.0	10.65	10.7	10.8
8. Head breadth	8.4	8.5	8.8	9.0	9.05
9. Ear length	2.85	2.9	3.0	3.0	3.15
10. Thigh Circumference	13.3	13.1	14.9	15.1	15.05
11. Calf circumference			12.2	12.6	12.6
12. Upper arm length	11.1	11.4	14.3	14.5	14.4
13. Lower arm length	10.9	11.3	11.3	11.6	11.9
14. Hand length	11.0	11.2	11.5	12.0	12.2
15. Upper leg length		8.0	7.5	8.7	8.8
16. Lower leg length		8.0	8.5	9.2	9.0
17. Foot length	12.0	11.9	12.3	13.0	13.2
18. Manus length	4.2	4.35	4.3	4.7	4.7
19. Pes length	2.8	3.7	3.4	4.0	3.85

Measurement	DATE 21.11.73	5.12.73	19.12.73	3.1.74	16.1.74	30.1.74	13.2.74	27.2.74
1.	36.5	36.7	37.0	37.3	37.8	37.95	38.1	38.3
2.	3.55	3.6	3.6	3.65	3.65	3.7	3.75	3.85
3.	11.2	11.3	11.45	11.45	11.8	11.9	11.9	11.95
4.	15.2	15.45	15.5	15.6	15.8	15.9	15.9	16.0
5.	12.2	12.45	12.55	12.85	13.05	13.3	13.5	13.7
6.	38.9	39.3	39.55	39.8	41.4	41.9	42.1	42.4
7.	10.9	11.2	11.35	11.45	11.4	11.5	11.5	11.6
8.	9.2	9.35	9.45	9.6	9.6	9.6	9.7	9.7
9.	3.2	3.2	3.2	3.4	3.3	3.3	3.35	3.3
10.	15.6	15.8	15.9	16.0	16.1	16.8	17.1	17.5
11.	12.8	13.3	13.7	14.1	14.1	14.3	14.4	14.6
12.	14.5	14.8	14.85	15.6	16.0	16.1	16.1	16.2
13.	12.2	12.7	13.5	14.3	14.35	14.6	14.8	14.8
14.	12.3	12.6	12.6	13.0	12.9	13.3	13.3	13.4
15.	8.9	9.5	9.9	10.1	10.25	10.4	10.6	10.8
16.	9.1	9.2	9.2	9.3	9.85	10.1	10.1	10.15
17.	13.35	13.5	13.7	13.75	13.75	14.5	14.65	14.75
18.	4.8	4.95	5.0	5.2	5.1	5.1	5.25	5.3
19.	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3

Measurement	DATE						
	14.3.74	27.3.74	10.4.74	24.4.74	8.5.74	22.5.74	5.6.74
1.	38.6	40.0	40.5	40.8	41.15	42.1	42.5
2.	3.85	3,85	3.85	3.8	3.85	3.9	3.9
3.	12.1	12.3	12.25	12.25	12.45	12.4	12.5
4.	16.2	16.6	16.75	16.8	17.0	17.1	17.3
5.	13.75	13.8	13.9	13.95	14.05	14.4	14.45
6.	43.0	44.1	44.6	45.0	45.6	46.0	46.4
7.	11.6	11.65	11.7	11.7	11.8	11.7	11.7
8.	9.7	9.75	9.75	9.8	9.85	9.85	9.95
9.	3.25	3.3	3.3	3.35	3.4	3.4	3.4
10.	17.9	18.4	18.6	18.6	18.7	18.9	19.2
11.	14.8	14.9	14.9	15.0	14.95	15.1	15.1
12.	16.45	17.3	17.45	17.6	17.8	18.0	18.3
13.	14.9	15.1	15.1	15.1	15.2	15.4	15.4
14.	13.55	13.8	13.9	13.9	14.0	14.25	14.3
15.	10.9	10.95	11.0	11.15	11.3	11.4	11.4
16.	10.2	10.4	10.5	10.7	11.0	11.4	11.7
17.	15.1	15.3	15.4	15.45	15.45	15.9	16.2
18.	5.3	5.3	5.3	5.4	5.4	5.5	5.6
19.	4.35	4.4	4.4	4.45	4.45	4.45	4.5
	18.6.74	3.7.74	17.7.74	31.7.74	14.8.74	28.8.74	2.10.74
1.	42.9	43.1	43.3	43.3	44.5	44.6	45.1
2.	3.9	3.9	4.0	4.0	4.0	4.0	4.05
3.	12.5	12.75	12.6	12.6	12.6	12.6	12.7
4.	17.6	17.6	17.75	17.9	18.1	18.2	18.2
5.	14.4	14.8	14.7	14.8	15.0	15.0	15.1
6.	46.6	46.4	46.6	47.0	47.2	47.2	47.4
7.	11.75	11.7	11.7	11.7	11.7	11.7	11.8
8.	9.9	9.95	9.9	9.9	9.9	9.9	9.9
9.	3.4	3.4	3.4	3.4	3.4	3.4	3.4
10.	19.3	20.0	20.0	20.1	20.1	20.2	20.4
11.	15.2	15.4	15.4	15.6	15.9	15.9	16.3
12.	19.0	18.9	18.9	19.0	19.0	19.1	19.1
13.	15.5	15.8	16.0	15.9	16.0	16.0	16.1
14.	14.4	14.7	14.9	14.9	15.0	15.2	15.5
15.	11.5	11.7	11.8	11.8	11.9	11.9	12.2
16.	11.8	11.8	11.7	11.7	11.7	11.8	12.0
17.	16.7	16.9	16.8	16.9	17.0	17.15	17.4
18.	5.7	5.65	5.7	5.7	5.8	5.8	6.1
19.	4.65	4.65	4.7	4.7	4.7	4.8	5.0

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