Attitudes of secondary school children to science, with special reference to differences in sex, age, ability and type of o-level course

Newton, D. P.

ABSTRACT.

Attitudes of Secondary School Children to Science, with special reference to Differences in Sex, Age, Ability and Type of O-Level Course.

Douglas P. Newton

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Related work was reviewed and fitted into a general scheme. A Thurstone attitude scale was constructed in a split-half form (19+19) to test attitudes to school science and science in general. Another, based on this, was constructed to test attitudes to school physics and physics in general. Reliabilities of both scales were 0.80 or more.

The sample was 1 066 pupils aged 11+ years to 15+ years in grammar and modern schools.

This sample was found to be significantly favourable to science and the grammar school sample was more favourable than the modern school sample. The younger pupils were more favourable in attitude than older pupils and boys were more favourable to science than girls. The samples were matched for proportions of each sex.

Using the attitude to physics scale, 117 fourth-year pupils of four grammar schools which taught physics according to the Nuffield Foundation Scheme were compared with 117 fourth-year pupils from equivalent streams in four grammar schools which taught physics in a conventional manner. There was no evidence to support the hypothesis that the Nuffield Scheme produced more favourable attitudes to physics than conventional approaches.

[Cont over]

There was a little evidence to support the view that a conventional approach produced more favourable attitudes to physics.

Some evidence was presented to show a small, significant and positive correlation between attitude to science and attainment in science. A model for simulating responses to the scales was constructed and compared favourably with the results.

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1.

INTRODUCTION

Not long ago, Professor Schofield wrote:

> 'We also need to look much more closely than perhaps we have in the past, at pupils' perception of the science we teach. We have too often thought of the problems we face in terms of our own perception, often idealized, of the science we place before our pupils. I do not wish to imply that we should teach simply in terms of our pupils' needs, but rather that we have failed to project ourselves into the minds of our pupils, and to imagine what school science is like to someone growing up in the extraordinary society we have bequeathed to them. The necessary imaginative leap may be beyond our powers, but the attempt should be made.'
>
> (1)

As Professor Schofield indicates, an awareness of the pupils' perception of science gives a self-conscious clarification of aims and objectives and a measure of the success or failure of any particular method of teaching. But, the pupil's reactions to that subject are not always known. Attitudes are an important aspect (2) of these reactions and perceptions.

At the beginning of science teaching, some attempts were made to assess interest and preference in school subjects but after that the field became, essentially, one of opinion. Often well-informed and based on experience these views are valuable in giving pointers to social attitudes and are helpful in formulating hypotheses for testing. The most common of these reflect on the sex-difference, as with Caroline Benn's article, 'Bring on the Girls':

> 'And there is one problem that women help to perpetuate themselves: our belief that we are unsuited for, unskilled at, and unwise to attempt to succeed in maths, mechanics, sciences, technology and engineering as we do in language or letters or commerce or catering. This goes back to the 19th century world of 'boys' subjects and 'girls' subjects.
>
> Even more damaging was the 1917 Board of Education regulation permitting girls over 15 in grammar schools to substitute domestic science for maths or physics in the academic course, thus spawning generations of under-numerate girls who went into teaching and back into schools unable to make others numerate.'
>
> (3)

As might be expected, such views were not restricted to Britain, for thirty years earlier, M. Lafitte defined his view of the difference as follows:

> 'Parlant en général, une femme semble plus frappée par un fait que par une idée générale; ..... nous (les hommes) sommes plus intéressés par la relation des choses que par les choses elles-mêmes. L'esprit des femmes est plus concret; celui des hommes plus abstrait.'
>
> (4)

Perhaps a succinct summary of these opinions is in the Gaelic proverb:

> 'Man to the hills, woman to the shore.'

Apart from the speculation, statistics do show a sex-difference. The entry figures in science for the Northern Universities Joint Matriculation Board for 1972 are:

SUBJECT	BOYS	GIRLS
Physics	25 235	8256
Chemistry	18 603	9510
Phys. with Chem.	1676	1727
Geology	1817	1037
Total	47 331	20530
Biology	13 777	22 459
General Science	952	1207
Human Biology	992	4639
Total	15 721	28 305

(Summary of N.J.J.M.B. Statistics. (5))

Some subjects, such as biology, do seem to be girls' subjects while others are the domain of the boys. In this particular year, the number of entries for boys up to the age of 16.11 years was 34 511 while for girls it was 36 705. In spite of a slightly greater number of girls, the entry in science was less than for boys.

This is also seen at a higher level;

Distribution of Students by field of study for U.K. (England and Wales). (6)

	Natural Sciences	Engineering	Medical Sciences	
Male	16 187	19 105	9 905	1957
Female	4 117	456	2 791	
Male	41 346	48 753	12 948	1967*
Female	11 324	565	5 192	

So the figures and opinions do indicate some sort of sex-difference. Will the pupils' attitudes to science reflect this difference? Do these attitudes contribute to it? Although, in the adult population, science is viewed favourably (7), is this still the case with pupils? After all, the pupil's concept of science must be based on limited, disparate information from classroom science, the mass media, peer groups and parents.

Furthermore, does a new approach, such as that of the Nuffield Project, affect the attitude? To know of any attitude which makes the teaching of science more difficult or inefficient, as well as easier and efficient is of great value.

This study attempts to answer some of these questions and thereby to help build a picture of how the pupil perceives science.

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*More recent figures show that there was little change, if any, between 1967 and 1971;

<u>Number of men for every woman for science subjects at various levels (120)</u>.

	O-level	A-level	new graduates
Biology	0.6	1.0	1.5
Chemistry	2.1	2.9	6.0
Physics	3.7	4.7	7.1

2.

Some General Points About Attitudes

Someone's point of view about a political party or about drinking alcohol or a child's attitude to school or , in particular, his attitude to science; these are all hypothetical constructs which cannot be observed directly. Attitudes have been postulated to explain certain consistent aspects of behaviour. If someone consistently refuses alcohol it could be that he simply does not like the taste, or he is following his doctor's orders or he may believe that no-one should take alcohol on the grounds that it causes a more or less loss of mental faculty. It could be that the reason has a wider basis, one which would exclude all drugs, or it may be seen as inimical to certain religious beliefs or moral values. These latter reasons are the ones at issue. They form a part of the attitude to drink. A. F. Shand (8), in the 1880's, saw a similar process in the way a mother cares for her child. The response may be varied and diffuse but the end is the same; one of succour, love and protection. In this sense the various responses of washing, feeding, teaching and talking to the child are all organised to that end. This organization of tendencies, Shand termed a sentiment. It was later described by Stout (9) while McDougall (10) used a related form of 'sentiment' "to denote those acquired conjunctions of ideas with emotional-cognative tendencies or dispositions" in his theory of character based on instincts. The concept of attitude as an 'organisation of psychological states' (11) is related to these early forerunners.

In the first example, the attitude to drink can range from favourable to moderate to most unfavourable, perhaps 'tea-total' in the extreme. Similarly a child's attitude to school can show the same variation. Thurstone (12) expressed this aspect as;

> 'the degree of positive or negative affect associated with some psychological object',

the objects here being alcohol and school.

Allport's definition of attitude embodies this view (13);

> (An attitude is) 'A mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to objects, or situations with which it is related.'

Social attitudes are distinguished from other attitudes in that a 'social attitude is formed in relation to social stimulus situations and is shared by members of a group or of a given society.' (after Sherif and Sherif (14)). An individual, isolated from birth, could not have social attitudes. His attitudes would be governed and instigated by the non-human environment. They might, indeed, be meta-physical but unless they are shared attitudes, they are not 'measurable' social attitudes. In addition, attitudes must be fairly stable. A transient 'attitude' need be no more than a passing thought and would present no observable tendency to act in a certain manner. These points are expressed by Campbell (15);

> 'A social attitude is (or is evidenced by) consistency in response to social objects.'

A more recent definition by Newcomb (et al) (16) follows the same lines;

> 'From a cognitive point of view, then, an attitude represents an organization of valenced cognitions. From a motivational point of view, an attitude represents a state of readiness for motive arousal. This double definition is due to the position of attitude between cognitive processes (thought and memory) and motivational processes (emotion and striving).'

Again, one by M. Rokeach (1966), (17), is as follows;

> 'An attitude may be defined as a learned and relatively enduring organization of beliefs about an object or situation disposing a person toward some preferred response.'

So, although Allport's definition has been rephrased, it still embodies the essential points about attitudes. They are ; readiness or tendency to 'act' in a certain direction with a degree of consistency.

Attitudes are learned and would seem to be based on experience. Mental processes organise past experiences into a coherent whole which can be used in a new situation. Past experience shows that men in authority like to be treated with respect, deference and, perhaps, to be addressed as 'sir'. Other people subscribe to this behaviour and relationships progress smoothly when it is accepted. When introduced to someone else in a similar position, the appropriate attitude gives the immediate response in terms of demeanour and choice of words. The attitude need not be so simple. An equivalence of authority with power would further colour the behaviour.

Thus, attitudes are means of adaptation to the environment. Katz (18) has listed the main functions of attitudes as follows;

1. The adjustment function:- this allows the organism to maximise rewards and minimise penalties when achieving goals. In some ways it could be thought of as a hedonistic function and can reflect the utility of the object.

2. Ego-defensive function;- some attitudes are aimed at protecting the self from the self and from others. A snobbish attitude could fall in this group.

3. Value-expressive function:- A group of attitudes may form a value system which can govern a wide section of behaviour, as with ethical systems. In this case they function to express the self to others as one would like to be seen, for example, intelligent, moral or devout.

4. Knowledge function:- Attitudes co-ordinate and group past experiences and knowledge into generalisations which are useful in the future behaviour of the organism. They 'provide a rational structure on which to suspend the perceived chaotic universe.'

He also observes that attitudes have the following components:

(a) a cognitive component; belief - disbelief

(b) an affect component; like - dislike

(c) an action component; readiness to respond

(19)

and, in use, employ these singly or in combination.

These functions and components will be referred to again in relation to attitude to science.

Some established general properties of attitudes (20)

1. Attitudes are learned.
2. Attitudes are more or less lasting.
3. Attitudes are directed from a person to an object.
4. Attitudes can form value systems.

In addition to these, by the definition of an attitude, it is expected that observable behaviour should have some positive correlation with the attitude. Some workers, for example, Campbell with American voting and associated attitudes (21) & Steininger (121), have had some success, others have established little or no correlation. Since our lives are governed, not by one attitude but by many and these may interact, basing predictions on only one attitude is often difficult. Campbell, in the same work, showed that knowledge of several attitudes allows a better prediction of voting intentions. In a classroom situation, if it is required to predict success in a subject from the attitude then, similarly, attitudes to other subjects, examinations and so on are helpful, or even essential. Further problems arise when the measure of overt behaviour (that is, success in examinations) is an examination of the General Certificate of Education type which is given to a year group of mixed ability streamed into, say, four classes. Here, lack of success in a 'D' stream could go with a very favourable attitude (attitude) while a less favourably inclined 'A' stream pupil exceeds the achievement of the other.

That attitudes affect perception and therefore learning and recall was shown long ago by Bartlett working with picture recall where the pictures were emotionally loaded (22).

So attitudes are important. Sherif and Sherif point out that;

> 'Some authors have gone so far as to equate social psychology with the study of social attitudes.'
>
> (23)

and K. M. Evans, writing on attitudes in education, says;

> 'It would be difficult to overstress the influence of attitudes and interests in the lives of individual people.'
>
> (24)

3.

Attitudes to Science

A young pupil's experience of science will be varied but mainly limited to the learner's side. In school, his scientific education may consist of physics, chemistry, biology and, perhaps, geology and physical geography. Or it may be compounded as one in general science. He will be shown or guided to discover basic laws, classifications and simple generalisations. Science in its most tangible form will be seen and interpreted from this point of view.

Outside of the formal learning situation, he may see other aspects of science through the mass media, especially the television. Pressing social problems of population and the environment may be presented to him from a scientific-moral point of view. His own reading and children's programmes could show him science as a pastime or a scientific hobby. Linked with his school work, the power of science, its aesthetic appeal or its intrinsic interest and utility may slowly percolate the mind of the pupil as he matures. The views and directions of parents will also be involved.

These experiences will go together to form an attitude to science. Other developing attitudes or value systems may interact and conflict with it until the view is assimilated. In this respect, children's attitudes may not be completely consistent and certainly not more so than adults'. For example, a child of a Jehovah's Witness studying biology may develop a very favourable attitude to that subject. However, the theory of the evolution of the species may produce deep conflict between this attitude and previous attitudes, especially where these are powerfully reinforced by parents (25). Piaget and Peel have shown that younger pupils have a more limited power of comparison so greater discrepancies might be expected here.

Of Katz's functions of an attitude, most can be seen to apply in the case of attitude to science. In the school, the adjustment function will operate for some pupils in that they will like the subject to please the teacher and obtain praise and approval. Certainly the knowledge function applies, since, as a branch of intentionally organised knowledge, science fits into the requirements. Older pupils, beginning to think in a certain manner may also incorporate something of the value-expressive function. Wishing to appear precise and logical, a general, positive scientific attitude would suit this purpose. The cliché: 'It stands to reason' fits into this category. With young pupils, the ego-defensive aspect may apply only in a limited way but at a more sophisticated age, once a point of view has been developed, the need to defend it will develop as well.

In summary, a pupil can have a wide, if sometimes second-hand, experience of science. The most immediate contact for the pupil is in school science since it is this in which he is most involved. This might lead us to expect an interpretation seen through the experience of school science and in some ways limited by it.

4.

Review of Related Research

The chart shows a summary of the relationship of science attitudes with its causes and effects. The links are shown to be true from research findings and many would apply to attitudes to other subjects, for example, the arts.

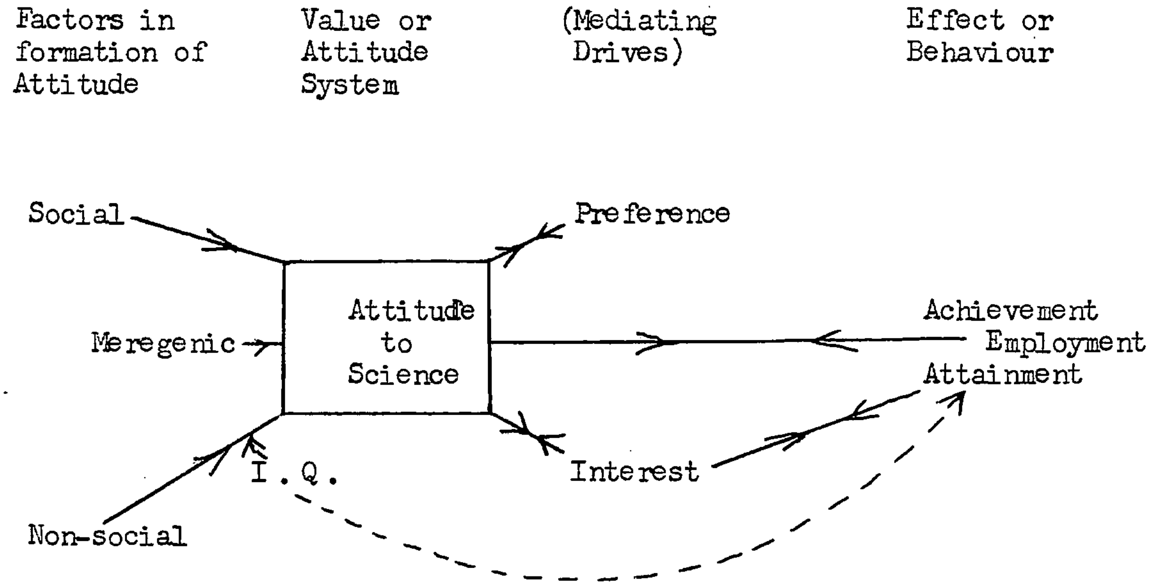


Fig. 1.

4.1 Factors in the formation of attitudes to science.

General Social Factors.

In the past girls have had less opportunity, even active discouragement, in science than have boys. Indeed, girls were ascribed with a lack of stamina such that the effort needed to acquire scientific knowledge would have been thought sufficient to cause mental damage (26). This attitude was still prevalent later as reported by B.A.Howard in 1928, when he writes of recommendations that 'the.... "First School Examinations should be taken by girls one year later than boys"; in other words, they suggest equating the girl of 17 to the boy of 16.' (27). Division of labour between the sexes was an axiomatic justification of differences in education (28) and governesses taught only 'accomplishments'; needlework, dancing and languages, to the girls (29).

By the turn of the century, where science was included in the curriculum for girls, it was mainly biological (30). In 1911, S. Bryant writes;

> 'Every well brought-up girl, for instance, shapes herself in accordance with the demand for sharing her mother's interest in domestic problems; as a student in the chemical laboratory it falls within her scope to investigate some of these, especially those problems of cleaning in which it is sometimes thought that none but women take an interest. Boys, on the other hand, with their greater interest in muscular achievement, turn from their earliest years to the investigation of muscle-saving and power displaying machinery of all kinds; these interests serve them well in the study of physics; especially if it be associated with some manual construction as well as with laboratory work.'
>
> (31)

However, pressure had already begun for, in 1901, Dorothea Beale was attempting to operate a timetable which included object lessons for girls under 8 years, botany, zoology, astronomy, hygiene, geography from 8 years to 16 years (between 2 and 4 hours per week) with elementary chemistry and physics for those over 12 years, in addition (32). During the remaining years, the move towards a fuller education continued. J. Kamm makes the comment;

> 'In class subjects there was a tendency (it is still noticed today in the vast majority of all schools for girls) for the girls to be weaker than the boys in mathematics and science but stronger in all literary subjects.'
>
> (33)

She ascribes this to the lack of equal opportunity and acceptance of the division of labour, both historically and at present.

Many parents and most grandparents will have been educated under these principles and have absorbed these attitudes. This provides a background and an early, social basis for the development of children's attitudes to science; an attitude which may incorporate a view of 'girls' subjects' and 'boys' subjects'.

A past lack of opportunity gives fewer females working in and teaching science. This is 'proof' for a child that women do not do certain jobs and is part of a self-fulfilling prophecy.

Particular Social Factors

Cross-cultural data has shown the division of labour between the sexes to be widespread (34). S.M. Dornbusch sums this up well;

> 'Socially, for the survival of the species, groups must not assign tasks to females that prevents their acting as mothers.' (35)

But role-differentiation extends deep into behaviour, as demonstrated by Terman and Miles (36), working in America. They found sex differences in word association, ink blot association, information, emotional and ethical responses, interests, personality, occupational preferences and introvertive responses. The general conclusion was that the female was concerned with aesthetic objects, personal embellishment, and dress while the male preferred adventure, extra-domestic interests (especially in employment) and scientific and mechanical affairs. In summary, the differences had two aspects, one of interests and the other of emotions and impulses.

In Britain, Hallworth and Waite (37 and 38), making a comparative study of value judgements of adolescents in the fourth year of the secondary school, found a well established 'Feminine Image' factor for the girls. This was defined as 'what the girls would like to be as a woman in terms of dress, pleasure, ambition, home and freedom.' They also found that girls associated school and the teacher with men and boys. For boys; success, ambition, reward, the future, games and study formed the most important cluster of concepts. Slee (39) found similar results for secondary modern school pupils. In addition, she found that the sex-image for boys is more generalised at this age.

So it seems reasonable to assume that sex-differentiation pressures exist and that they will be expressed in views about things like employment, especially might this be noticed with girls. Since science is a field of employment which may have masculine loading factors, then these could be reflected in attitudes.

Ormerod (40), with a Likert scale for measuring the 'social implications' factor in attitudes to science administered to 261 boys and 264 girls in the 13 - 14 year age group, found that choice for or against a science option appeared to be influenced strongly by this factor in the case of girls. By 'social implications' he refers to the benefit or harm science is supposedly bringing to mankind.

In America, there is evidence of a greater social orientation among women (41) which may be related to a similar 'social implications' factor there.

This concern with the social implications of science would fit in well with the general Feminine Image factor with its concern for the home.

The learning of subtleties of the sex-image starts very early in the child's life. Although 3 year old children show incomplete sex-awareness in toy selection (42), by 11 years old, more than half realise that only genitalia distinguish between men and women regardless of hair and clothes (43). At that age girls are better at discrimination than boys. Prior to that there must be a sufficient concensus to give sex-typing according to other cues. A very young child will call all men 'Daddy', so their behaviour and appearance must agree with <u>his</u> 'Daddy'-image. His mother teaches further discrimination.

The play, hobbies and collecting patterns of a child are often guided by parents (44). A boy is encouraged to play with a constructional toy, such as Meccano, or with a train set or with his tipping lorry. Girls' pursuits are guided to prams and dolls' houses. In a study of children's interests at a

British science museum, Brooks and Vernon (45) found that 133 500 boys attended compared with 54 000 girls in one year. Either more boys attend of their own accord or more are sent or taken by parents.

In collecting things, Witty and Lehman (46) have shown that American girls were 'attracted by objects which may be used for personal adornment' while the objects American boys collected tended not to have aesthetic or sentimental appeal. These factors would point to the differing experiential background of boys and girls. Male superiority in mechanical comprehension has also been demonstrated with matched male and female groups (47). There is some British evidence of boys drawing on their mechanical experience (for example, rotation of cogs) (48) in their school work but their superiority does not become apparent in answering science questions until the secondary school age. This was based on children's answers to deductive scientific problems.

Yet one would expect that there is a minimum level of experience to which everyone is exposed and that this would be sufficient to remove, by incidental learning, sex-differences. Perhaps socially-directed selective-learning is also brought into play, discriminating against the learning of non-appropriate material. Women do tend to retain household information better than men, for example, spoon-size capacities, while men retain other numerical data, for example, population figures, better (49). This is for a sample matched on digit-span memory.

The importance of parents and peer groups has been further brought out in some American studies on attitude to mathematics. Elton and Rose (50) found that girls avoid mathematics because it is masculine in character, while, on a more general level, Poffenberger and Norton (51) showed that a factor in separating poor attitude students from good attitude students was the attitude of the father to mathematics and the expectation of achievement in mathematics of both parents. Elton and Rose concluded that their evidence supported the hypothesis 'that cultural differences in sex training lead to female ineptitude in maths.' and that 'sex incongruence is an inhibitory motive in learning.'

Similar sex-differences in attainment in mathematics in Britain have been found by Saad (55) which will be discussed later in another context.

In society at large, Evans (7) has recently shown science to have a favourable image. The attitude to science is positive in that the majority see science as helping mankind and being of great value to society. This attitudinal background should have an influence on the children who live in it. In a highly organised, industrial society the dependence on science and engineering is great and employment reflects this. Children will be submerged in the aspect from birth. (The favourable, general attitude is also found in America at the present time (122).)

Meregenic Factors.

Intelligence is a factor which, to some extent is innate yet can be influenced by socialization and personality. Other factors are similarly indeterminate. They have elements of being genetically determined and yet are manipulated by the social and physical environment. Such factors will be termed 'meregenic' — fated from birth (52). This term is adopted because it would be difficult, if not impossible, to rank such factors between the two extremes of purely social influences and purely innate.

In the case of intelligence, high achievement could be obtained independent of attitude. In some respects, intelligence can by-pass attitude where an overriding value of success applies. This is indicated on the diagram (Fig. 1.). An individual's intelligence may seem to apply only to science. Past experience and social background may have discriminated against subjects like languages. Here a skill in one area will have been acquired to advantage in terms of achievement and favourable attitude.

Another such factor is spatial ability. American and British studies have established that spatial ability exists and that boys are generally better than girls working with spatial concepts. As long ago as 1917, E. F. Mulhall (53) showed American boys between 8½ - 17½ years to remember forms better than girls while girls remembered words better. Hertzberg and Lepkin (54) confirm these results with 16 - 18 year old American children. The boys were higher in appreciation of space concepts than the girls while the girls were higher on word fluency. Saad (55), with 100 British pupils of each sex in the fourth and fifth years of a grammar school, making a study of ability in mathematics found that the boys were better at geometric problems than the girls. This he interprets as a superiority in spatial ability. The understanding of numerical concepts and principles followed the same pattern.

It is significant that Lewis (56) found that spatial ability was needed for physics while verbal ability helped in biology, in relation to his work on 300 mixed pupils in Northern Ireland. American studies have also shown boys to be superior on 'restructuring' in problem solving and this could have an effect in fields such as physics (57).

Innate Factors.

There are indications that spatial ability is inherited via a sex-linked, recessive gene (123). In this case, this automatically lowers the proportion of girls relative to boys with spatial ability and hence ability in physics (for further details see note 124).

In the case of rate of maturation, girls mature faster than boys, as is shown in the rate of hand-bone development (58). Yet this does not mean that girls' mental abilities develop at this faster rate. Boys can draw simple scientific inferences by the age of 9 years while this ability is not apparent in girls until 10½ or 11 years old.

Basic, physical differences could have an effect through the intermediaries of emotion and personality. It has been established that menstruation not only affects the physical state of the female but also her mental abilities. Eagleson, as long ago as 1927, found that the most efficient time during a cycle was post-menstrual and the least efficient pre-menstrual (127) when it came to testing such abilities as simple arithmetical calculation. It seems likely that the reaction time of a female is impaired pre and during menstruation (see also Appendix S). These findings may reflect a difference in an ability to concentrate during the cycle. In terms of attitude, this particular point should affect all subjects needing concentration to the same extent and need not give rise to differences between subjects.

Korner (115) has reviewed some sources of sex differences and comments that;

> 'While there is cumulative evidence in the literature that males and females are treated differently from the start, a review of the sex differences found among neonates clearly points to innate sex differences as well.'

It remains difficult to separate the causes of such differences. Korner discusses the work of Moss and Robson (1968) and Thoman (1972) which show differences in maternal behaviour towards their children from birth, there being more vocalising with girls and more holding of boys in response to fretting. Lewis, Kagan and Kalafat (116)report that for a sample of 16 boys and 16 girls a t 24 weeks old responding to projected pictures, girls studied faces more than boys and boys showed a longer fixation to a helix than a point. It may be that, for girls, this is a result of the higher rate of vocalisng they experiance. Basic differences in strength and skin sensitivity do exist at or near birth and this may be due to androgens in foetal life required for the foetus to become male. The full extent of hormones on sex differences is not known.

So it is possible that 'scientific ability' or some aspects of it can be inherited. Indeed, the geneologies of exceptional families like the Darwins lends some weight to the theory. Just as with the Strauss family and music and the Bernouilli family and mathematics, excellence in science can be concentrated in one family. This is not only so laterally, that is, amongst siblings; but is found to occur longitudinally over great lengths of time (126).

Summary.

The values of society in terms of science education and scientific employment, while generally favourable, have been twofold in their view of the male and female. This may still exist by working through a feminine image factor. Socialization for sex-roles is different for the two sexes and would seem to both cause and encourage differences which result in differences in achievement and may result in differences in attitude. Such factors as spatial ability, with its association with boys and its relationship with mathematics and physics, and verbal ability and its association with girls, are examples.

The influence of the family, community and school will be important since the child's experience arises from these.

Although some of the research is on the American society and so care must be taken in applying it elsewhere, the general results seem to fit in well with the British work and add weight to it.

4.2 Science: Preference, Interest and Attitude.

While attitude to science represents a general orientation or valenced cognition regarding science in terms of school subject, social implications and future employment, 'interest is more specific and is directed towards a particular object or activity.' (59). Interest in science may refer to interest in lessons in terms of laboratory work, demonstrations or understanding the way things function. On the other hand, it could refer particularly to some other aspect under the title 'science'. The function of interest is internal satisfaction rather than success (60).

Preference is also directed towards a particular object but its basis is wider than that of interest. Preference for an object —— that is, science —— may be a result of interest or it may be because it is a necessary step for some goal, such as employment, or it may be to avoid something preferred less. This latter point brings out the essence of preference as one of comparison or choice. Given two or more objects or subjects, one may be preferred. Given one subject, it may or may not be interesting. Interest and preference are more specific than attitude but bear some importance in attitude formation. Kelly (61), in measuring factors influencing preference for science, accepts preference as indicative of attitudes. Meyer and Penfold (62) have found significant positive correlations between attitude towards science as a general concept and interest in science of 0.48 and between attitude to science as a school subject and interest in science of 0.58. On these bases, interest and preference will be considered as having some value in studying attitudes.

Amongst the earliest work is that of E.O Lewis (63) of 1913 - 1914 on 8 000 mixed pupils of standards II to VII (aged 7 years to 14 years) in London and South Wales, most in elementary schools. Science and nature study were relatively less popular than the manual subjects but 'science' here was mainly hygiene and object lessons. However, he noted 'that science, when taught by a special teacher, was much more popular than in schools where the class teacher taught the subject.'

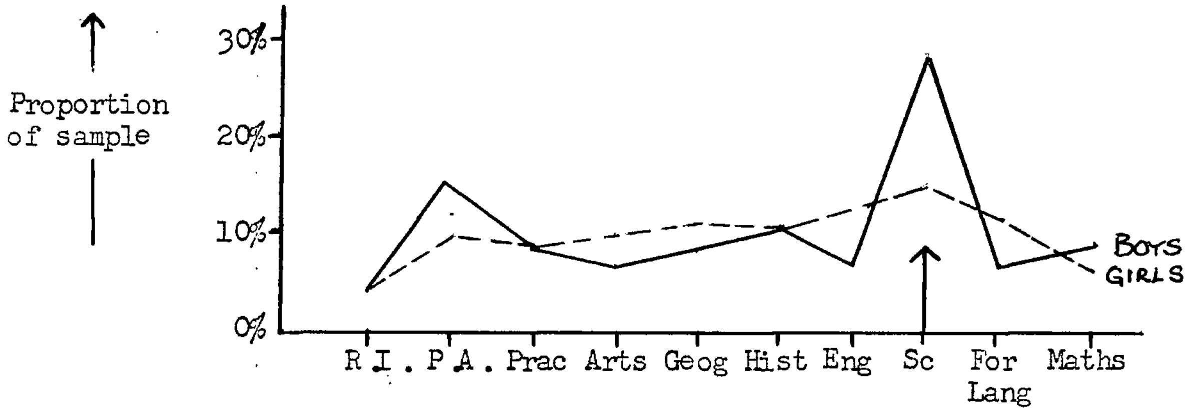
Of more value is the work of 1919 (published 1921 - 22) of Don and Grigor on the preferences of 3 620 mixed pupils at the Intermediate Certificate Stage in the West of Scotland (64). Their results are presented in a form which can be subjected to statistical analysis (see Appendix A). The results show a highly significant difference between boys and girls, with boys more favourable to science ($\chi^2 = 244$ with 2 d.f. $p \ll 0.001$ Kolmogorov - Smirnov test (65)). Mathematics shows a similar result while in English and French the situation reverses. This fits in well with what might be expected from the factors operating at that time.

In 1935, Pritchard reports on the relative popularity of subjects in secondary schools using 8 273 children (66). The system of coding popularity does not facilitate statistical analysis but the figures do have some interest. For physics, boys' interests tended to stabilise at about 15 years while girls' showed a dip in popularity at 14 years, followed by an increase which may have been due to selecting out those girls showing least interest or aptitude for the subject. In chemistry, popularity with the boys remains fairly steady while for the girls it slowly declines. (See Appendix B).

In the following year, Shakespeare did some similar work for elementary school subjects with 9 127 mixed London pupils (67). He ranked the main subjects for boys and girls for the age 13 years according to preference. Analysis shows the two lists to differ, nature study and handwork being at the top for the boys while much further down for girls. (See Appendix C). The Spearman rank correlation coefficient is 0.35 and is not statistically significant. So girls and boys generally 'preferred' different subjects.

How much a pupil 'enjoys' a subject was assessed by Stevens from over 2 000 grammar school pupils in the South of England (69) and was published in 1960. Results of a questionnaire were collected from second and fourth year pupils. The graph, (Fig. 2,) illustrates the results with 26% of boys compared with 15% of girls. Taking both together, science ranked as one of the most enjoyed of subjects. The discrepancy between the sexes could be ascribed to the feminine-image factors or to the other social, meregenic or innate factors or to the way in which the subject is taught.

Fig. 2. Proportion choosing the given subjects as 'most enjoyed'.



KEY:		
	R.I.	Religious Instruction
	P.A.	Physical Activities
	Prac.	Practical Work (Crafts etc.)
	Arts	Art, Pottery etc.
	Geog.	Geography
	Hist.	History
	Eng.	English
	Sc.	Science
	For Lang.	Foreign Languages
	Maths.	Mathematics

In the case of 'least liked' the figure for both boys and girls was 12% for sciences.

When asked about which was their 'best' subject, 20% of boys thought science was and 12% of girls thought the same. The graphs, (Fig. 3,) show this and Fig. 4. does the same for the 'weakest' subjects.

Fig. 3. Proportion choosing the given subjects as their 'best' subjects.

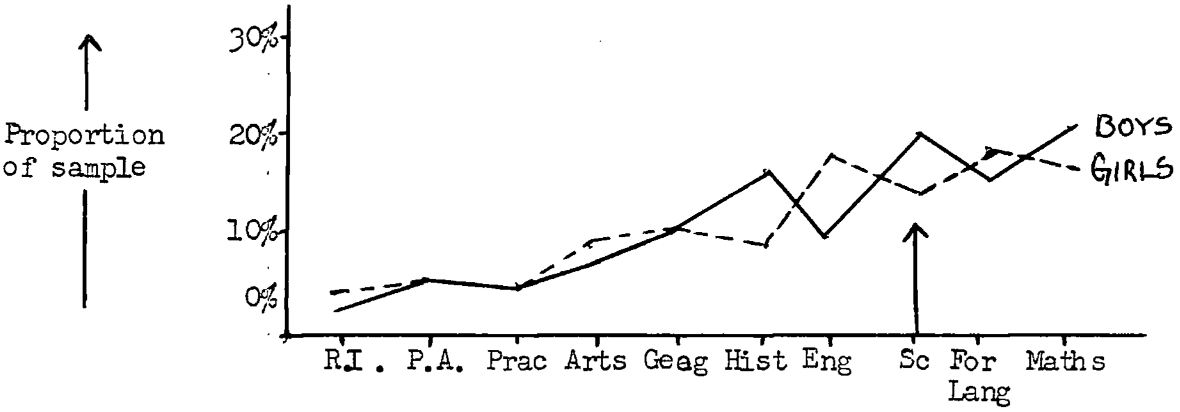
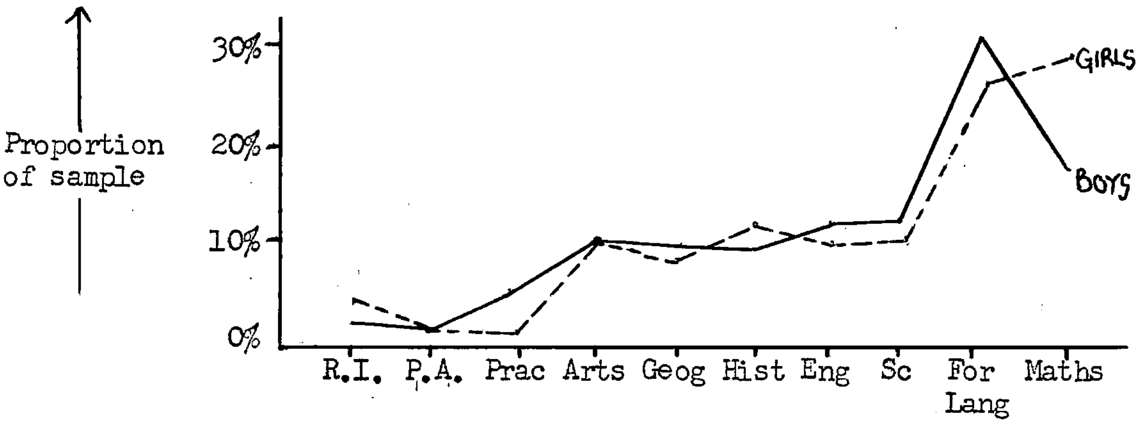


Fig. 4. Proportion choosing the given subjects as their 'weakest' subjects.



The 'most enjoyed' classification can be loosely equated with interest. Although the reasons for enjoying a subject may not be interest alone it seems a possibility that where science is enjoyed it will tend to dispose the pupil favourably to it in terms of attitude. The pupils' views of their own ability in terms of 'best' and 'weakest' subjects follows what might be expected from the 'most enjoyed' results. 'Best' subjects are approximately those 'most enjoyed' and the 'weakest' are those less enjoyed.

More recently, chapter three of Enquiry 1 (70) was concerned with the value and interest of school subjects as seen by parents, present and ex-pupils and has some relevant data. Considering the 13 - 16 year old group and, in particular, the 15 year old group of leavers taking science, the proportions saying that the subject is useful were:

BOYS	60%	GIRLS	40%

Similarly, those saying it was interesting were:

BOYS	60%	GIRLS	44%

The parents who considered science of importance for their child were:

for BOYS	40%	for GIRLS	24%

These figures would seem to confirm those of Don and Grigor of half a century earlier. In some respects, the change is remarkably small in comparison with the expansion of science. Boys favour science and girls do not. The parents support this difference.

In 1968, the Educational (Research) Committee of the A.S.E. collected information about the attitudes of 12/13 year old pupils to science as it is taught and towards scientists (71). This consisted of 50 hours of tape-recordings of small groups of children who were encouraged to talk freely about their reactions to science, science teaching, and to science and scientists as a whole. C. Selmes worked on the initial analysis and based his report on about one-quarter of the edited recordings.

To encourage freedom of expression, no teacher was present and an older boy led the discussion. Selmes sees the weakness here in that many questions are 'loaded' towards the older boy's attitudes and that sometimes discussion is limited to agreement on the part of the pupils.

Analysis consisted of counting recurring phrases and expressions in the responses. One conclusion in the attitude to physics was that pupils thought that science was more suitable for boys (5%) than for girls (10%). (The percentage indicates the frequency of that response.) 8% considered that scientists are usually men and that the job is not one for women.

The technique can be criticised on the grounds that group dynamics will allow certain members a disproportionate part in the discussion and that the discussion is being led by an unskilled boy. Negative points of view could be emphasised easily compared with positive comments, and vice versa.

Ashton and Meredith considered the attitudes of sixth-formers to science by examining answers to a question on the General Studies paper of the Joint Matriculation Board (72). The question was to account for the increase in university arts and social? science applications at the expense of the natural sciences. From 92 girls and 86 boys, over half thought that science required a high level of intelligence but offered little scope for self-expression. The greatest differences were with 25% of boys explaining the arts/social science bias on grounds of a desire to help the community directly while 4% of girls gave that reason. 25% of boys used as an explanation a 'late introduction to science and an early arts bias' compared with 42% of girls.

Unfortunately there is no way of assessing the intensity with which the various comments are held. Nor is the sample necessarily representative. It is possible that those who are involved in the arts, social science/ natural science choice will not have contributed to that question. The answers themselves need not reflect the truth but may be widely held or 'expected' opinions. However they do give a hint of the way in which the pupils are thinking.

More generally, at the Sixth Form level, Wilkinson (73) has discussed pupils preferences and attitudes in relation to subject choice and found that boys doing sciences expressed preferences for things over people and ideas. Girls tended to have an interest in activities involving companionship.

Zinn, in an American study (74), showed that the future scientist's interest shows early in life, in fact between the ages of 10 and 12 years. Kelly (61), with London grammar school boys mentioned earlier, also found that those who specialise in science had a long- standing interest, but did not find an approximate age of origin of this bias. Of great importance, he also found that the influence of the teacher on the pupil's attitudes to science was small. This suprising result was confirmed in more detail by Meyer and Penfold (62), also mentioned earlier, who found interest in science not to be related to the attitude of the science teacher to the pupil. This was for the 1st and 3rd year pupils of a bilateral London co-educational school of modern school ability range. Together, these results would indicate that attitude to science has its roots deeper than simply in secondary school experience, and possibly earlier than in the secondary school. Other workers have also found that the attitude to the science teacher does not affect the attitude of the pupils to science (128).

Kelly, Meyer and Penfold also conclude that the father's and mother's actual interest in and attitude to school science is not related to their children's interest. It is the pupil's own appraisal of parental attitudes rather than the parents' stated views which seem to be important, according to Meyer and Penfold. These workers also showed a lack of association between the father's occupation and the child's degree of scientific interest.

Summary

Interest and preference was related to attitude and the early work examined. More recent work still indicates sex-differences in interest but also an overall interest in science which has an early basis in the child's life. There is evidence that the attitude/interest is not related to the teacher's attitudes. The parents' contribution was in what their children thought their attitudes to be.

4.3 Science: Achievement and Attainment as Attitude-based Behaviour.

Previously, interest and preference were shown to be positively related to attitude. Interest is similarly related to behaviour and, in particular, to achievement. Barrilleaux (75), with 800 American students found that in the I.Q. range 86 - 139 there was a high, and very significant relationship between the relative intensity of science interest and the probability of success in high school science. He also cites the work of Mallinson and Van Dragt (76) who showed that the interests in science and mathematics are stable over long periods of time. Meyer and Penfold (62) believe this to be the case for British children;

> 'There is evidence that a good attainment may follow an interest in science.'
>
> (p. 36)

This link between attitude and behaviour supports the definition of attitude as a 'tendency to act' or as a measure of 'behavioural intentions'.

But, on a general level, some evidence is conflicting. The link between attitude and behaviour is difficult to demonstrate. In American studies, Brooks, Melvin and Weynard (77) found the Kuder preference record to have no predictive value of academic success at the college level. Postman and Murphy (78) found conflicting evidence in the relationship between attitude and associative memory with 8th graders and Manello (79) found attitude did not interfere with or facilitate learning and recall with 8th graders. However, Manello does accept (80) that 'There already exists a large body of experimental evidence indicating how attitudes affect our perceptions, our judgements, and our overt behaviour.' One such piece of work is that of Bartlett (22), in Britain, on remembering, mentioned earlier.

Clues to the reasons for this conflict are in the work of Campbell (21) in which he increased the predictive value of political attitudes in voting behaviour by assessing other relevant attitudes. Similarly, Holman (81) was able to predict particular behavioural intentions by increasing the supporting information. This would indicate that a greater knowledge of supporting and conflicting attitude or value systems allows a fairer assessment of behaviour.

In the relationship between interest and formation of occupational choice among British children, Chown (82) found that the factor of interest in school subjects being related to job choice was more important for grammar school pupils than for modern school pupils. (In addition, the girls tended to make their decision earlier than the boys.) This brings out another point. To use a measure of attainment intended for those of higher ability across the full ability range in a school may lead to low correlations. For example, the G.C.E. may provide a measure of success for all of relatively high I.Q. regardless of attitude while those of favourable attitude and low I.Q. will have a low achievement. In the example provided by Chown, the higher ability of the grammar school pupils will afford them the opportunity to follow their interests. The lower ability of the others could preclude them from their interests. This serves to illustrate that at least one more factor is helpful when predicting behaviour from an attitude.

American studies of achievement and attainment in science have shown a clear sex-difference with the girls being inferior to the boys. Some early work by Hughes (1925) on achievement in physics (83) found this to be especially the case in mechanics, heat, electricity and magnetism. The difference was insignificant for sound and light. For nature study and science, Heilman (84) confirmed the sex-difference in 1933 and in the following year, Hurd (85) repeated the confirmation for high school physics. In Hurd's experiment, with 134 pupils of each sex, the boys had a superiority on a preliminary test, indicating some existing knowledge and, although the girls gained more in the test after instruction, they had not gained sufficient to remove the initial difference. Stroud and Lindquist (86) in 1942 again confirmed the sex-difference in science and cite other similar conclusions. They found the greatest sex-difference for General Science followed by Physics.

In Britain, the sex-difference in attainment in physical science seems to be generally accepted to the extent that some schools channel girls into biology as an option to physics. As reported by Miller and Dale (87) in 1972, this difference is again apparent by the later years of a university degree course, although not at the beginning. D.G. Lewis (56) found, in work on Northern Ireland grammar school pupils, that attainment in elementary science was related to a general intellectual ability factor, a general personality factor and, as mentioned before, verbal, spatial and numerical group factors, depending on the subject.

Summary

Attainment is related to intellectual ability but, in addition, a sex-difference in favour of the boys might be expected. As well as intelligence, other factors are operating.

Once again, it should be emphasised that some of the work is on the American society but the British research does lead to similar conclusions which would suggest that common factors are operating. Indeed, other research in Western societies is reported which shows similar results. Leutke (88), in Germany, assessing high school students' interests in school subjects has found that boys prefer mathematics, physical education and the sciences, while girls prefer German and physical education. As boys grew older they selected more sciences than languages. Even in India, Dave (89) reports that technical interests are associated with boys and George and Abraham (90) report that boys achieve more than girls in English, social studies, general science and general mathematics.

5.

Construction of Hypotheses.

The work discussed illustrates historical, ascribed sex-differences and their affect on subject interest. As a result of image factors, these differences might be expected today. Yet, how do these differences express themselves? Are they apparent throughout the secondary school and how does ability affect them?

There is a movement of pupils away from science. Dainton (91) found that, in spite of an increase in sixth-form size, the increase in those taking science was less than expected. The present concern about the social implications of science could be adversely affecting pupils' attitudes via parents, the mass media and adults generally or some other cause might result in an unfavourable attitude to science. Or, perhaps, the attraction of more widely available options such as in the social sciences might account for the decline. Exactly how do the pupils' attitudes to science stand at the present time? Are they generally favourable, neutral or unfavourable?

Recent attempts to renew the vigour, attractiveness and efficiency of science teaching with the work of the Nuffield Science Teaching Project may be expected to have an effect on the children's attitude. In the three subjects; physics, chemistry and biology, the aim of the project is to;

> 'develop materials that will help teachers to present science in a lively, exciting, and intelligible way.'
> (92)

In all subjects the emphasis is on the child establishing concepts, usually with the help of class experiments, carefully designed models and demonstrations. The conventional approach may or may not depend largely on the pupil establishing the concept himself. Such an approach would probably imply more direction by the teacher, perhaps less critical thought and an acceptance of facts as given. The Nuffield approach usually requires more teaching time and more time spent on discovering a meaning to each basic concept and exploring the links with other established facts.

In the case of physics, a sufficient number of schools were involved in the Project to allow a comparison with the conventional approach to be made. These schools had taught the subject by the new scheme for sufficient time to have fourth year groups who had done no other approach in their secondary school life.

For physics, the founders of the Nuffield Project express the hope that they might 'attract some of the waverers into a scientific career.' (93) However, it seems that the chances of doing this would be diminished or enhanced according to how the pupils' attitude to physics is affected by the Project.

In view of these aims and hopes, how does the attitude compare with those pupils who have followed a conventional physics course?

The hypotheses may now be formally stated;

1. H_0: There is no tendency for a random sample of pupils to have an attitude

for or against science, as against H_1: That there is a tendency for the sample to have a favourable attitude to science.

2. H_0: In a random sample of pupils there is no difference in attitude to science between boys and girls, as against H_1: That the boys in the sample are more favourable in attitude to science than the girls.

3. H_0: In a random sample of pupils there is no difference between the more able and the less able pupils in attitude to science, as against H_1: That the more able pupils are more favourable in attitude to science than less able pupils.

4. H_0: In a random sample of pupils there is no difference in attitude to science between younger and older pupils as against H_1: That the younger pupils are more favourable to science than the older pupils.

5. H_0: In a random sample of pupils there is no difference in attitude to physics between those pupils following the Nuffield approach and those following a conventional course as against H_1: That a difference does exist between these two groups.

Some indication has already been given of the conflicting results from experiments to find if a relationship exists between attitude and behaviour. The definitions imply that a positive relationship should hold. For attitude to science, it is reasonable to call attainment or achievement the related behaviour. To what extent does a favourable attitude to science lead one to expect a higher achievement in, for example, examinations? Does the converse hold, too? Since achievement is, at least, also dependent on ability or intelligence, no exact relationship could be expected. Generally, high or low intelligence could easily over-ride the effects of attitude and mask a correlation, as already discussed. However, some allowance could be made for this factor since the grammar school in the sample had one year group, the third form, which was streamed according to ability. By considering each form as a unit, attitude scores could be compared with examination attainment within each form. Hence, within each sample, the over-riding variation introduced by the factor of ability or intelligence would be reduced. Stated formally, the hypothesis becomes;

6. H_0: There is no correlation between attitude to science and attainment, as against H_1: That there exists a positive correlation between the two, those having a favourable attitude also attain more on science, provided that some allowance for intelligence is made.

(H_0 = null hypothesis. H_1 = alternative hypothesis.)

6.

The Measurement of Attitude to Science.

6.1 The Attitude Test and its Construction.

In the construction of this test, the following general requirements were borne in mind;

(a) The test needed to be understood by as wide an ability range as possible to allow comparison between high and low ability groups.

(b) It must be suitable for a wide age-range in the secondary school to allow comparison between age groups.

(c) It must require a minimum of skill and intelligence to complete the test. This is a corollary of (a) and (b) and facilitates (d).

(d) It should be easily administered and take as little time as is convenient in order to encourage as many schools as possible to take part.

To satisfy these points, the Thurstone scale of equal-appearing intervals was selected (94). Here, administration would be simple and unlikely to lead to variations in procedure while the test would require the pupils only to ticks in endorsement of the statements. It could be as short as about forty items (95), including the split-half technique for checking reliability.

Considering the alternatives. Some methods are not intended for this particular kind of assessment, for example, the Bogardus Social distance scale, originally designed to assess racial prejudice. The Osgood semantic differential approach, in which a range of adjectives about the object is used, would give a test something like;

SCIENCE

1. pleasant .... unpleasant
2. dark .... bright
3. and so on.

The subject must endorse the position on the dots which most matches how he would apply the adjectives to the object. Of course, the object, in this case 'science', could be broken down into more elementary facets or concepts but the test could prove too complex to be understood by young pupils and those of low ability. The limits of vocabulary and understanding could create severe problems.

Possibly nearer the requirements might be the Hammond Error Choice Scale in which the subject must polarise his attitude in endorsement. For example; Science is more important now than it ever was. TRUE or FALSE

However this test can prove too blunt in its simplest form. Two groups different in attitude yet both favourable would not be separated. The more complex form brings it near the Likert scale (and the related Unfolded Partial Rank Order Scale). This test is more commonly used in this type of work and could prove suitable. Given a statement about science the subject endorses shades of agreement or disagreement ranging from strongly agree to strongly disagree. Once again, the breadth of ability and age in the intended sample brings in doubts if some children could appreciate what was required and separate shades of their feeling about a statement.

There is an interesting error choice scale known as the Repertory Grid, devised by Kelly (129) and adapted for use with school subjects by Duckworth and Entwistle (130). The pupil has pairs of polarized statements (obtained from previous samples of pupils by a technique of Kelly) one of which he selects as nearest to his own opinion for each subject. This is a convenient way of quickly collecting data about interests, preferences and attitudes. Its limitations are those of the Hammond scale in that it forces an extreme choice and thus magnifies any differences and masks any shades of similarity. A simplified test, with some sample results, is included in Appendix T.

The Thurstone scale made least demands on the pupils' ability, instructions were simple and an ordinate scale could be established which might give an idea of how large any differences were. It was hoped that shades of attitude might be detected. Little, or no, explanation would be required of the supervisor and the time taken by the test was not excessive.

6.2 Collection of Opinions.

Following the method of Thurstone and Chave (96), 121 opinions about school science in general and scientists were collected from pupils of a secondary school. These were extracted from essays written by about thirty pupils in each year group from the first form, (11+ys), to the sixth form (16+ years). The essay titles were;

1st, 2nd, and 3rd forms: 'Why I would like to be a scientist.' OR 'Why
I would not like to be a scientist.'

4th and 5th forms: 'Will learning science be useful to me?'

The statements selected ranged from extremely favourable to extremely unfavourable with some neutral opinions. Roughly equal numbers were taken from each year group so that the final scale would be intellible to as wide an age range as possible.

These statements are given in appendix D.

6.3 The Sorting Procedure (97).

The 121 statements were typed on slips of paper and placed in an envelope. Another eleven envelopes were clearly marked A to K.

On envelope A was written:

'Attitudes most favourable to science and to scientific careers.'

On envelope F was written:

'Neutral statements about science and scientific careers.'

On envelope K was written:

'Attitudes least favourable to science and to scientific careers.'

These statements were given to thirty 'judges' for sorting. Thurstone recommends about three hundred judges but subsequent work has shown as few as fifteen give reliable results (98). It is preferable that the judges be the same as those for whom the scale is intended (99). However, teachers were used as judges because they were familiar with the way the pupils thought and the pupils themselves needed too much individual guidance in instructions to ensure that no bias was introduced. The judges were male and female arts and science teachers and were selected on the basis of volunteers. It was thought that volunteers would take more care over sorting the slips than those who felt obliged to agree to take part.

The directions for sorting the slips were as follows;

DIRECTIONS FOR SORTING SLIPS.

1. The 121 slips contain pupils' statements about science.
2. These are to be sorted into eleven piles.
3. Arrange the envelopes A to K in order and place the statements which you believe express most favourable attitudes to science on A, those which express neutral attitudes on F and those which are least favourable on K. On the remaining envelopes, arrange the statements in accordance with degree of favourability, from most to least.
4. Do not try to get the same number in each pile, they are not evenly distributed, but there should be eleven piles.
5. The numbers on the slips are for coding only, and have nothing to do with the piles.

6. It will help if, before sorting, a number of slips are read, chosen at random.

7. It will take at least 30 minutes.

8. Please place the piles in the appropriate envelopes.

The results of the sorting were tabulated, first as indicated in the example (Table 1.), then all were consolidated (Table 2.). This allowed the number of times a statement was placed in one of the groups A to K to be determined and hence, the proportion in each group found.

JUDGE No. 24. Table 1. NAME: Mr. H.

A	B	C	D	E	F	G	H	I	J	K
92	51	94	53	30	56	52	54	32	13	69
16	17	23	50	31	57	128	8	21	26	22
25	38	93	11	9	109	29	98	114	115	18
55	33	28	20	58	110	15	117	7	72	108
				and so on						

Table 2.

MASTER COPY.

Statement	A	B	C	D	E	F	G	H	I	J	K	Statement
1												1
2												2
•												•
•												•
•												•
18												18
19												19
20		111	卌1		11		1					20
21												21
•												•
•												•
•												•
120												120
121												121

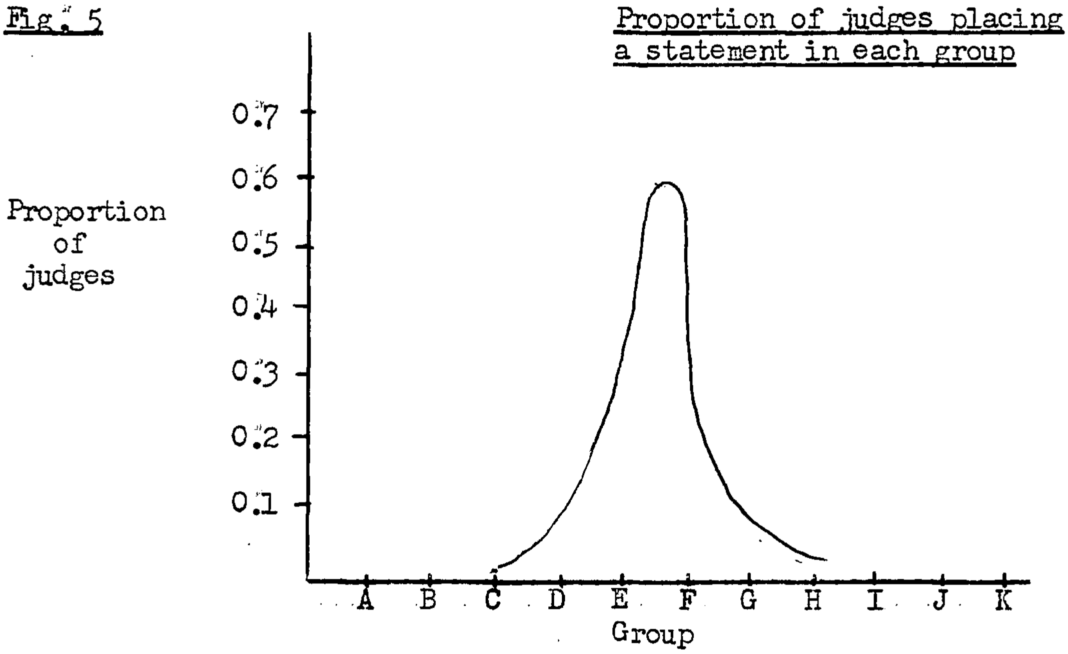
Referring to Table 1., it shows that Mr. H. placed statement 92 in group A, 51 in group B, 94 in group C and so on. Table 2 shows that for statement 20, no judge placed it in group A, three placed it in group B, six in group C and so on.

The procedure was explained in detail to each judge but, to eliminate those who had not understood, following Thurstone, those who placed more than a quarter of the statements in one group or those who left one or more groups empty were eliminated. On this criterion, two judges were rejected.

6.4 The Scale-Values

For an unambiguous, precise statement, all judges should place it in one group (100). However, each judge has a different view of the statement because of differing life patterns, values and experiences. The most which might be expected is that the statement would be placed mainly in one group, distributed normally. Where there is great accord between judges, the distribution would be narrow, as indicated in Fig. 5, that is, the standard deviation would be small.

Fig. 5



It is these statements which are unambiguous and therefore of value in the experiment.

The curves for each statement are drawn more conveniently as accumulative proportion ogives, using the data in Table 3. This was compiled directly from the information in Table 2 and shows, for example, that for statement 20: 0.00 of the judges placed it in group A, 0.18 placed it in group B, 0.39 placed it in group C or B, 0.68 placed it in group D, C or B and so on. In other words, this table represents the accumulative proportions of the figures in Table 2.

Accumulative Proportions

Table 3

Statement	Scale Value	Q	A	B	C	D	E	F	G	H	I	J	K
			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
1	7.0	2.3	0.00	0.00	0.00	0.00	0.03	0.34	0.66	0.72	0.83	1.00	1.00
2	9.0	2.1	0.00	0.00	0.00	0.04	0.04	0.07	0.18	0.25	0.50	0.79	1.00
3	3.4	2.2	0.04	0.25	0.43	0.64	0.89	0.97	0.97	1.00	1.00	1.00	1.00
4	2.8	2.1	0.04	0.21	0.57	0.61	0.94	1.00	1.00	1.00	1.00	1.00	1.00
5	3.0	2.0	0.14	0.29	0.50	0.79	0.97	1.00	1.00	1.00	1.00	1.00	1.00
6	3.3	1.5	0.00	0.11	0.29	0.68	0.89	1.00	1.00	1.00	1.00	1.00	1.00
7	8.2	2.4	0.00	0.00	0.00	0.00	0.04	0.07	0.36	0.43	0.64	0.89	1.00
8	3.8	2.5	0.04	0.18	0.39	0.52	0.78	0.96	0.96	1.00	1.00	1.00	1.00
9	4.0	2.2	0.00	0.07	0.30	0.48	0.74	0.93	0.93	0.96	1.00	1.00	1.00
10	7.6	3.0	0.00	0.00	0.00	0.00	0.00	0.21	0.43	0.50	0.79	0.86	1.00
11	6.7	2.2	0.00	0.00	0.00	0.07	0.07	0.29	0.57	0.75	0.89	0.96	1.00
12	5.2	1.1	0.00	0.00	0.00	0.00	0.35	0.73	0.92	0.96	0.96	1.00	1.00
13	9.6	2.3	0.00	0.00	0.03	0.03	0.07	0.07	0.07	0.27	0.33	0.60	1.00
14	2.6	1.8	0.03	0.24	0.59	0.79	0.97	1.00	1.00	1.00	1.00	1.00	1.00
15	5.6	1.2	0.00	0.03	0.03	0.10	0.17	0.66	0.83	0.93	0.97	0.97	1.00
16	0.1	1.8	0.70	0.82	0.93	0.96	0.96	1.00	1.00	1.00	1.00	1.00	1.00
17	3.5	1.8	0.00	0.11	0.37	0.67	0.78	1.00	1.00	1.00	1.00	1.00	1.00
18	8.1	1.6	0.00	0.00	0.00	0.00	0.00	0.04	0.18	0.50	0.71	0.93	1.00
19	2.2	1.8	0.14	0.36	0.67	0.96	0.96	0.96	0.96	0.96	1.00	1.00	1.00
20	3.2	2.0	0.00	0.18	0.39	0.68	0.96	1.00	1.00	1.00	1.00	1.00	1.00
21	8.8	1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.29	0.54	0.86	1.00
22	8.5	1.8	0.00	0.00	0.00	0.00	0.00	0.04	0.18	0.32	0.68	0.84	1.00
23	6.5	2.2	0.00	0.00	0.04	0.11	0.18	0.48	0.59	0.89	1.00	1.00	1.00
24	7.9	1.4	0.00	0.00	0.00	0.00	0.00	0.07	0.18	0.54	0.82	0.93	1.00

Statement	Scale Value	Q	A	B	C	D	E	F	G	H	I	J	K
			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-1
25	1.0	1.8	0.47	0.77	0.93	0.93	0.93	0.97	0.97	1.00	1.00	1.00	1.00
26	6.9	2.5	0.00	0.00	0.00	0.04	0.11	0.39	0.57	0.68	0.89	0.93	1.00
27	7.4	1.4	0.00	0.00	0.00	0.00	0.00	0.04	0.41	0.74	0.89	0.96	1.00
28	1.8	1.4	0.18	0.56	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
29	5.5	2.8	0.00	0.04	0.04	0.23	0.46	0.54	0.81	0.96	1.00	1.00	1.00
30	2.9	1.7	0.07	0.14	0.55	0.76	1.00	1.00	1.00	1.00	1.00	1.00	1.00
31	4.1	1.4	0.04	0.04	0.11	0.44	0.85	0.96	0.96	0.96	0.96	1.00	1.00
32	6.3	2.0	0.00	0.00	0.04	0.04	0.11	0.39	0.71	0.79	0.93	1.00	1.00
33	0.7	1.8	0.61	0.82	0.93	0.93	0.96	1.00	1.00	1.00	1.00	1.00	1.00
34	5.2	3.4	0.00	0.00	0.00	0.00	0.00	0.61	0.71	0.86	0.96	0.96	1.00
35	8.2	2.5	0.00	0.00	0.00	0.00	0.00	0.14	0.25	0.46	0.64	0.89	1.00
36	3.3	1.5	0.04	0.15	0.37	0.74	0.96	1.00	1.00	1.00	1.00	1.00	1.00
37	4.0	1.8	0.00	0.11	0.18	0.54	0.82	1.00	1.00	1.00	1.00	1.00	1.00
38	1.1	1.6	0.46	0.79	0.96	0.96	0.96	1.00	1.00	1.00	1.00	1.00	1.00
39	3.4	2.7	0.07	0.28	0.54	0.82	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	3.6	2.8	0.04	0.22	0.41	0.56	0.67	0.93	1.00	1.00	1.00	1.00	1.00
41	2.0	1.9	0.15	0.50	0.73	0.85	0.92	1.00	1.00	1.00	1.00	1.00	1.00
42	3.3	1.3	0.00	0.57	0.43	0.75	0.96	1.00	1.00	1.00	1.00	1.00	1.00
43	3.0	2.9	0.07	0.30	0.48	0.67	0.81	0.93	0.96	1.00	1.00	1.00	1.00
44	3.6	1.6	0.00	0.15	0.30	0.67	0.93	0.96	0.96	1.00	1.00	1.00	1.00
45	2.2	2.7	0.21	0.43	0.50	0.75	0.93	1.00	1.00	1.00	1.00	1.00	1.00
46	7.2	3.3	0.00	0.00	0.00	0.04	0.07	0.36	0.57	0.64	0.75	0.89	1.00
47	2.5	1.6	0.07	0.19	0.48	0.78	0.96	0.96	1.00	1.00	1.00	1.00	1.00
48	6.6	2.0	0.00	0.00	0.00	0.00	0.04	0.39	0.57	0.82	0.96	1.00	1.00
49	8.2	2.5	0.00	0.00	0.00	0.00	0.00	0.04	0.25	0.46	0.64	0.82	1.00
50	3.1	1.4	0.04	0.19	0.56	0.85	0.93	1.00	1.00	1.00	1.00	1.00	1.00
51	2.6	1.9	0.03	0.35	0.62	0.79	0.97	0.97	1.00	1.00	1.00	1.00	1.00
52	6.0	2.3	0.00	0.00	0.07	0.21	0.24	0.52	0.86	0.97	1.00	1.00	1.00
53	4.1	2.9	0.11	0.21	0.32	0.50	0.64	1.00	1.00	1.00	1.00	1.00	1.00
54	8.1	4.0	0.00	0.00	0.00	0.00	0.00	0.24	0.35	0.52	0.59	0.69	1.00
55	1.7	1.8	0.22	0.59	0.74	0.93	0.96	1.00	1.00	1.00	1.00	1.00	1.00
56	6.7	0.9	0.00	0.04	0.07	0.07	0.15	0.89	0.89	0.97	1.00	1.00	1.00
57	5.6	1.5	0.00	0.00	0.00	0.04	0.33	0.74	0.81	1.00	1.00	1.00	1.00
58	6.8	2.4	0.00	0.00	0.03	0.07	0.10	0.31	0.55	0.79	0.86	0.97	1.00
59	8.1	1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.38	0.77	0.85	1.00
60	6.2	1.5	0.00	0.00	0.00	0.04	0.04	0.44	0.76	0.96	1.00	1.00	1.00
61	7.8	2.4	0.00	0.00	0.00	0.00	0.00	0.10	0.35	0.59	0.72	0.90	1.00
62	4.5	3.0	0.11	0.18	0.29	0.46	0.50	0.86	0.93	0.96	0.96	0.96	1.00
63	4.8	1.8	0.00	0.00	0.07	0.30	0.52	0.85	0.96	1.00	1.00	1.00	1.00
64	7.8	1.9	0.00	0.00	0.00	0.00	0.00	0.07	0.21	0.55	0.76	0.93	1.00
65	8.8	2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.31	0.48	0.79	1.0
66	9.5	1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.14	0.32	0.68	1.0
67	5.5	2.0	0.00	0.04	0.04	0.11	0.36	0.64	0.82	1.00	1.00	1.00	1.00
68	10.5	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.12	1.00
69	9.2	3.1	0.00	0.00	0.08	0.00	0.00	0.04	0.29	0.32	0.46	0.64	1.00
70	8.3	2.5	0.00	0.00	0.00	0.00	0.00	0.04	0.21	0.43	0.68	0.82	1.0
71	9.9	1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.11	0.29	0.50	1.00
72	2.5	1.7	0.00	0.00	0.00	0.00	0.00	0.11	0.29	0.43	0.64	0.79	1.00

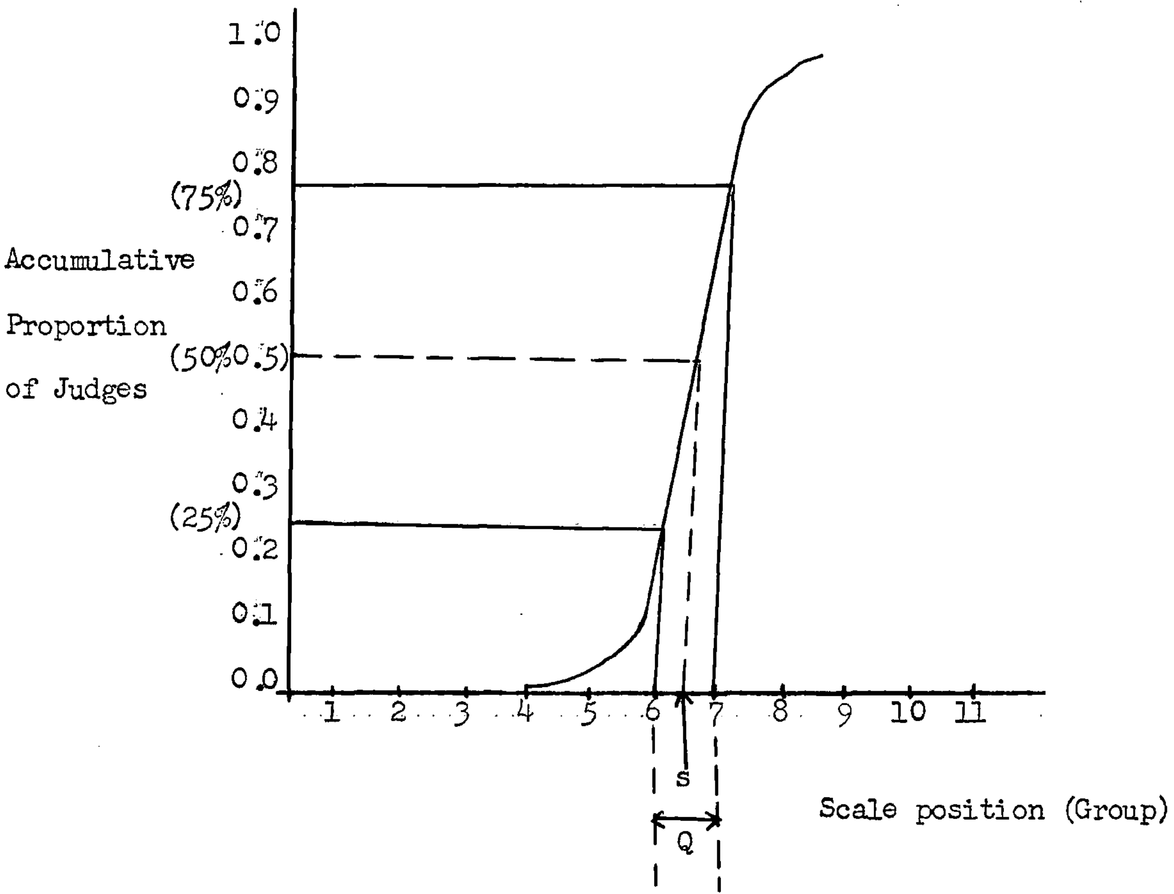
Statement	Scale Value	Q	A	B	C	D	E	F	G	H	I	J	K
			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
73	2.5	1.7	0.15	0.33	0.67	0.89	0.96	1.00	1.00	1.00	1.00	1.00	1.00
74	6.9	1.8	0.00	0.00	0.00	0.00	0.07	0.22	0.59	0.78	0.89	0.96	1.00
75	3.1	2.0	0.12	0.21	0.54	0.71	0.93	1.00	1.00	1.00	1.00	1.00	1.00
76	5.6	2.2	0.04	0.08	0.12	0.19	0.35	0.65	0.85	0.80	1.00	1.00	1.00
77	7.6	2.2	0.00	0.00	0.00	0.00	0.07	0.21	0.36	0.61	0.86	0.89	1.00
78	8.7	2.2	0.00	0.04	0.04	0.04	0.04	0.14	0.25	0.43	0.54	0.71	1.00
79	8.4	2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.46	0.61	0.89	1.00
80	3.7	2.3	0.00	0.19	0.35	0.50	0.85	0.96	1.00	1.00	1.00	1.00	1.00
81	3.8	2.0	0.00	0.10	0.31	0.55	0.89	0.97	0.97	1.00	1.00	1.00	1.00
82	2.4	2.0	0.08	0.44	0.60	0.88	0.96	1.00	1.00	1.00	1.00	1.00	1.00
83	7.6	3.4	0.00	0.00	0.00	0.04	0.14	0.18	0.43	0.57	0.75	0.86	1.00
84	9.0	2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.29	0.50	0.79	1.00
85	5.3	2.9	0.00	0.00	0.00	0.00	0.00	0.14	0.29	0.46	0.64	0.79	1.00
86	9.5	1.9	0.00	0.00	0.00	0.00	0.00	0.07	0.14	0.18	0.36	0.68	1.00
87	2.8	2.6	0.21	0.36	0.57	0.75	0.93	1.00	1.00	1.00	1.00	1.00	1.00
88	1.2	2.0	0.39	0.71	0.82	0.89	0.93	1.00	1.00	1.00	1.00	1.00	1.00
89	2.7	5.2	0.41	0.44	0.52	0.67	0.67	0.89	0.93	0.93	1.00	1.00	1.00
90	3.7	3.6	0.18	0.32	0.46	0.50	0.54	0.96	1.00	1.00	1.00	1.00	1.00
91	3.0	2.1	0.07	0.28	0.55	0.69	0.89	1.00	1.00	1.00	1.00	1.00	1.00
92	2.4	3.0	0.28	0.45	0.66	0.76	0.86	0.97	1.00	1.00	1.00	1.00	1.00
93	2.4	3.8	0.11	0.41	0.63	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00
94	2.7	2.0	0.14	0.32	0.75	0.79	0.96	0.80	1.00	1.00	1.00	1.00	1.00
95	3.2	3.2	0.07	0.31	0.45	0.66	0.72	0.86	0.97	1.00	1.00	1.00	1.00
96	9.5	2.0	0.00	0.00	0.00	0.00	0.00	0.04	0.14	0.25	0.39	0.75	1.00
97	2.5	1.6	0.04	0.37	0.63	0.93	0.96	1.00	1.00	1.00	1.00	1.00	1.00

Statement	Scale Value	Q	A	B	C	D	E	F	G	H	I	J	K
			0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
98	8.5	2.3	0.00	0.00	0.00	0.00	0.04	0.07	0.18	0.46	0.61	0.86	1.00
99	7.3	2.0	0.00	0.00	0.00	0.04	0.11	0.19	0.44	0.67	0.81	1.00	1.00
100	7.0	1.7	0.00	0.00	0.00	0.00	0.00	0.14	0.50	0.79	0.93	1.00	1.00
101	3.8	2.6	0.00	0.07	0.25	0.57	0.82	0.93	0.93	0.96	1.00	1.00	1.00
102	3.6	1.1	0.00	0.04	0.11	0.18	0.71	0.89	1.00	1.00	1.00	1.00	1.00
103	4.1	2.5	0.00	0.14	0.36	0.43	0.68	0.93	0.93	0.96	0.80	1.00	1.00
104	3.7	1.5	0.00	0.04	0.32	0.50	0.96	1.00	1.00	1.00	1.00	1.00	1.00
105	4.9	1.3	0.00	0.04	0.11	0.14	0.61	0.93	0.96	1.00	1.00	1.00	1.00
106	2.1	2.2	0.24	0.52	0.66	0.86	0.97	1.00	1.00	1.00	1.00	1.00	1.00
107	3.4	2.1	0.04	0.21	0.39	0.68	0.93	1.00	1.00	1.00	1.00	1.00	1.00
108	10.8	0.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.14	0.21	1.00
109	5.1	4.7	0.29	0.43	0.46	0.46	0.46	0.96	1.00	1.00	1.00	1.00	1.00
110	4.8	1.9	0.07	0.11	0.18	0.36	0.50	0.89	0.96	1.00	1.00	1.00	1.00
111	8.2	1.6	0.00	0.00	0.00	0.04	0.04	0.07	0.18	0.43	0.79	0.89	1.00
112	4.3	1.7	0.04	0.14	0.14	0.39	0.75	0.96	1.00	1.00	1.00	1.00	1.00
113	8.5	2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.39	0.61	0.82	1.00
114	9.4	2.1	0.00	0.00	0.00	0.00	0.00	0.04	0.18	0.21	0.43	0.68	1.00
115	10.3	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.18	0.43	1.00
116	7.5	1.8	0.00	0.00	0.00	0.00	0.00	0.07	0.37	0.63	0.85	0.76	1.00
117	7.5	1.5	0.00	0.00	0.00	0.00	0.00	0.03	0.31	0.66	0.89	0.96	1.00
118	3.0	2.0	0.07	0.29	0.46	0.79	1.00	1.00	1.00	1.00	1.00	1.00	1.00
119	4.5	2.7	0.04	0.15	0.26	0.33	0.62	0.81	0.96	1.00	1.00	1.00	1.00
120	8.8	1.8	0.00	0.00	0.00	0.00	0.00	0.07	0.29	0.57	0.82	1.00	1.00
121	2.3	1.6	0.12	0.35	0.77	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00

The purpose of these figures is to allow accumulative proportion graphs to be drawn for each of the 121 statements, illustrated in Fig. 6. Note also that the groups have been coded numerically; A = 0 to 1, B = 1 to 2, and so on. Referring to Fig. 6, for the graph shown, the position assigned to the statement on the 'most favourable' — 'least favourable' scale is numerically that which gives 50% of the judges placing it to the left. This is called the scale value, s.

<u>Fig. 6</u>

<u>Accumulative proportion of judges placing a statement in each group.</u>

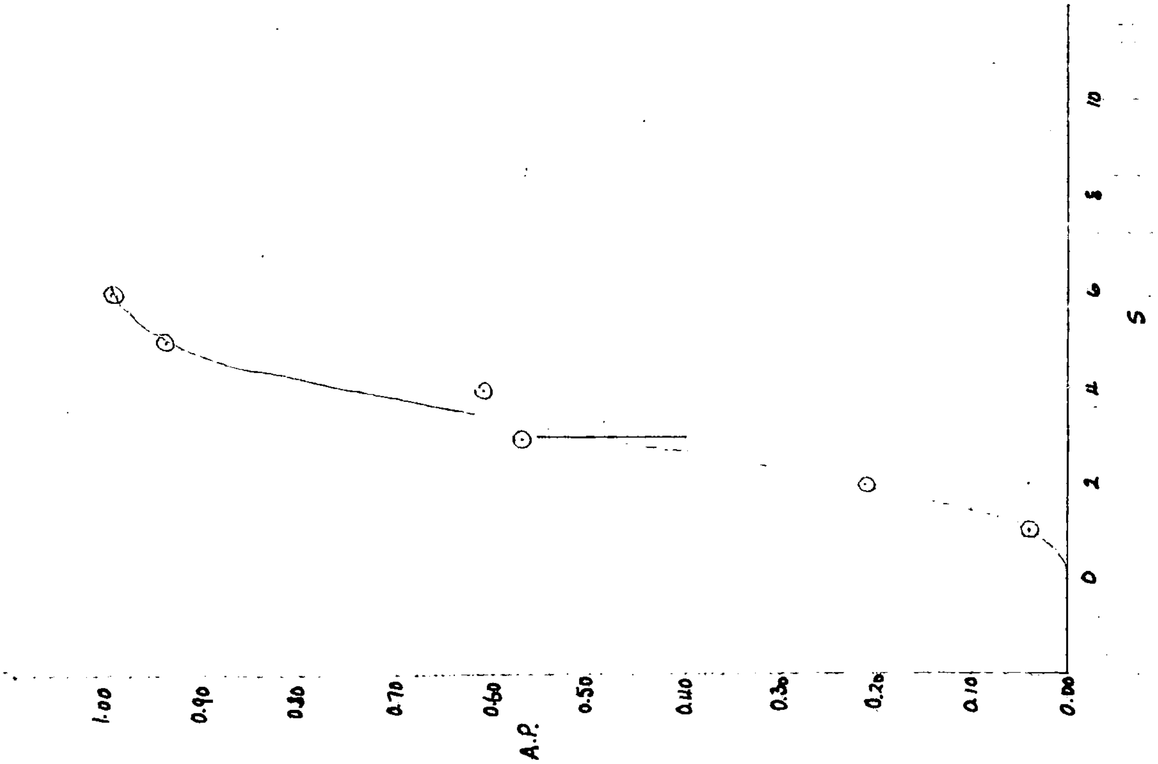


To measure the spread, dispersion or width of the graph, it is convenient to use the 'inter-quartile' distance, Q. This is the distance on the horizontal axis between the 25% and 75% points, that is 25% on either side of s.

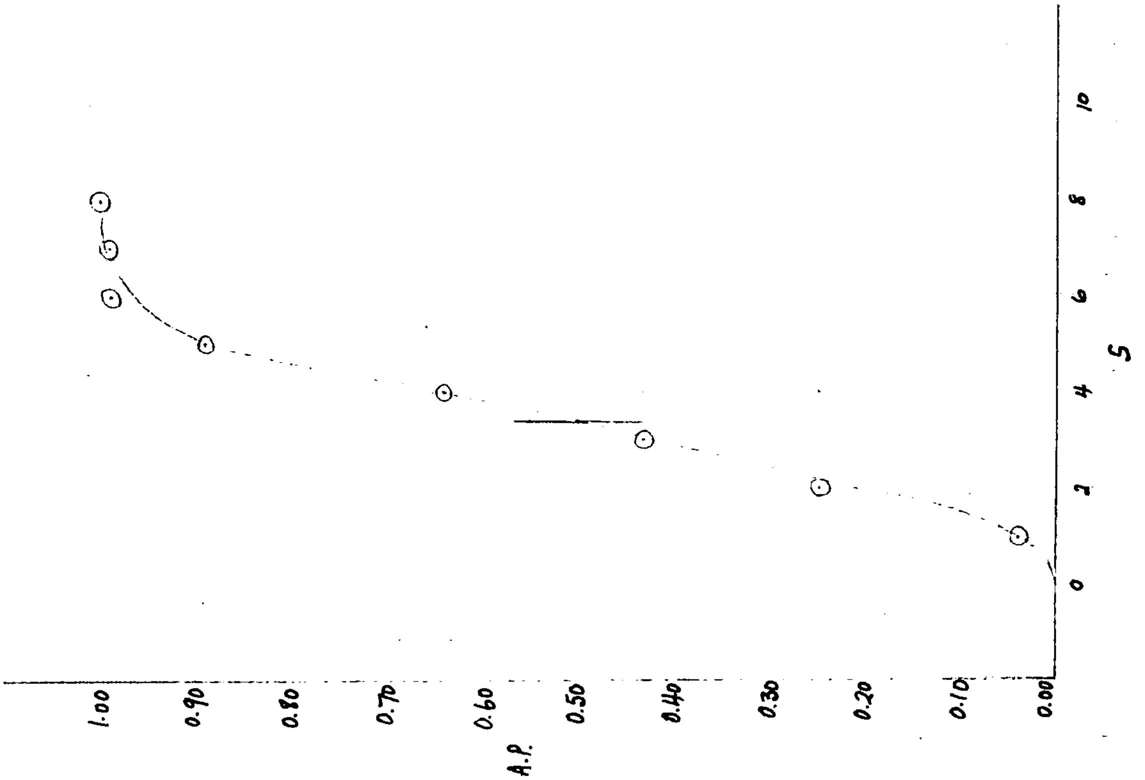
The 121 graphs for the statements are given in Appendix E. Considering statement 3, the point on the s axis corresponding to 0.50 on the accumulative proportion axis A.P. is 3.4. Thus the scale value is 3.4. The distance between the 0.25 and 0.75 points is 2.2. Thus, Q is 2.2.

Examples of the graphs of Appendix E mentioned in the text.

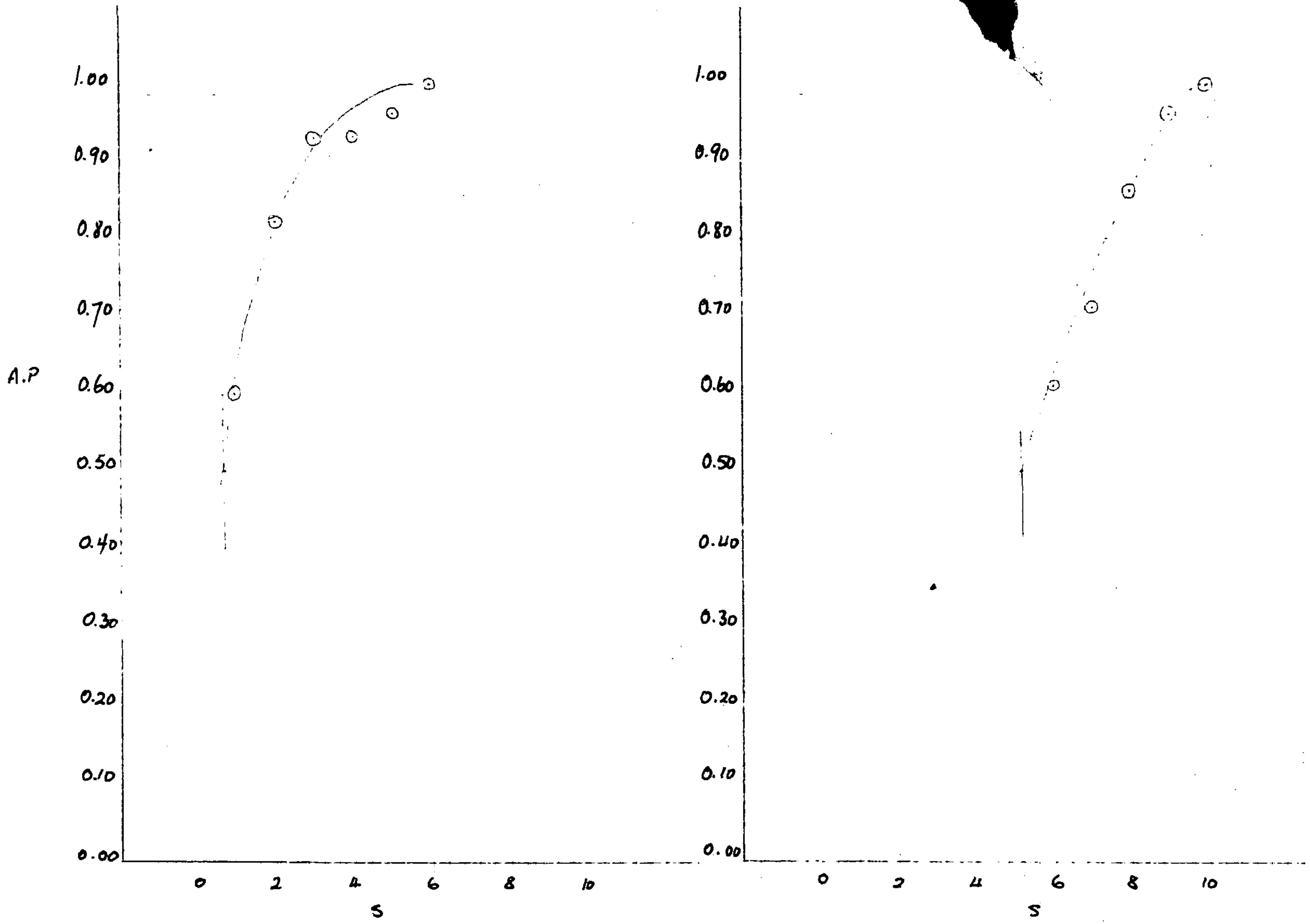
No. 4.



No 3.



No 33.


A.P
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
2
4
6
8
10
S
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
2
4
6
8
10
S

The values for s and Q for all the statements are included in Table 3.

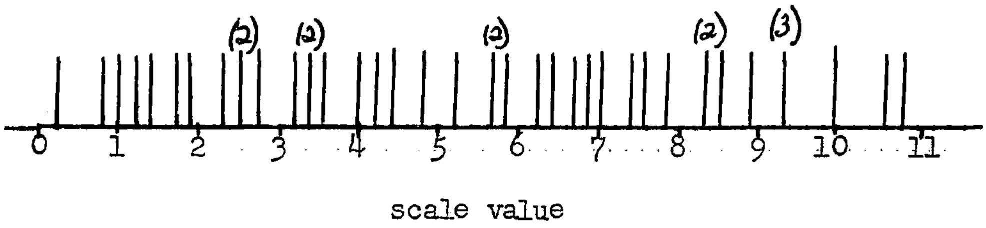
When graphs fell near one end of the axis they were incomplete, as for statements 16, 33 and 34 in Appendix E. In these cases, s could be determined by extrapolation and Q estimated either by further, reasonable extrapolation or by doubling the distance between the 0.50 and the 0.75 points (or the 0.25 and the 0.50 points).

It would have been possible to code the horizontal axis from -5 to +5 but 0 to 11 was adopted as being easier to manipulate statistically.

6.5 Criteria for Selection of Statements.

The aim of determining the Q values was to provide an objective criterion of ambiguity as described by Thurstone and Chave (101). A statement with a high Q value shows a high dispersion in placing and should be eliminated. Low Q values should tend to be less ambiguous. They also list informal criteria for the rejection of unsuitable statements (102) and these have been supplemented by Edwards (103). Using these, a scale of 41 statements was drawn up such that they covered the range of scale values 0 - 11 reasonably well. Fig. 7 illustrates the position of these statements on the scale, each vertical line being one statement, multiple statements being indicated by the number in brackets.

Fig. 7.



These were split into two equivalent tests, Form A and Form B (118). This was done by extracting every other item so that two tests, each half the original length and each with statements of approximately the same scale value, were obtained. Where, say, two items scaled at the same value were obtained, either could be taken. The items in each test were put in random order to reduce the likelihood of endorsements due to 'halo' effects and to encourage the subject to read the whole test. The odd item scaling at 10.5 was included in both tests to balance them. Forms A and B are given complete with Q and s values in Appendix F. The mean of the Q value for these statements was 1.55.

6.6 Testing the Scale.

A trial questionnaire was drawn up and duplicated with the following instructions preceding Forms A and B. (All numbers for each item being omitted.)

Name: ____________ Form: ____________

1. There are 42 statements about science given below. Put a tick (✓) next to those with which you most agree.
2. When you have done this, look at the statements you have ticked and put a 1 next to the one you agree with most, then put a 2 next to the one you agree with next and so on until all have numbers beside them putting them in order.

The test was then given to about 150 pupils in a mixed secondary school, ranging in age from 11+ to 16+ years.

As suggested by Edwards (104), the score on the final test for each pupil would be found by obtaining the median of the scale values of those statements endorsed by that pupil. Edwards demonstrates the similarity of result when finding means and medians. In this smaller, test-sample, the mean was found in order to compare results with a theoretical model. The deductions can reasonably be expected to apply to the median which follows the movements of the mean. This is justified later.

On examining the results, three statements were found to be endorsed by almost everyone, without regard to each individual's score. These were sub-numbers 3 and 4 of Form B (statements 55 and 28) and sub-number 2 of Form A (statement 38). The sharpness of the scale could be increased by removing them from the questionnaire so this was done. The additional item at s - 10.5 (sub-number 21, Form B) need only appear on one Form now, resulting in a balanced 19-19 test (38 statements).

In effect, this was an informal criterion of irrelevance in which statements irrelevant to the attitude were eliminated. Thurstone and Chave also describe a more precise method (105) but this is not used much now (106).

A closer examination and comparison of results led to the suspicion that some pupils, especially the younger ones, when given the instruction 'put a tick next to those with which you most agree', were 'over-endorsing'. Evidence for this was that the average endorsements for the 11+ to 13+ year group was in excess of 12 with one or two over 20 on the 19 - 19 test.

This indicated a degree of ambiguity in the word 'most'. The final individual score would record all endorsements equally so that those weakly agreed with would be given an equal weight with those strongly agreed with. It was necessary to consider the effect of 'over-endorsement'.

Assuming no faults in the theory, the scale and the subject, then someone with a given attitude should select only those statements which agree exactly with his attitude scale-value. This would be possible with an infinite number of statements at each point. For only one statement at each point, after the first, the subject should select equally on either side until the nearer 'edge' or 'end' of the scale is reached. Further endorsement could be in one direction only.

Consider the diagram (Fig. 8) showing a scale of length D. The number of statements is $^{D}/_{d}$ where d is the distance between two adjacent statements (all equally spaced). This would be the aim in constructing the best, practical scale.

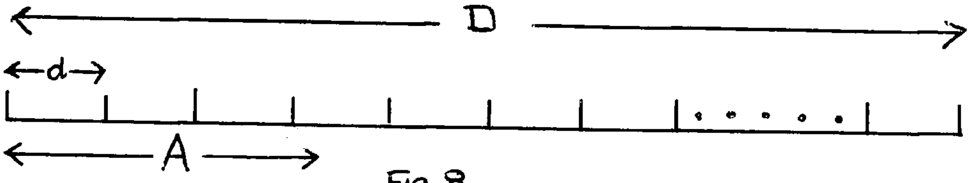


Fig. 8.

Suppose the attitude of the subject to have a single focus at A from the end on scale D.

The number of units 'below' A is $A/_{d}$.

So the total number which may be chosen on either side in order, without significantly affecting the mean, is $2A/_{d}$.

> (The subjects first selection would be at A, subsequent selections would be the nearest statements on either side of A, until one end of the scale was reached. One end is $^{A}/d$ away, therefore the total is twice this.)

More than this will produce drift away from the true focus A, because subsequent selections must be in one direction only and so the mean will adjust in that direction.

Assuming the rest to be chosen in order, when drift begins it would be a straight line of slope $^{d}/2$.

For the scale in question which has 38 statements for 11 divisions;

$$D = 11 \quad \text{and} \quad d = \frac{11}{38} \quad \text{(if perfectly spaced)}$$

For someone with one attitude focus at 2; $A = 2$.

Therefore the number chosen before drift of attitude mean score occurs is;

$$2A/d \doteq \frac{(2 \times 2 \times 38)}{11} \simeq 14.$$

This means that this individual, if selection and scale were perfect could choose up to 14 items and still have a mean which closely approximated his true score. Selecting more items would add a small amount to the mean (about $\frac{11}{76}$) for each item so the mean would drift away from its true value.

The following table (Table 4) shows the maximum number before drift for this scale for a perfect individual with one attitude focus. For example, someone with a single focus at 1.0 could choose up to seven statements and still register his correct score of 1.0. Further endorsement would result in the score drifting away from 1.0. The more extreme the score, then the fewer the statements which may be endorsed before drift.

Table 4

No. chosen before drift $E \doteqdot$	2	3	7	10	14	for 38
Attitude focus	0.25	0.5	1.0	1.5	2.0	statements

N.B. limits on E, (number before drift $\doteqdot \frac{2A}{d}$);

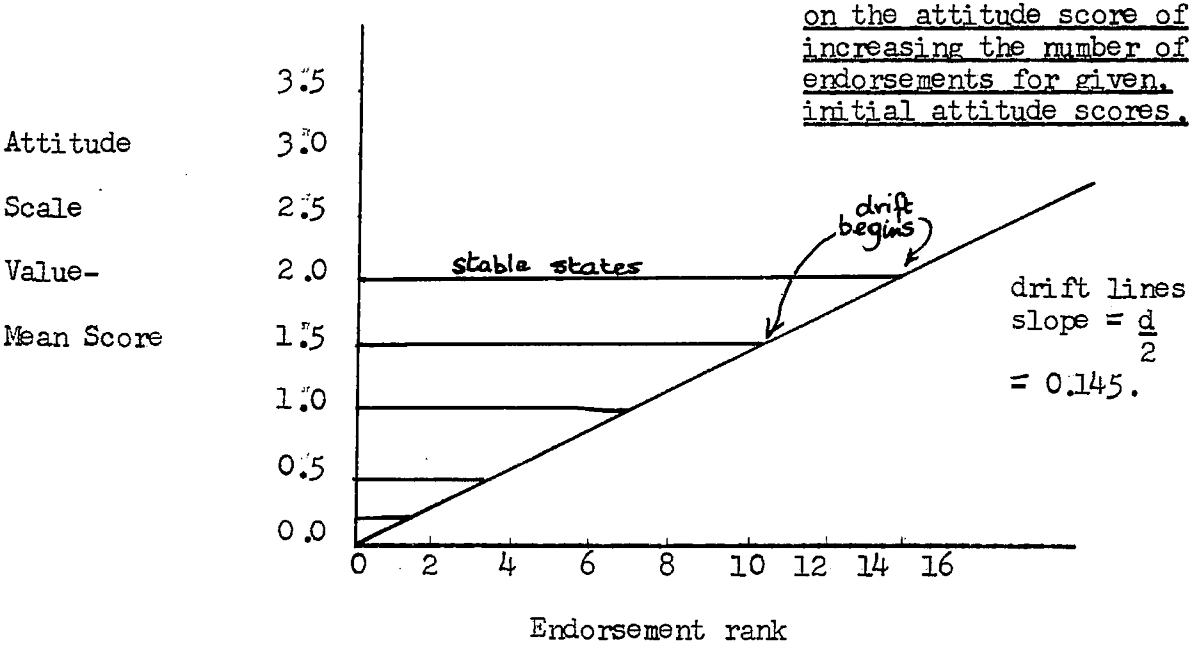
for $0 \leqslant A \leqslant \frac{D}{4}$ $\quad E = \frac{2A}{d}$

for $\frac{D}{4} < A \leqslant \frac{D}{2}$ and $\frac{D}{2} < A \leqslant \frac{3D}{4}$ Drift is not established

for $\frac{3D}{4} < A \leqslant D$ $\quad E \doteqdot -\frac{2A}{d}$ ie. slope is negative.

Table 4 shows that over-endorsement will affect those whose attitude is nearer the ends of the scale sooner than the others. This is easily seen from the graphs of Fig. 9.

Fig. 9



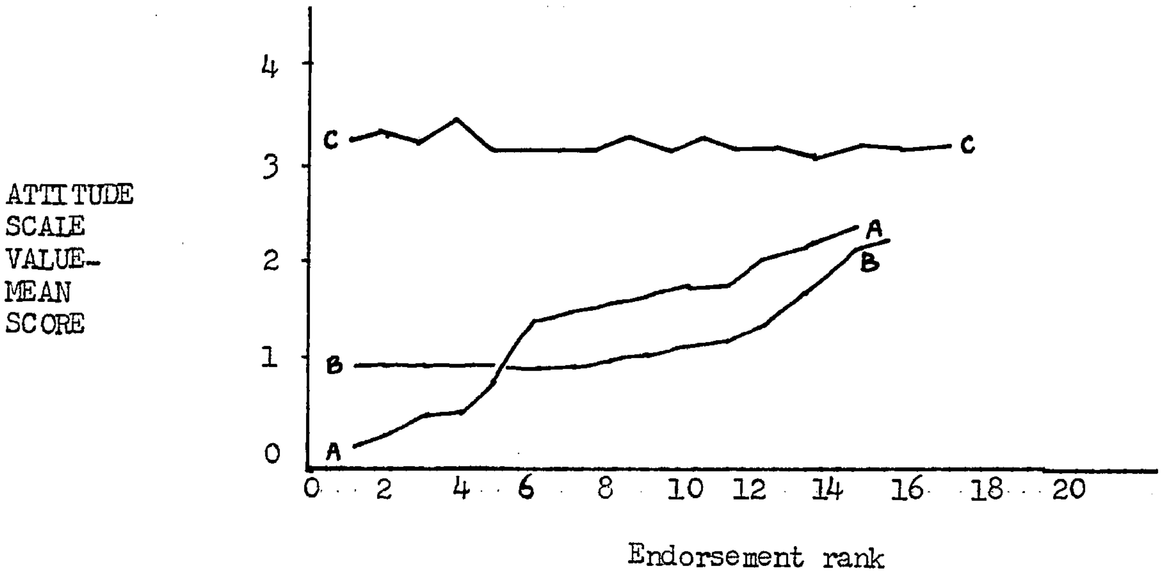
Graph showing the effect on the attitude score of increasing the number of endorsements for given initial attitude scores.

(N.B. In practise, since fractions of statements cannot exist, each mean score would continue to the integer given in Table 4 then drift in close parallel lines, slope d/2)

These graphs show what happens to the mean for a given focus as successive endorsements occur. For attitudes near the extreme, drift is almost immediate. (At the other end of the scale, 11 - 6, the drift occurs similarly to the centre). While statements are available on either side, the mean is stable, after that it moves towards neutral. It is important to note that over-endorsement can result in reversal of rank order of means. For example, someone of true score 0.25 endorsing five items is given a score of approximately 1 while someone of true score 0.5 only endorsing three items is given his true score. This is an extreme case. Scores as extreme as this may not occur often so that attitude foci of 1.0 to 1.5 for which E $\simeq$ 7 and 10 respectively are more likely to be observed.

This was a simplified, theoretical model. Pupils cannot be expected to endorse only those clusters of items around their attitude foci. Nor can they be expected to have only one focus, however, when actual results are considered, the model is a good fit. Since the pupils had been asked to rank their selection, graphs like Fig. 9 could be drawn for comparison. Some are given in Fig. 10. They were drawn by finding the new mean each time an item was endorsed in the rank order.

Fig. 10. Graph of three pupils attitude scores showing how it alters as the number of endorsements increased.



AA illustrates drift from an extreme.

BB illustrates a stable region up to about the seventh endorsement with drift starting.

CC illustrates a stable state where sufficient items exist to delay drift.

These would indicate that in spite of d not being exactly uniform for the practical scale, pupils with one attitude focus were behaving like the model.

It is also possible to simulate multiple foci, and to give a particular focus a heavier weighting than the rest. Appendix G gives an example of how this was done. Again, the results obtained agree very well with the theoretical model which adds weight to its value. This work was done with the mean of the endorsements as the score of each subject because this allowed a clear, general solution. It also applies to the alternative method of finding the score, that of using the median of the endorsements. For example, for a similar uniform endorsement around a focus such as 1.0, say; 1.0, 1.0 + 0.28, 1.0 - 0.28, 1.0 + 2(0.28), 1.0 - 2 (0.28) in that order, (as in Appendix G), the median is 1.0. This is in the stable region. When available statements are used up, the median as the central value, begins to drift, as before. The more extreme the initial focus, the sooner the drift begins.

Summary

The trial questionnaire of 42 items was tested on the age-range of mixed, secondary school children for which the scale was intended, that is, 11+ years to 16+ years. One form of about 30 mixed pupils in each year group were chosen at random giving a total of 158 pupils, 70 of whom were boys. As a result, three statements were removed. It was also found that at least six endorsements would be desirable and generally not more than ten. There should be at least three on each Form to allow an estimate of reliability.

Conclusions.

The questionnaire was redesigned to meet these requirements and proved to be satisfactory in use. It was as follows;

FULL NAME ____________________ AGE ______years __________months.

INSTRUCTIONS

1. Read through all the statements.
2. Choose the TEN that you most agree with and put a tick ( ) on the line next to each one.
3. Look at the ten you have chosen and put 1 next to the one you agree with most. Then put 2 next to the one you agree with next and so on until all ten have numbers, one to ten.
4. When this has been done, at the end make a list of the school subjects you prefer, beginning with the one you like most.

_____ I don't see why anyone who does not need science for the job he wants should have to take science.

_____ In modern times, science is the most important occupation in life.

_____ I might like science when I'm older.

_____ Science is difficult to learn.

_____ The things I have learned in my science lessons have been useful in my hobbies.

_____ Those who find mathematics difficult can't do science.

_____ Being a scientist you learn about the Earth and its ways.

_____ Lots of things in science can't be seen and you just have to believe that things are there and imagine what they look like.

_____ Science means progress.

_____ In many ways science can be a curse on mankind.

_____ Science requires a flair for mathematics.

_____ It is interesting to work in a laboratory with scientists.

_____ If I were a scientist I would not be using the same equipment all the time like a factory worker.

_____ Science is uninteresting.

_____ Science sharpens the mind.

_____ Science and its inventions have done more harm than good.

_____ Today the scientist is not held in very high esteem.

_____ I would not like to do all the calculating and measuring involved in a scientist's work.

_____ Science leads to an interesting job.

_____ Science is a waste of time.

_____ To become a scientist means too much study.

_____ Science is the future.

_____ My parents like me to know about science.

_____ I sometimes wish I was better at science but I don't really think it matters.

_____ Science will be very useful as it helps to know how things work in the house.

_____ Sciences are about facts and substances.

_____ Scientists make the world a better place to live in.

_____ Scientists are respected members of the community.

_____ The work in science is hard.

_____ Science is cold and impersonal.

_____ Scientists are born not made.

_____ Science helps people think along logical lines.

_____ Scientists are wrongly blamed for the troubles of the world.

_____ A scientist is usually uncultured.

_____ I find science boring.

_____ There is too much science in my timetable.

_____ A scientist's job is alonely one.

_____ I would like to be a scientist because I like to use equipment.

Put your list of subjects in order here:

In the instructions the pupils were still asked to rank their choice as this appeared to encourage the study of the statements and also allowed the first ten to be extracted should any still over-endorse. In addition, they were asked to rank the subjects they studied. This allowed a check on which sciences were being studied and, more important, since an indication that preference and attitude bear some relationship, this would give one of the assessments of the validity of the test. The pupils were asked to give their names because this reduced spoiled papers. Staff were requested to emphasise their lack of interest in the results.

The reliability, based on the split-half method, was satisfactory. This is discussed in detail later.

For studying attitudes to physics for the Nuffield/conventional comparison another form of this questionnaire was produced in which some statements were slightly altered to make them more specific to physics. This is given in Appendix H. The changes were considered to be so small that the same scale values would apply to this test as well. No statement was altered in such a way that it might affect its scale value. Many were left as they were. This modified test would now tend to reflect attitude to physics rather than the more diffuse attitude to science.

In both tests, Form A ends at the nineteenth statement and Form B begins at the twentieth. The mean Q value of the complete test was 1.57.

7.

Validity

In assessing the validity of a test it is hoped to establish or demonstrate that the test does measure what the experimenter intended it should. One way of doing this is to compare the results obtained from groups whose attitude to the object in question is known. Although this involves certain assumptions, it has been widely used.

In a sixth form, when the subjects of study have been freely chosen, it might be expected that attitude to science would be one factor in deciding whether the pupils selected the arts or the science side. Although other influences such as, employment aspirations and parental or staff wishes will be operating, it could be expected that those selecting subjects totally from the arts group would be less favourable to science than those who select the sciences. Therefore, 66 sixth formers who could be classified as doing purely arts or science subjects were selected to give an indication of the validity. Thirty-two did arts and thirty-four did sciences. The 19-19 test was given to them with instructions 4 and 5 deleted as these did not apply. The tests were scored, as indicated previously, by finding the median.

Since normality of distribution could not be assumed (107), the results were analysed using the nonparametric, median test (108). Those above and below the median were compared for the two groups, arts and sciences, (Appendix I). It was found that the two groups differed significantly ($\chi^2 = 15.9$ with 1 d.f. $p < 0.0005$ one-tailed test) with the arts group less favourable to science than the other. So it was concluded that this was evidence for the validity of the scale.

Other evidence, obtained from the application proper and relating to the attitude to science test and the attitude to physics test, is given later.

8.

Application of the Scale

8.1 Sample

The questionnaire was given to all pupils in the first four forms of the four, mixed secondary schools of a multilateral unit in County Durham. Exceptions were those pupils absent and those remedial pupils who were considered, on the advice of their teachers, to be unable to understand what was required. These four schools comprised the three secondary modern schools taking the lower ability range and the grammar school which took the higher ability range. This gave a total of 468 boys and 458 girls.

In addition, the test was given to a small sample of junior pupils in the final classes of a junior school which supplied the secondary schools in order to establish the limits of the test.

The sample was restricted to the first four forms of the secondary schools because, by the age of 15+ years, the attitude should have begun to stabilise, (74) and also because of some confusion in the modern school over the raising of the school-leaving age, in their case.

According to Zinn and others, the attitude to science has its roots very early in the child's school life and so this limitation was not considered to be important.

For the comparison of Nuffield physics with conventional physics, the modified questionnaire was given to the fourth year groups of ten grammar schools of which five followed the conventional course while five followed the Nuffield course. The schools were widely separated in Durham and had no overlap in intake. It was assumed, therefore, that equivalent streams in each would be roughly equal in ability. Of the information gathered, eight schools were selected on this basis of matched streams, the other two consisted of one unstreamed class and one top stream class which could not, therefore, be compared in case ability affected attitude. The other **eight** consisted of equivalent streams, four Nuffield and four non-Nuffield. These were top or second streams, the same number in each. This gave a comparison of 117 pupils doing Nuffield physics with 117 doing conventional physics.

It has been found in an American study that pupils' attitudes decline throughout the school year (109). To avoid risking differences arising from this source, the test was administered to the multilateral schools and junior sample in the Spring term, as near to each other as possible and all within some two or three weeks. Similarly, with the grammar schools used in the Nuffield/conventional comparison, the tests were applied at the same time during the Spring term of the following year.

8.2 Method of Analysis.

The medians of the endorsements of Forms A and B were found and also the overall median. The overall median was the score of the subject as indicated previously.

Median Test:- Using this overall median, comparisons between groups were made using the median test (108). For example, in comparing the scores of boys with those of girls, the number of boys above and below the median was compared with the number of girls above and below the median. This was cast in a 2 x 2 table as in Table 5.

Table 5. 2 x 2 Table to compare boys above and below the median of the sample with girls above and below the median of the sample.

	Above Mdn.	Below Mdn.	Σ
BOYS	a	b	a+b
GIRLS	c	d	c+d
$\sum$	a+c	b+d	n

The frequencies were compared using the χ^2- test with 1 d.f. (single or double-tailed where indicated) where

$$\chi^2 = \frac{n\left[(bc - ad) - \frac{n}{2}\right]^2}{(a+c)(b+d)(a+b)(c+d)}$$

including the $\frac{n}{2}$ of Yates' correction for continuity (110), (frequencies in 2 x 2 table discrete but χ^2 is continuous).

Reliability:- Since the scale cannot be said to be more than ordinal with certainty, the Spearman rank correlation coefficient r_s (111) was used to compare the split-half median scores of Forms A and B as a test of reliability.

Reliability, or the ability of the test to give the same answer whenever the test is applied to a given subject, could be calculated by repeating the test on all subjects at a later date, long enough for the subjects to have forgotten what they had already endorsed but not so long that attitudes may have changed anyway. This method was avoided because it brought in other problems such as the possibility of attitude change throughout the term, the influences of changes of staff and the possibility that some headmasters would not wish to take part in a prolonged test. For these reasons, the questionnaire was constructed in the parallel Forms so that a correlation between the two Forms could be made for each subject.

Correlation tables of grouped data were made as in Table 6.

Table 6

		Score on Form B (Y) 0 - 0.9; 1 - 1.9;	Totals	Joint Rank
Score on Form A (X)	0 - 0.9			
	1 - 1.9			
	2 - 2.9			
	⋮			
	Totals			
	Joint Rank			

and r_s was calculated, corrected for ties, from

$$r_s = \frac{\sum x^2 + \sum y^2 - \sum d^2}{2\sqrt{\sum x^2 \sum y^2}}$$

where $\sum x^2 = \frac{N^3 - N}{12} - \sum T$, similarly for $\sum y^2$ and where

$T = \frac{t^3 - t}{12}$ with t = number tied in any one group.

and where $\sum d^2$ = difference squared between corresponding ranks.

N = number of observations.

Since N is always large in this case, then significance of r_s can be tested with the Student's t distribution;

$$t = r_s \sqrt{\frac{N - 2}{1 - r_s^2}} \qquad \text{with d.f.} = N - 2$$

The reliability for the whole test r can then be found from the Spearman - Brown Prophecy Formula (112).

$$r = \frac{mr_s}{1 + (m - 1)r_s} \qquad \text{with } m = \frac{k}{n} \quad (\text{n for no. in } r_s\text{:k for total})$$

where test is divided equally in $m = \frac{k}{n} = \frac{2n}{n} = 2$.

$$\text{So } r = \frac{2r_s}{1 + r_s}$$

In this case, for the age range for which the test was designed, the reliability was over 0.80, as given in detail later.

Validity:- The main test of validity has already been given but subsidiary tests as checks could be made. The link between attitude and subject preference has already been shown, some limited correspondence existing. Since the pupils were asked to rank the subjects in order of preference, a comparison could be made between this ranking and the score. Each ranking was coded by calling the first (most preferred) pair of subjects; one, the second pair; two, and so on. When science fell in the first pair, the score for that pupil was 1. If the sciences were separate, a mean score was taken as a rough estimate of the position of the mean rank. In this way, numbers ranging from 1 to 5 were obtained for each pupil.

From the results a 2 x 2 table was formed as in Table 7.

Table 7

Attitude Scale

	Score Category	Above Median	Below Median	$\sum$
↑ Preference Rank ↓	1 or 2			
	3 or 4			
	$\sum$			

and the following hypothesis could be tested;

H_0: That there is no difference between the number above the median on the attitude scale and those below the median in the way they rank subject preferences, as against

H_1: Those above the median on the attitude scale also tend to rank science highly (ranks 1 and 2) in subject preference.

Hence a χ^2 one-tailed test with 1 d.f. could be used and a contingency coefficient

$$C = \sqrt{\frac{\chi^2}{N + \chi^2}}$$ could be calculated (113)

(C_{max} for a 2 x 2 table = 0.707 and C_{min} = 0).

This method was applied first to the multilateral unit sample and then to the Nuffield versus conventional sample.

On this basis, H_1 was confirmed for both samples and so favourable attitude scores were generally associated with a preference for science, as is shown in detail in the following chapter.

9.

Results.

9.1 Subject-Preference Validity.

From the sample, 1 066 pupils gave sufficient information to allow the scale values to be compared with their subject preference. A 2 x 2 table was formed from the results (Appendix J) and χ^2, with Yates' correction, was 139 with 1 d.f. which was highly significant. The contingency coefficient was 0.339.

This was interpreted as confirming the hypothesis that those who are above the median on the attitude scale score tend also to prefer science while those who are below the median tend to rank sciences lower in their order of subject preference.

This adds further weight to the main assessment of validity based on sixth form answers to the questionnaire. Taken together, these were accepted as validating the test.

Since the main test had been modified slightly in order to make it specific to physics, a further test of validity was carried out on the smaller group involved in that particular experiment. Of the fourth formers involved in the Nuffield/conventional comparison, 209 gave sufficient information to allow the preference for physics, ranked as for science above, to be compared with the attitude scores. Again, a 2 x 2 table was formed (Appendix J) and χ^2, with Yates' correction, was 56.1 with 1 d.f. which was highly significant. The contingency coefficient was 0.461. (Also see Appendix J).

This was interpreted as confirming the hypothesis that those who are above the median on the attitude to physics score tend also to prefer physics while those who are below the median tend to rank physics lower in their order of subject preference. Thus, the small changes made do not seem to have affected the test adversely.

9.2 Reliability

The correlation coefficient between Forms A and B, corrected by the Spearman-Brown formula are given in Table 8. These are the measure of reliability.

Table 8.

SUBJECT	r
Junior	0.57
YEAR 1 secondary	0.80
YEAR 2 "	0.83
YEAR 3 "	0.84
YEAR 4 "	0.82
Nuffield v. Conventional	0.80

The lower correlation of the junior sample would indicate that the lower limits of application of the test have been reached. This would seem reasonable since many statements do not apply to pupils who take little or no science. The rest may hold some above the comprehension of those children. Results for such a sample must be treated with caution. The remaining coefficients are a satisfactory indication of reliability. These figures compare favourably with those usually accepted in attitude measurement (114).

Appendix K contains specific information on the reliability calculations.

9.3 Testing the Hypotheses.

1. Null hypothesis H_0: That those above and below the neutral (5.5) on the attitude scale tend to be the same in number so the overall median is 5.5, as against,

   Alternative hypothesis H_1: That there are significantly more pupils who are favourable to science than who are not.

   Attitude Scale. As derived here for attitude to science.

   Sample. 1 066 mixed pupils (used in the subject-preference validity, median 3.685). This excludes the junior sample.

   Statistical Test. The median scores were grouped into two independent samples, namely, those above 5.5 and those below 5.5 on the scale. Normality of distribution cannot be assumed but the scale is ordinal so a non-parametric test was used.

   Significance Level. H_1 to be accepted if the probability of finding such a deviation is less than 5% by chance alone.

   Sampling Distribution. Chi-square , d.f. = 1, with Yates' correction for continuity.

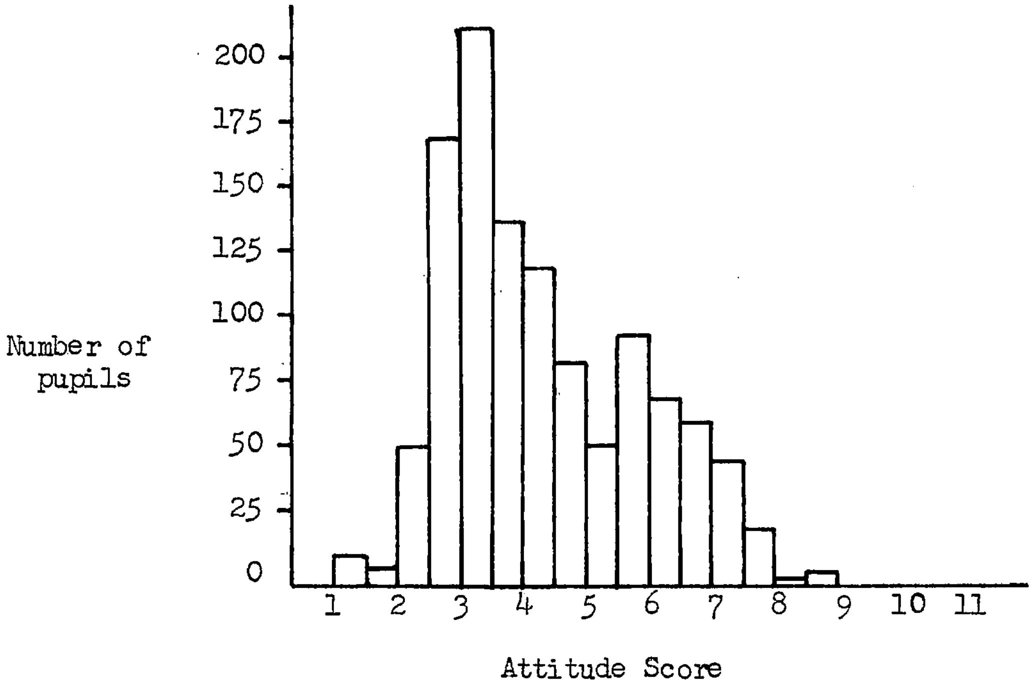
   Rejection Region. Since H_1 predicts direction of the difference, a one-tailed test is used.

   Decision. From the results in Appendix L, $\chi^2 = 435$, with 1 d.f. This is highly significant so H_1 is accepted. The number of pupils on the more 'favourable' side of the scale significantly exceeds those on the 'unfavourable' side.

   Therefore, the pupils in the sample tended to be favourable to science.

Fig. 11 illustrates this.

Fig. 11 Overall Distribution of pupils against their attitude to science.



This histogram was constructed from the frequency distribution of all the pupils in the sample, given in Appendix L. It is apparent from this figure that the majority of scores are on the favourable end of the attitude scale, that is, towards the origin. The statistics above show this displacement to be significant.

2. Null hypothesis H_0: There is no difference in the attitude to science between boys and girls, as against,

Alternative hypothesis H_1: The boys are more favourable to science than the girls.

Attitude Scale. As derived here for attitude to science.

Sample. The 468 boys and 458 girls of the multilateral unit, (three modern schools and one grammar school) and a sample of the 62 boys and 61 girls (10+ years old) contributing to the same schools.

Statistical Test. The hypothesis was to be tested in each year group to see if boys were more favourable to science than the girls. It was similarly tested on the overall sample, that is, with modern and grammar school results combined. It was again tested within the whole grammar school sample and within the whole modern school sample. In this way, any difference between boys and girls in attitude was tested for in;

(a) the overall, combined sample for each year group.

(b) the modern school sample for each year group.

(c) the grammar school sample for each year group.

(d) the junior school sample (one year group).

Year 0 was the junior sample, Year 1 was the first-year secondary school sample and so on, to Year 4.

Normality cannot be assumed but the scale is assumed to be ordinal so a non-parametric test was used.

Significance Level. Accept H_1 if the probability of finding such a deviation by chance alone is less than 5%.

Sampling Distribution. Chi-square, calculated for a median test, with Yates' correction for continuity. d.f. = 1.

Rejection Region. Since H_1 predicts the direction of the difference, a one-tailed test is used.

Decision. The attitude-score frequency distributions for each year group, in Appendix M, allowed medians to be calculated and 2 x 2 tables formed to test boys above and below the median with girls above and below the median for each distribution or combined distribution. Table 9 summarises the results of these median tests, intended to find if one group (boys or girls) exceeded the other in number, above or below the median. ('Above the median' is on the more favourable side of the attitude scale, that is, towards lower scores.)

Table 9 Showing χ^2 values and associated probability for each year group. χ^2 given first. 1 d.f. p = probability by chance alone.

AGE	Overall boys v. girls	Grammar boys v. girls	Modern boys v. girls
Year 0	2.9 $p < 0.05$	-	-
Year 1	3.5 $p < 0.05$	0.6 $p < 0.25$	8.5 $p < 0.005$
Year 2	7.7 $p < 0.005$	1.7 $p < 0.10$	8.0 $p < 0.005$
Year 3	3.1 $p < 0.05$	0.07 $p < 0.40$	8.5(5) $p < 0.005$
Year 4	13.5 $p < 0.0005$	20.3 $p < 0.0005$	6.6(4) $p \leq 0.005$

Table 9 shows, for each age group, first; the results of the comparison between all boys and girls in that age group, second; a comparison between the boys and girls in the grammar school for that age group and finally; the same for the boys and girls of the modern schools. Note that for Year 0, the junior sample, they cannot be split for the second two comparisons. Any $p < 0.05$ is accepted as confirming H_1, that a difference in attitude exists. Thus, all of the first column are significant, similarly with the last column and for Year 4 of the grammar school sample. This leads to the following conclusions:-

(a) For the overall sample, H_1 could be accepted at all ages. This indicates that significantly more boys were above the median than the girls amd that there is a difference in attitude with the boys being more favourable to science than the girls.

(b) For the grammar school sample, H_0 was accepted for Years 1, 2 and 3. H_1 was accepted for Year 4. That is, no difference was detected until Year 4. In Year 4 the boys were more favourable in attitude to science than the girls.

(c) For the modern school significantly more boys were above the median than the girls so H_1 was accepted at all ages, therefore, the boys were more favourable in attitude than the girls throughout.

At this stage it is necessary to consider the effect of such a difference in attitude between boys and girls before comparisons are made which group them together.

Appendix N shows that if the number of girls in a sample is increased while the number of boys remains the same, then the overall mean score will move towards the mean of the girls (that is, become less favourable). In other words, when two mixed groups are compared, unless the proportion of girls in each is the same, a difference could be detected due solely to the difference created by the unbalanced number of girls. This would also apply to the median.

In the work which follows, the proportion of girls will be equal in groups that are compared. Excess numbers of girls and boys will be removed by a random process to obtain such a balance.

3. Null Hypothesis H_0: There is no difference between more able and less able pupils in attitude to science, as against,

Altenative Hypothesis H_1: The more able are more favourable to science than the less able.

Attitude Scale. As derived here for attitudes to science.

Sample. The pupils of the first four years of the secondary modern schools and the grammar school. The former represented the less able while the latter represented the more able. In each year group the proportions of boys and girls were made equal by random removal of excess scores. For the actual number of pupils in each year group, see Appendix O.

Statistical test. After this balancing, the secondary modern sample was compared with the grammar school sample. Normality could not be assumed but an ordinal scale is assumed so a non-parametric median test was used.

Significance level. Accept H_1 if probability of finding H_1 is less than 5% by chance alone.

Sampling distribution. Chi-square from the median test with Yates' correction for continuity.

Rejection region. Since H_1 predicts the direction of the difference, a one-tailed test is used.

Decision. From the results in Appendix O the following table was compiled;

Table 10. p=Probability by chance alone

AGE	χ^2	Probability, p
Year 1	14.0	$p < 0.0005$
Year 2	20.5	$p < 0.0005$
Year 3	29.0	$p < 0.0005$
Year 4	3.4	$p < 0.05$

This table gives the value of chi-square from the median test and the significance of any difference in attitude between high and low ability at each year level.

It shows that the high ability group (that is, the grammar school sample) was more favourable to science than the low ability group (the modern school sample), especially during the first three years of the secondary school. H_1 was accepted at all levels, although only just for Year 4.

4. <u>Null hypothesis H_0:</u> There is no difference in attitude to science between younger and older pupils in the secondary school, as against,

<u>Alternative hypothesis H_1:</u> Younger pupils are more favourable to science than older pupils.

<u>Attitude Scale</u>. As derived here for attitude to science.

<u>Sample</u>. As used in hypothesis 3, matched for the proportion of girls and boys in each year group. By a similar reasoning to that given in Appendix N, the proportions of modern to grammar school pupils should be the same since the modern school pupils have been demonstrated to be less favourable in attitude (Hypothesis 3). However, since the grammar school took about 50% of the total intake, the proportion of modern to grammar pupils for Years 1 and 2 was 0.97 and for Years 3 and 4 it was 1.02. These were considered close enough to make it unnecessary to adjust the group sizes in this particular sample. The medians were;

Year 1: 3.71, Year 2: 3.70, Year 3: 3.83, Year 4: 4.15.

so years 1 and 2 were taken together and combined for comparison with combined Years 3 and 4. The sample sizes were;

Years 1 and 2: 398, Years 3 and 4: 424.

The overall median was then 3.846. The frequency distributions are given in Appendix P.

<u>Statistical test</u>. Normality cannot be assumed so a non-parametric median test was used, as before.

Significance Level. H_1 is to be accepted if the probability of finding such a deviation by chance alone is less than 5%.

Sampling Distribution. Chi-square from the median test with Yates' correction for continuity . 1 d.f.

Rejection Region. Since H_1 predicts the direction of the difference, a one-tailed test is used.

Decision. From the results in Appendix P, $\chi^2 = 3.507$ for the median test with 1 d.f. for which the probability, by chance alone, is less than 0.05 (1-tailed). Therefore the alternative hypothesis H_1 is accepted.

ie. The younger pupils are slightly more favourable to science than the older pupils.

Figs. 12 and 13 below illustrate the distributions.

Fig. 12 YEARS 1 & 2: Histogram: Number of pupils against attitude scores.

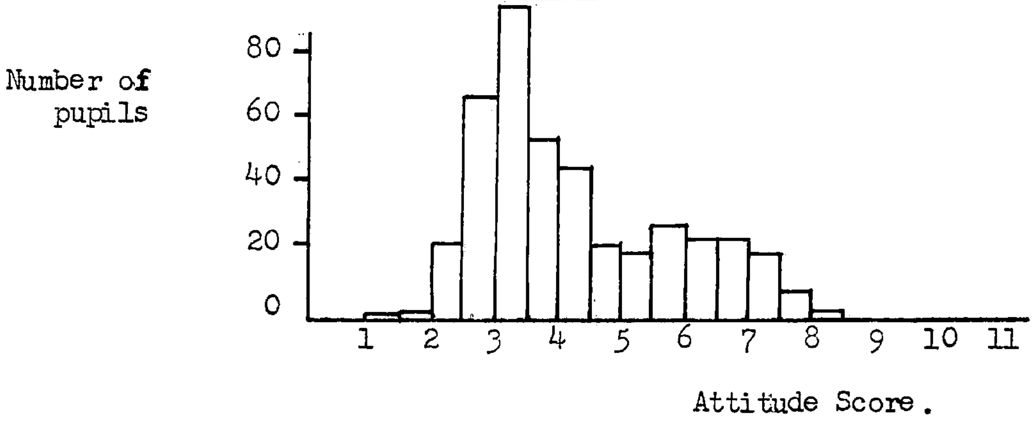
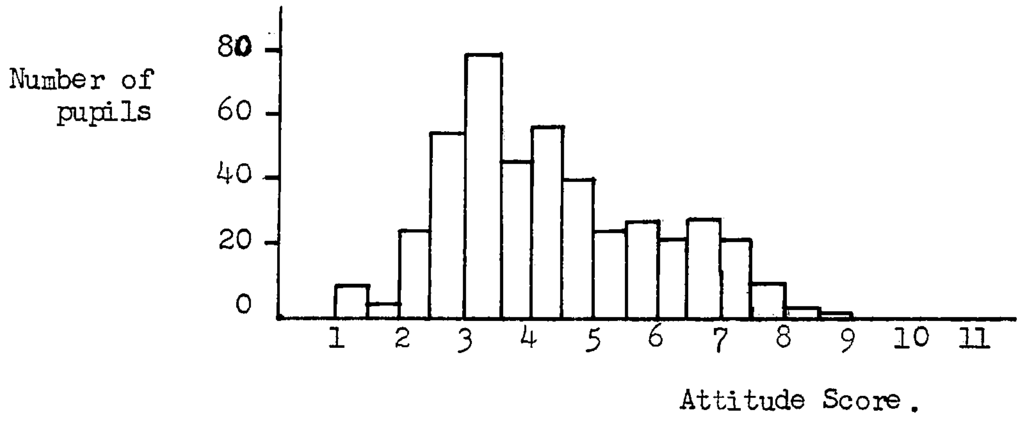


Fig. 13 YEARS 3 & 4: Histogram: Number of pupils against attitude scores.



5. <u>Null hypothesis H_0:</u> There is no difference in attitude to physics between those pupils following a Nuffield Project course in physics and those following conventional courses in physics, as against,

<u>Alternative hypothesis H_1:</u> One group is more favourable in attitude to physics than the other.

<u>Attitude Scale.</u> The modified scale for attitude to physics was used, as derived here and discussed earlier.

<u>Sample.</u> Eight grammar school fourth year forms were selected such that four were from schools which had followed the Nuffield Project scheme throughout the school life of those forms and four were from schools which did not follow this or another scheme. These eight had been selected from ten on the basis of matched ability since extremes in ability are related to attitude (Hypothesis 3), so equivalent streams in the two samples were taken for comparison. This gave 90 boys and 36 girls following the conventional course and 81 boys and 38 girls following the Nuffield course. To eliminate bias due to disproportionate numbers of each sex, the largest random sample was taken giving 81 boys and 36 girls following the Nuffield course and the same following the conventional course, that is 117 in each group. The schools were widely spread through Durham County and did not overlap in intake. Appendix Q gives the frequency distributions.

<u>Statistical Test.</u> Normality of distribution cannot be assumed so a non-parametric median test was used.

<u>Significance level</u>; Accept H_1 if the probability of finding H_1 by chance alone is less than 1%. (In testing this hypothesis, the 1% level is prefered to the 5% in order to allow for any residual variation between teachers causing attitude variations in pupils not detected by Meyer and Penfold and Kelly (61 and 62).)

Sampling Distributions. Chi-square from the median test, with Yates' correction for continuity. 1 d.f.

Rejection Region. as below, for H_1 not predicting the direction of the difference the test is two-tailed otherwise it is one-tailed.

Decision. From the results in Appendix Q, $\chi^2 = 5.547$ 1 d.f. for the median test, for which $p \leqslant 0.02$ (two-tailed) and H_0 is accepted. However, if the test had been one-tailed, $p \leqslant 0.01$ which would just allow the conclusion that H_1 is true and, in this case, those following the conventional courses were slightly more favourable in attitude to physics than those following the Nuffield course. The histograms (figs. 14 and 15) illustrate the distributions. These were constructed from the information in Appendix Q.

Fig. 14 Histogram showing the frequency distribution for the pupils following a conventional physics course.

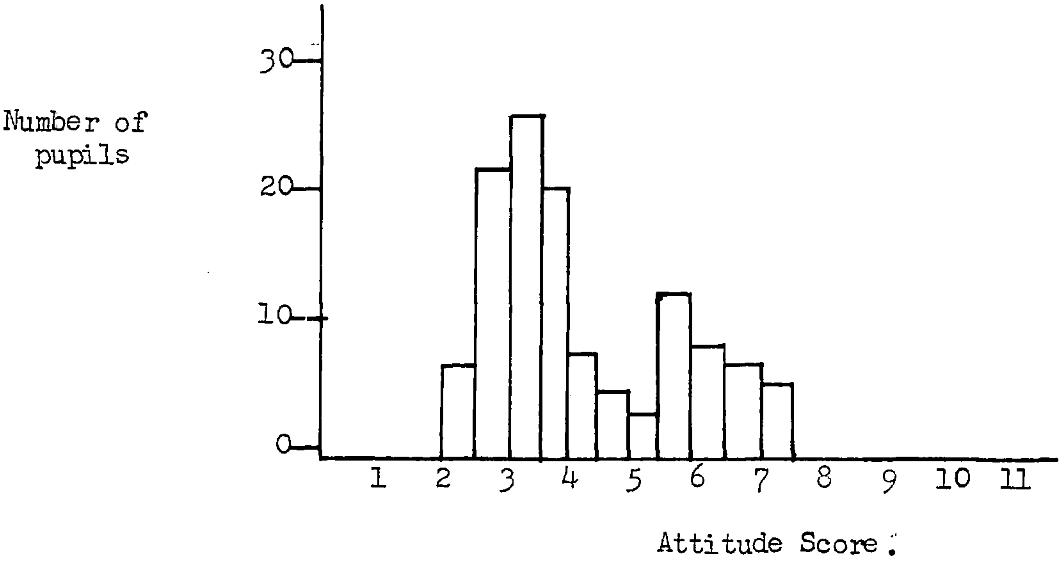
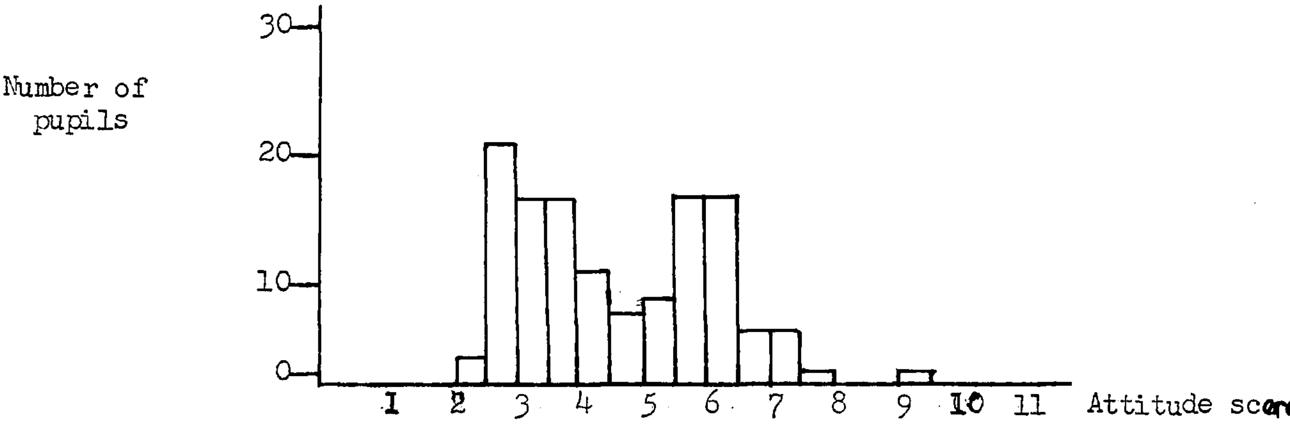


Fig. 15 Histogram showing the frequency distribution for the pupils following a Nuffield Project physics course.



It can be concluded that, at the least, there is no significant difference in attitude to physics between these two groups; one following a Nuffield course and the other following conventional courses. It also seems that the latter group, in this particular sample, gave indications of being slightly more favourable to physics than the former. Examination of the histograms in Figs. 14 and 15 also indicate a degree of polarisation of attitude present in both samples.

6. Null hypothesis H_0: There is no correlation between attitude to science and attainment, as against,

Alternative hypothesis H_1: That there exists a positive correlation between the two, those having a favourable attitude also attain more in science, provided that some allowance for intelligence is made.

Attitude and Attainment. The attitude to science scale derived here and the results of end-of-term examinations were used. A mean of the chemistry and physics examination marks was found for each pupil and used as a measure of attainment. This somewhat crude measure was used since it is the commonly 'accepted' measure of achievement in and out of schools.

Sample. Three, streamed grammar school forms were used. The pupils were all in the third year, after selection at the end of the second year based on school examination results. For each pupil, his attitude score and attainment (percentage) was recorded in separate correlation tables according to form (Appendix R). In effect, this was ranking the pupils for attitude and attainment within each form, thus making an allowance for over-riding effects of intelligence. The number in each form was, 33, 25 and 27.

Statistical test. The Spearman Rank correlation coefficient, r_s, was calculated for each form to find the measure of association between attitude and attainment.

Significance Level. Accept H_1 if probability of finding H_1 is less than 5% by chance alone.

Sampling Distribution. Student's t was calculated for each correlation coefficient to test for significance.

Rejection Region. Since H_1 predicts the direction of the association, a one-tailed test was used.

Decision. From the results in Appendix R, for form

3B, $r_s = 0.37$ $t = 2.24$ with 31 d.f. $p < 0.025$

3C, $r_s = 0.38$ $t = 2.06$ with 25 d.f. $p \leq 0.025$

3D, $r_s = 0.40$ $t = 2.42$ with 23 d.f. $p \leq 0.025$

(all one-tailed)

so for each form H_1 was accepted and this was interpreted as meaning that within each streamed form, there was a positive correlation between attitude to science and attainment in the examination. That is, a favourable attitude to science tended to be associated with higher attainment in examinations when the factor of ability was allowed for.

10.

Discussion of Results

There is no evidence from these results that the drift away from science noted by Dainton and others is due to the development of an unfavourable attitude to science. In spite of adverse publicity that science and scientists have received mainly directed at a lack of social conscience, as described by Professor Cotgrove (119), the pupils' attitudes, as seen in this sample, are very favourable. This has its origins in, or earlier than, the first year of the secondary school since the distributions (Appendix 0) for the junior sample and the year 1 sample show this favourable disposition, paralleling Zinn's findings in America (74). The drift away from science may be due to increased competition from other fields of work and study now available.

That, generally, the girls had a less favourable attitude than the boys was confirmed. This was the case throughout the modern school, and the junior sample, in spite of little or no contact with school science, showed a similar difference.

This was not the case until the fourth year for the grammar school sample. At this stage, the grammar school sample would begin specialisation and take an arts or science biassed combination of subjects. If the results for the junior sample are valid more widely then this would indicate that the difference in attitude has its origin outside of school science and possibly in hobbies, parental influences, sex-differentiated play or general dispositions which are innate (115) or introduced by differences in the socialisation process. The 'Feminine Image' of Hallworth and Waite and historical differences would contribute to the differences.

It should be noted that the difference is small and that there is considerable overlap with the attitudes of the boys.

That the lower ability group showed less favourable attitudes to science than the higher ability group was shown to be true. Whether it is a lack of achievement or intelligence that gives rise to a less favourable attitude or whether the latter gives rise to the lack of achievement has not been established. It could be that the lower ability group is characterised by less favourable attitudes to most school activities. But, once again, the attitude is not totally negative. A glance at the frequency distributions, for example, Years 1, 2, 3 and 4 of Appendix O, shows that the median score is still favourable to science. By Year 4, the difference was less in the sample, possibly due to the specialisation in the grammar school sample, mentioned before.

For the overall sample, the attitude of older pupils is slightly less favourable than for the younger pupils. More experience in science, the introduction of quantitative work and a general rationalising of attitudes for the older child could produce the observed difference. It may be the case with most school subjects as their nature changes throughout the course. Elsewhere, outside and inside school, conflicting interests could engender value systems and attitudes which are inimical to favourable inclinations to science. The older pupil is also directed into, or chooses, specialisation. This may well result in a polarisation of attitudes.

There is no evidence that the attitude of pupils taking Nuffield Project physics is better than those following conventional courses. Indeed, for this sample, those taking the Nuffield course were slightly less favourable in attitude to physics.

The results discussed prior to this particular result are, to some extent, expected since they fit in well with the work already examined. This validates the scale further so that more weight is given to this result.

So some of the aims of the Nuffield scheme for physics, namely; 'to present science in a lively (and) exciting way', and to 'attract some of the waverers into a scientific career.' are unlikely to be fulfilled any better than is done by conventional physics courses.

It might be argued that this sample included teachers whose influence produced the less favourable attitudes in Nuffield Physics, in spite of evidence that the influence of the teacher on attitudes to science is small. There is evidence, Zinn et al, (74), and also here, (Hypothesis 4), that the favourable attitude generally noted has its origin earlier than the secondary school. Together, it indicates that the embryonic attitude has already been formed for secondary school pupils before they go to the secondary school. The frequency distribution for the final-year, junior sample shows a general favourability (Appendix M), in spite of many pupils not doing school science and most with only one year or less experience of it. Indeed, a general vague disposition towards science could develop as an extension of a child's natural curiosity towards the environment (117). Evidence has already been presented for an early bias in related fields (115). The influence of the teacher at the secondary stage would be confined to one of attitude change rather than formation. Kelly, Meyer and Penfold (61 and 62) have shown this influence to be surprisingly small, if it exists at all.

Material produced for the Nuffield Project is also available to those who do not follow that course. In some way, the 'good' parts of text-books and equipment could be incorporated slowly into conventional approaches. This may well have an effect on the quality of teaching by the latter method.

It still remains that, whatever the cause, the teacher is at least as important as the method. He is the strongest and, at the same time, the weakest link in the process.

In view of past work and the findings here, it seems reasonable to accept that, at the least, the Nuffield Project in physics does not produce a more favourable attitude than a conventional method. There is a little evidence that the attitude of those following a Nuffield Project in physics is slightly less favourable to physics than the other group.

The frequency distributions of both groups, (Figs. 14 and 15), show a polarisation of attitude which is interesting. This is not so apparent in the results for the more diffuse concept of science seen in Fig. 11. The cause of this was not determined. It may be due to the increased use of mathematics and multiple-step or abstract deduction or it may be characteristic of that age group to simplify and polarise their attitudes at an age when they might be expected to rationalise their value systems.

A significant relationship exists between attitude to science as measured by the scale and achievement or attainment as measured by examination results when ability or intelligence is allowed for. Had ability not been taken into account, the correlation would have been masked and reduced by its over-riding effects as shown in the final table of Appendix R. As expected, although it was significant ($\simeq 0.4$), the correlation is not exceptionally high. This indicates the operation of other factors of which intelligence will be one. However, the correlation is high enough to make it of some importance. Whether or not high attainment reinforces or even causes a favourable attitude (and the converse) has not been established but it seems likely that a favourable attitude will predispose a pupil to tend to succeed in examinations and to achieve more. From the teacher's point of view, apart from it making teaching easier, it is of value in that it may act in the same direction as intelligence.

There are also Nuffield Projects in biology and chemistry. Examination of attitudes in these subjects would be of interest for comparison. As to the overall work, if it was repeated in different areas with similar results it would further reinforce the findings. In the correlation between attitude and achievement, the sample was small but the results were significant. More precise measures of achievement and ability would be useful in further work.

Methods of attitude change have not been discussed but it seems that teachers should encourage a favourable attitude amongst their pupils. Differences due to sex, age and ability can be expected to make this more difficult. New approaches, while they should be welcomed, should be compared with existing methods in all aspects. In this way, the best of all methods can be combined into an efficient whole.

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Appendix A

Don and Grigor collected the preferences of school subjects from 1858 boys and 1762 girls at the Intermediate Certificate Stage in the West of Scotland in 1919. Their results were given in the form showing the numbers of pupils placing each subject first, second, third, fourth and fifth in preference. Their conclusions were drawn without statistical analysis. The table selects some of these results and they are seen to be frequency distributions which would allow a comparison between boys and girls. The nonparametric Kolmogorov-Smirnov method for comparing frequency distributions was adopted to test any differences in the distributions. For each subject, the results were first accumulated and then converted to proportions by dividing by the totals, 1858 for boys and 1762 for girls. The difference in each division was determined, D. The modulus of the maximum D was selected and the χ^2 statistic calculated from $\chi^2 = 4D^2 \frac{n_1 n_2}{n_1+n_2}$ with two degrees of freedom. The probability of such a χ^2 occurring by chance alone was found, p. As the results show, this was small enough in all cases to accept the hypothesis that the two distributions differed significantly. The manner of the difference is given. (n_1= number of boys. n_2= number of girls.)

	PREFERENCES						
SUBJECT	SEX	1st	2nd	3rd	4th	5th	Total
ENGLISH	Boys	457	441	413	386	161	1858
	Girls	620	456	330	244	112	1762
MATHEMATICS	Boys	317	322	377	421	421	1858
	Girls	280	240	293	354	595	1762
FRENCH	Boys	181	219	271	373	814	1858
	Girls	366	369	347	296	384	1762
SCIENCE	Boys	575	448	385	284	166	1858
	Girls	232	304	342	495	390	1763

Table showing the frequency distributions for selected subjects.

Tables showing accumulated proportions for the results on the previous page.

$n_1 = 1858 \qquad n_2 = 1762$

ENGLISH

	1st	2nd	3rd	4th	5th
BOYS	0.246	0.477	0.706	0.914	1.000
GIRLS	0.351	0.612	0.800	0.937	1.000
Difference D	−0.105	−0.135	−0.094	−0.023	—

$|\text{Max}\,D| = 0.135$

$\therefore \chi^2 = 4D^2 \frac{n_1 n_2}{n_1 + n_2}$

$= 66 \quad 2\text{ d.f.}$

$p \ll 0.001$

Therefore girls prefer English more than boys.

MATHS

	1st	2nd	3rd	4th	5th
BOYS	0.171	0.344	0.548	0.774	1.000
GIRLS	0.159	0.295	0.461	0.662	1.000
Difference D	0.012	0.049	0.087	0.112	—

$|\text{Max}\,D| = 0.112$

$\therefore \chi^2 = 45.2 \quad 2\text{ d.f.}$

$p \ll 0.001$

Therefore boys prefer Maths more than girls.

FRENCH

	1st	2nd	3th	4th	5th
BOYS	0.098	0.215	0.361	0.562	1.000
GIRLS	0.208	0.411	0.615	0.782	1.000
Difference D	−0.110	−0.196	−0.254	−0.220	—

$|\text{Max}\,D| = 0.254$

$\therefore \chi^2 = 232 \quad 2\text{ d.f.}$

$p \ll 0.001$

Therefore girls prefer French more than boys.

SCIENCE

	1st	2nd	3th	4th	5th
BOYS	0.309	0.551	0.757	0.912	1.000
GIRLS	0.131	0.304	0.497	0.780	1.000
Difference D	0.178	0.247	0.260	0.132	—

$|\text{Max}\,D| = 0.260$

$\therefore \chi^2 = 244 \quad 2\text{d.f.}$

$p \ll 0.001$

Therefore boys prefer science more than girls.

Appendix B

The following information was extracted from the research.

The sample size was 8 273 which comprised:-

3 834 boys in boys' schools
3 108 girls in girls' schools
747 boys in mixed schools
584 girls in mixed schools

The various school subjects were ranked in order of preference and this ranking taken to indicate the relative popularity of the subjects. Scores were then assigned to each subject as follows;

0 represented that the subject was placed last in popularity by everyone.

100 represented an 'average' popularity.

200 represented that the subject was placed first in popularity by everyone.

Intermediate scores then represented degrees of popularity or unpopularity. In particular, for physics and chemistry, the results for boys and girls at different ages were as follows;

BOYS

Physics	95	88	89	97	89	96	94	98	
Chemistry	124	127	129	133	128	127	116	120	
Age	12½	13	13½	14	14½	15	15½	16	years

GIRLS

(at same ages)

Physics	98	98	92	81	74	82	83	97
Chemistry	110	106	108	105	96	101	96	97

These show how physics maintained its position with the boys while it fell markedly to 74 for girls at 14½ yrs. The subsequent increase may be a result of selection and specialisation. For chemistry for the boys, the popularity is above average and is maintained, while for girls it generally declined with increase in age.

Appendix C

The following information was selected from the research;

9 127 boys and girls aged 13 years in London Elementary Schools were asked to put the school subjects in rank order of preference, beginning with the most preferred subject. The average rank was taken, and the subject placed in an average rank order, again with the most preferred first. The results were as follows:-

	Boys	Girls
1.	Handwork	Dancing
2.	Nature Study	Reading
3.	Drawing	Composition
4.	History	Handwork
5.	Geography	Literature
6.	Reading	Drawing
7.	Drill	Singing
8.	Composition	Nature Study
9.	Singing	History
10.	Literature	Drill
11.	Arithmetic	Scripture
12.	Dancing	Geography
13.	grammar	Spelling
14.	Spelling	Grammar
15.	Scripture	Arithmetic

The order of preference for the boys appears to be different from that of the girls. To test the statistical significance of this difference, the Spearman Rank correlation coefficient was calculated. That is, the rank order of each subject in one group was compared with its position in the other to see if there was any association in position, or positive correlation.

The following results were obtained;

$\sum d_i^2 = 362$ N = 15 (d_i = difference between the ranks for each subject in the two groups. N = sample size.)

Correlation coefficient, $r_s = \frac{1 - 6\sum d_i^2}{N^3 - N}$

$= \underline{\underline{0.35}}$

To test for significance, $t = r_s \sqrt{\frac{N-2}{1-r_s^2}} = 1.35$ with 13 d.f.

(t = Student t distribution with N - 2 d.f.)

A number as large as 1.35 would occur by chance alone 10% of the time so r_s is not significant and no significant relationship between the two preference rankings of subjects was found.

<u>Therefore, boys preferred different subjects to girls.</u>

Appendix D

The numbers are for identification only.

1. I know that my scientific abilities are extremely limited.
2. I think that most people think science is of little use.
3. Science leads to jobs with better wages.
4. I think lessons for such subjects as scripture and music should be replaced by science, which is more useful.
5. Practical science is enjoyable.
6. In nearly all decent jobs at least one science is needed.
7. As I do not intend to pursue science as a career, I find it of less use than the arts subjects.
8. A science job is a secure one.
9. Some of the benefits of learning science I will not know until I am mmch older.
10. Scientists are generally old men.
11. If a scientist invents something which does not work he is generally laughed at.
12. I might like science when I'm older.
13. I have yet to see anything worth while at the end of a microscope.
14. Scientists are constructive.
15. Scientists are born not made.
16. In modern times, science is the most important occupation in life.
17. Scientists are respected members of the community.
18. I don't see why anyone who does not need science for the job he wants should have to take science.
19. Scientists have an interesting job.
20. Experiments are interesting.
21. The work involved in an experiment is boring.
22. There is too much science in my timetable.
23. Being a scientist is hard work.
24. To become a scientist means too much study.
25. Scientists make the world a better place to live in.
26. Scientists think a different way to me.

27. I would not like to do all the calculating and measuring involved in a scientist's work.

28. Science is an important thing in our lives.

29. Science is interesting but I could not be bothered to work out formulas.

30. I would like to be a scientist because I like to use equipment.

31. If I were a scientist I would not be using the same equipment all the time, like a factory worker.

32. Lots of things in science can't be seen and you just have to believe that things are there and imagine what they look like.

33. Science is the future.

34. Scientists spend most of their time in laboratories.

35. Scientists work for years on one thing and seldom find what they are ~~working~~ looking for.

36. The things I have learned in my science lessons have been useful in my hobbies.

37. Being a scientist you learn about the Earth and its ways.

38. Without scientists, the human race would still be almost as primitive as men of the stone-age.

39. We learn useful things from science.

40. A scientist must be able to look at things from many different angles.

41. Work on science is time well spent.

42. Science will be very useful as it helps to know how things work in the house.

43. The modern subjects are the sciences so learning them will help me a great deal.

44. It is an advantage to have some qualification in science no matter what career is intended.

45. I enjoy doing science.

46. I am not clever enough to do science.

47. It is interesting to work in a laboratory with scientists.

48. The work in science is hard.

49. A scientist's work is monotonous.

50. Science leads to an interesting job.

51. I am interested in finding out how and why things work.

52. To be good at science you must be mechanically minded.

53. The main task of a scientist is to find out as much as he can about the world around us.

54. I have never considered being a scientist.

55. Science has made our high standard of living possible.

56. Sciences are about facts and substances.

57. Science requires a flair for mathematics.

58. A scientist has a dangerous job.

59. A scientist has a dull life.

60. Those who find mathematics difficult can't do sciences.

61. A scientist has no social life.

62. Scientists have to be dedicated.

63. A scientist has to have patience.

64. A scientist tends to be cut off from the rest of the world.

65. Most people don't find a use for science in the future.

66. Science is uninteresting.

67. I study the work in science until it finally sinks in.

68. Science is a waste of time.

69. Science is not important for the ordinary person.

70. After the examinations I forget all that I have learned in science.

71. I find science boring.

72. Later on in life I won't remember anything I've learned in science.

73. Understanding science gives a greater understanding in other subjects.

74. I sometimes wish I was better at science but I don't really think it matters.

75. The training science gives helps unscientific people to understand the basic principles of what makes thing work.

76. Many people who have not been taught science are frightened by it.

77. Science should be left to those who are dedicated to it.

78. The world and nature are to be enjoyed, not exploited.

79. Science is not very useful.

80. In most careers, a knowledge of science is helpful, if not essential.

81. Nowadays, passes in science are in demand.

82. Science is becoming more and more important.

83. Lessons in science could be used more profitably.

84. Sciences are only to make life easier and the human species even more lazy.

85. In the name of science, many animals are killed each year.

86. In many ways, science can be a curse on mankind.

87. Anyone who is interested in science should have a very good career.

88. Science means progress.

89. Science rules the world.

90. Science is the means by which life is preserved, created or destroyed.

91. All the luxuries we take for granted are of scientific origin.

92. Science provides all the ideas upon which the artist can elaborate.

93. If it were not for science, things would not be done so quickly or efficiently.

94. Science has helped to make our lives more comfortable and enjoyable.

95. It is impossible to escape from science today.

96. Science is cold and impersonal.

97. Science helps people to think along logical lines.

98. Common sense is of far more use than science.

99. Science should only be taught to those who want to use it as a basis for study and employment.

100. Science is difficult to learn.

101. I doubt if I could find a decent job if I did not have an 'O'-level in science.

102. Science is sometimes interesting.

103. Science is not difficult to understand.

104. It will be useful for me to learn science.

105. My parents like me to know about science.

106. Science is important.

107. Science can be fun.

108. Science is usually misused and one day will destroy the world.

109. The fate of the world is in the hands of the scientist.

110. A scientist must be humane.

111. Today, the scientist is not held in very high esteem.

112. Scientists are wrongly blamed for the troubles of the world.

113. Scientists are too narrow in their views.

114. Scientists possess too much power in our society.

115. Science and its inventions have caused more harm than good.

116. Scientists are usually solitary people.

117. A scientist's job is a lonely one.

118. We should understand simple everyday events and science helps us to do this.

119. Someone intending to do science must be keen and really like his subject.

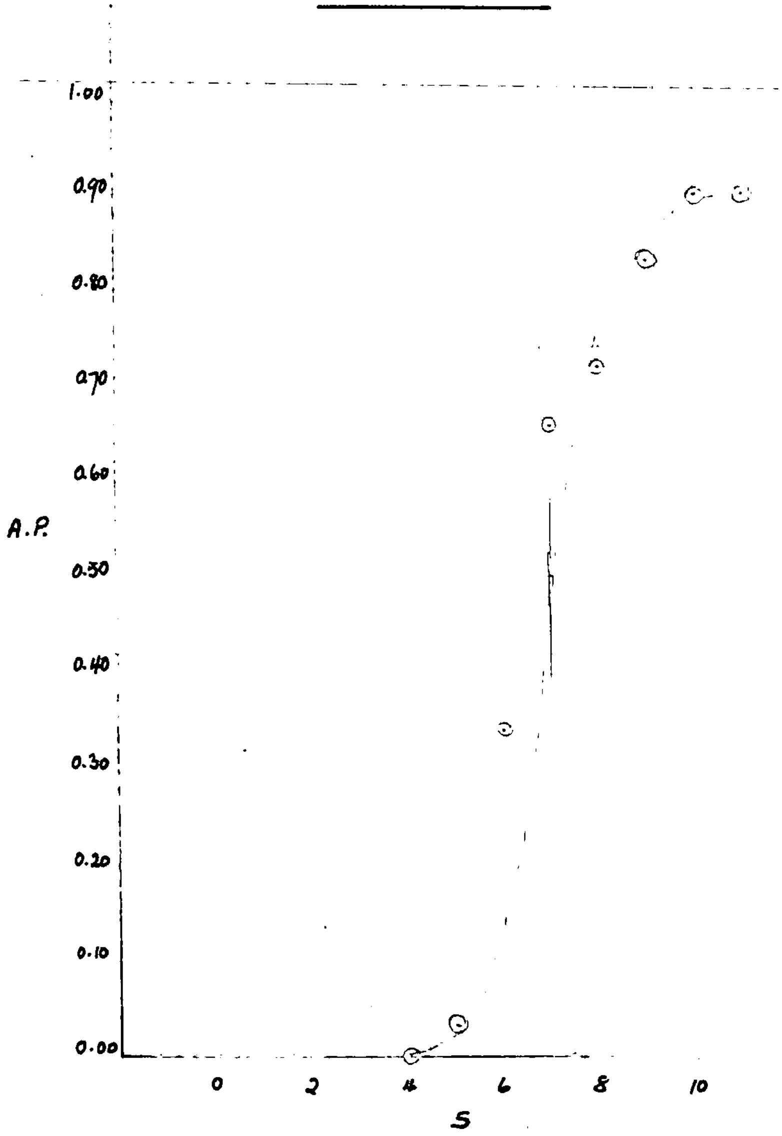
120. A scientist is usually uncultured.

121. Science sharpens the mind.

~~[cont overleaf]~~

Appendix E.

Graphs showing accumulative proportions of judges placing a statement in each group. Graphs 3, 4, 33, and 34 are incorporated in the text as pages 45 and 46.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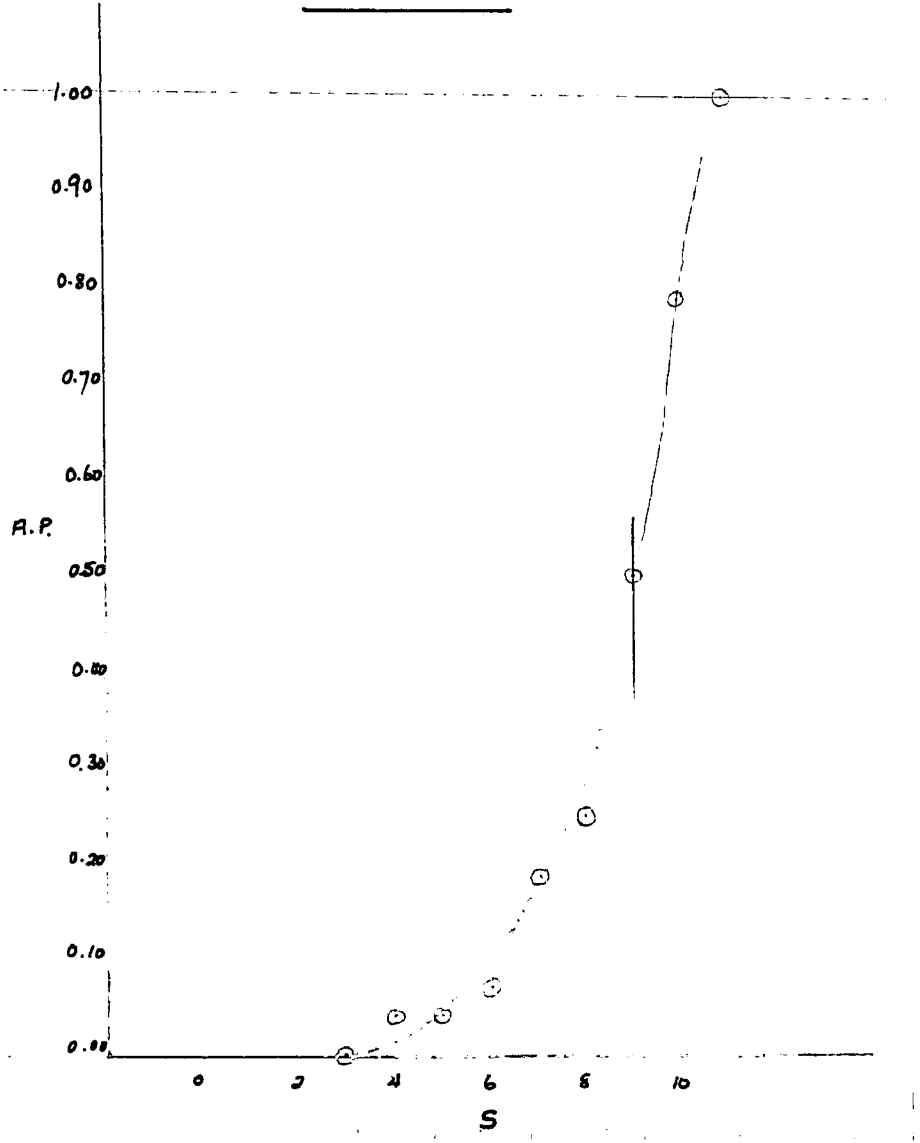
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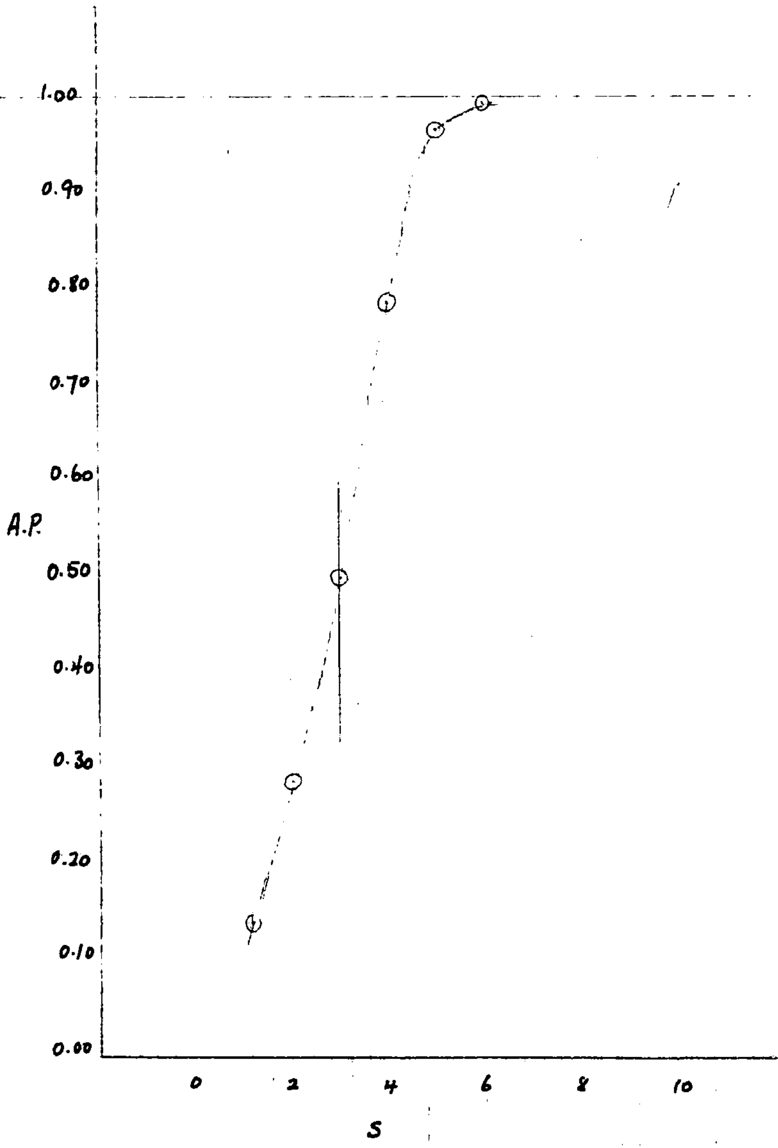
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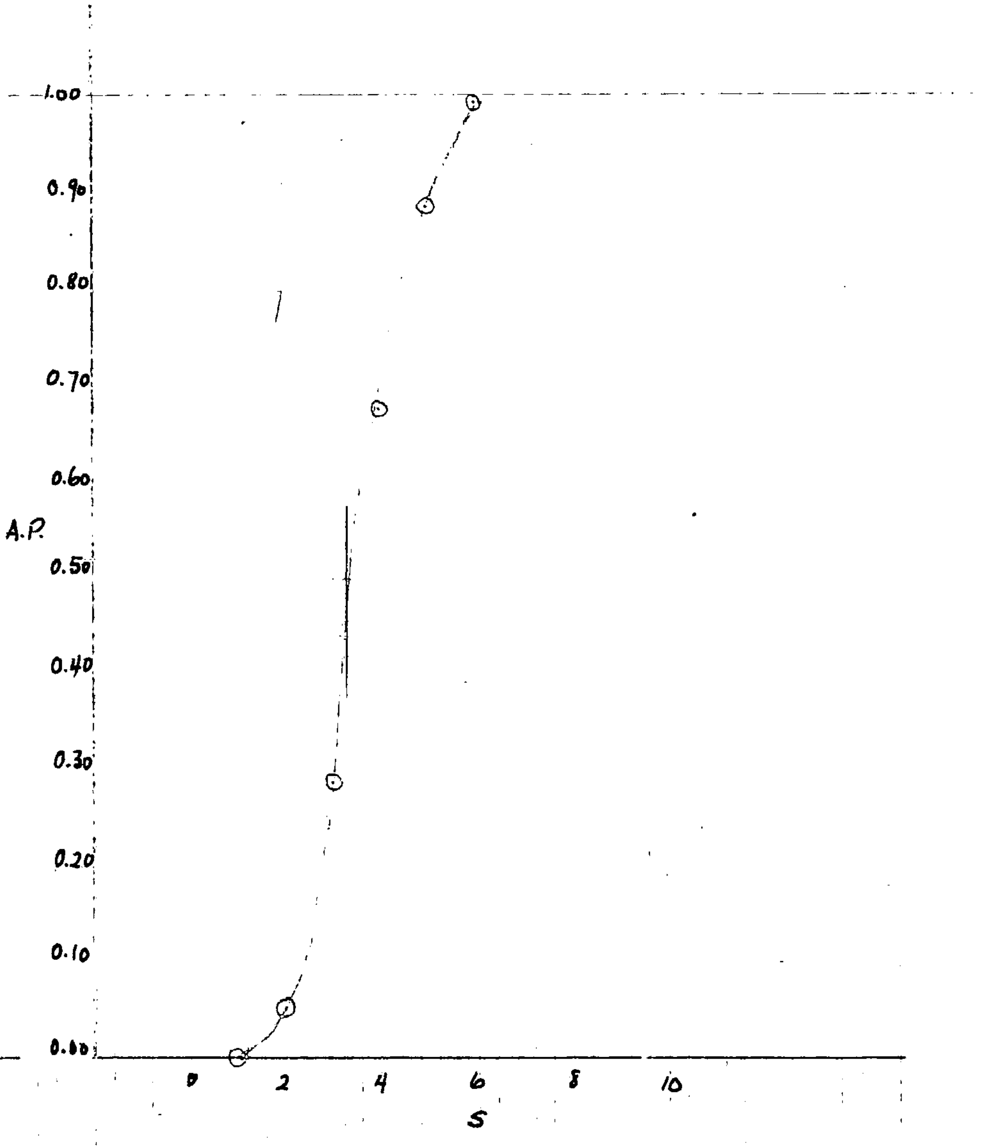
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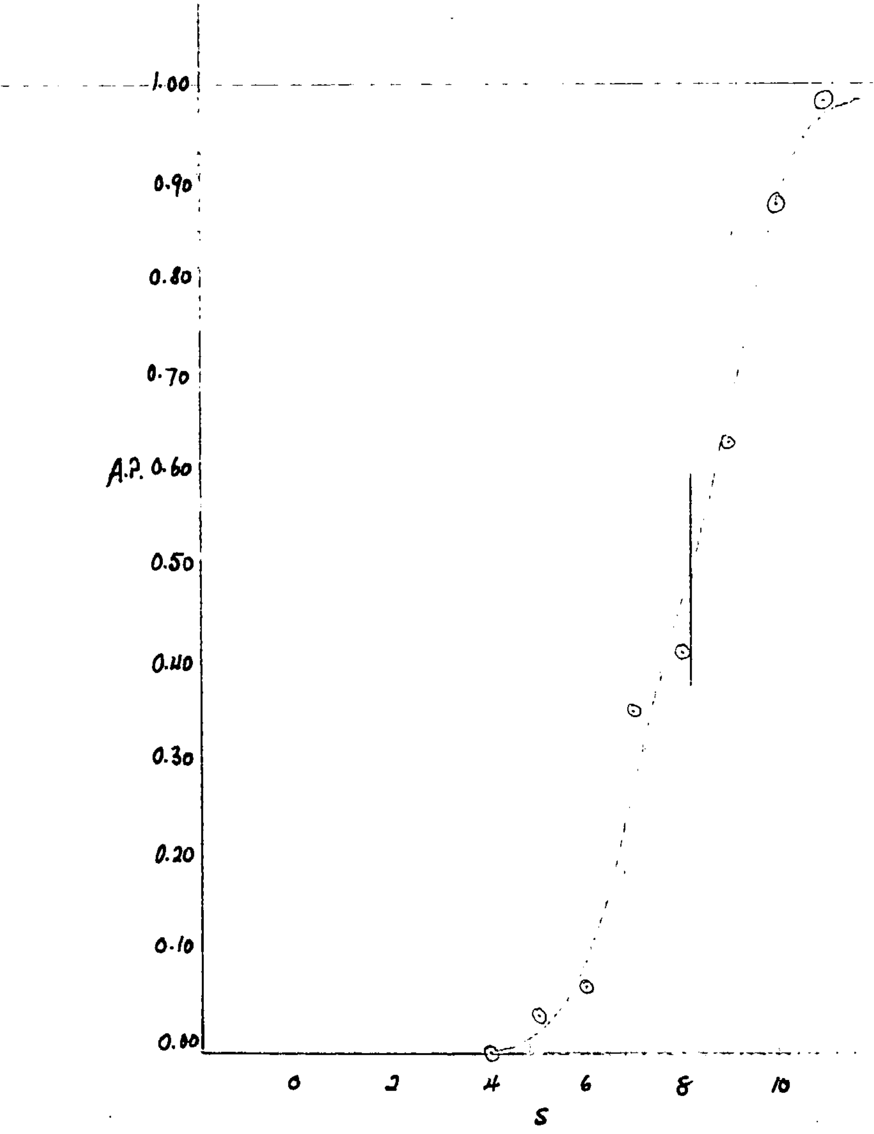

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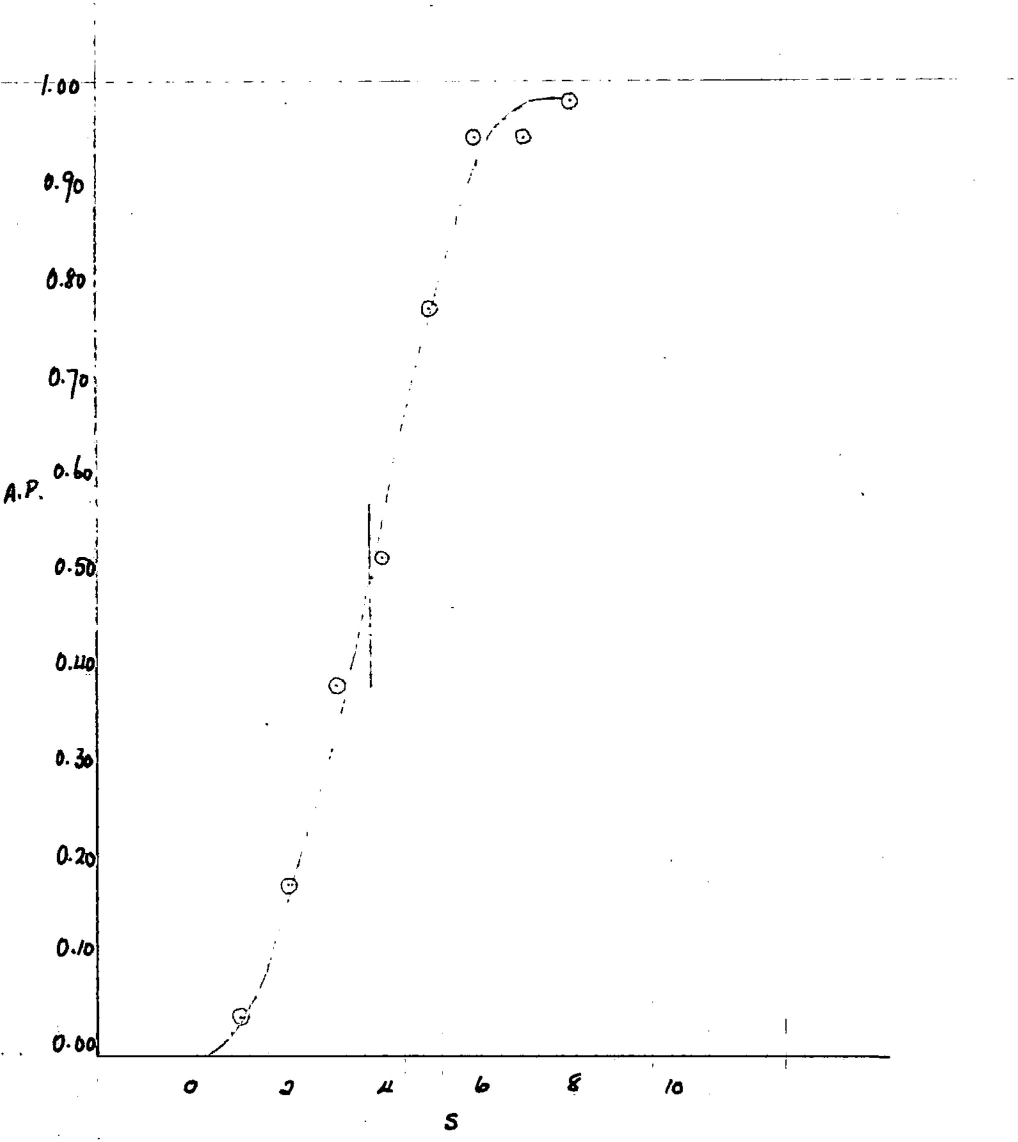

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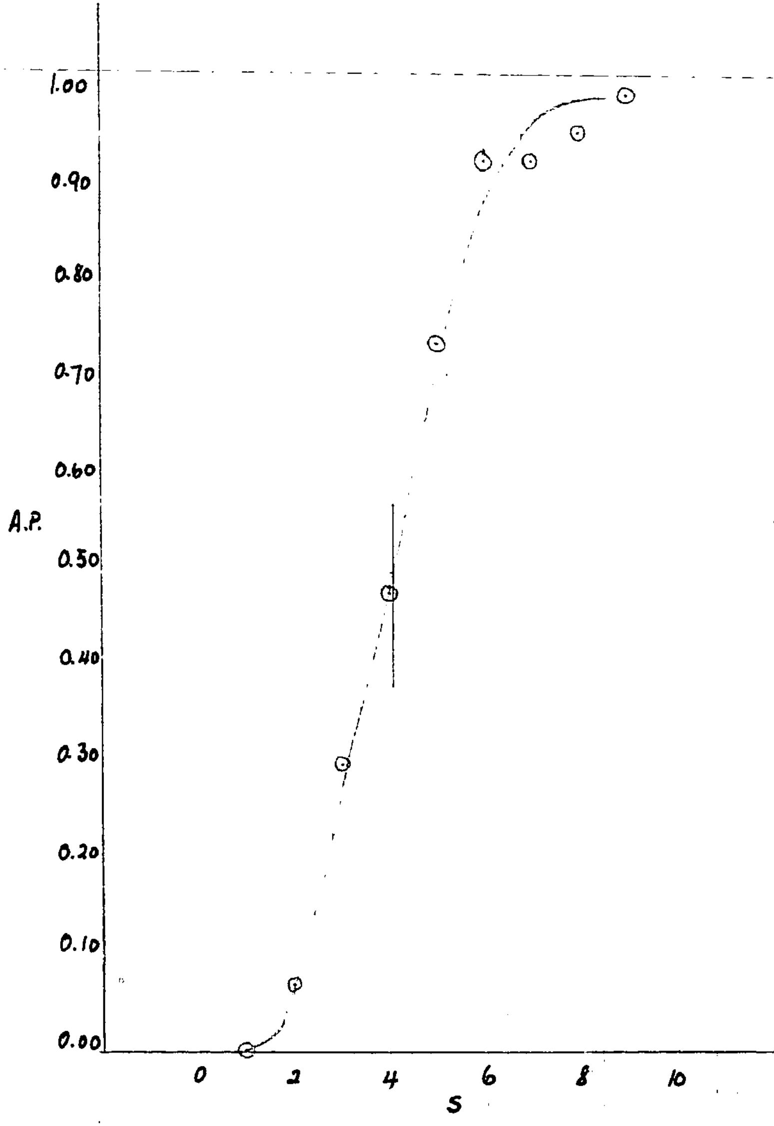
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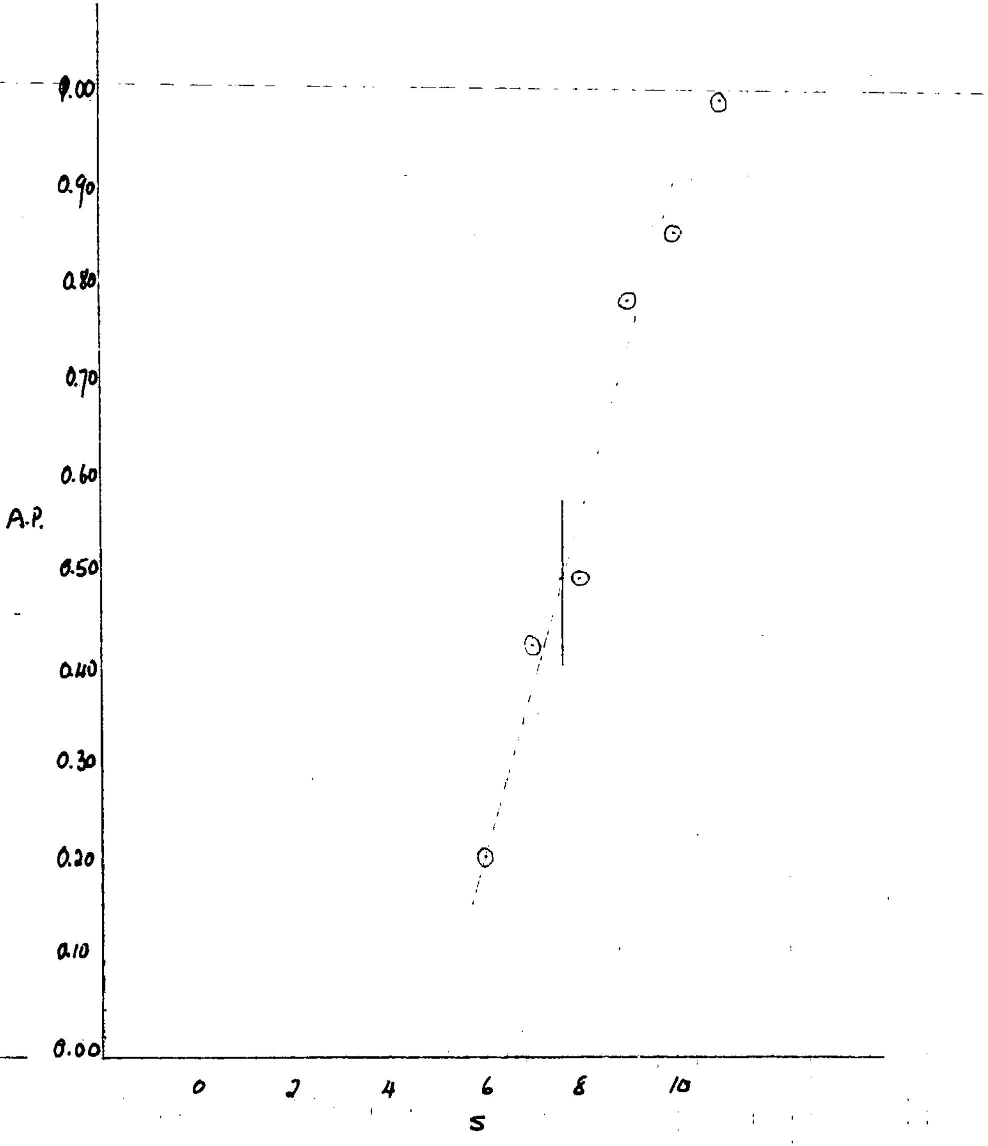
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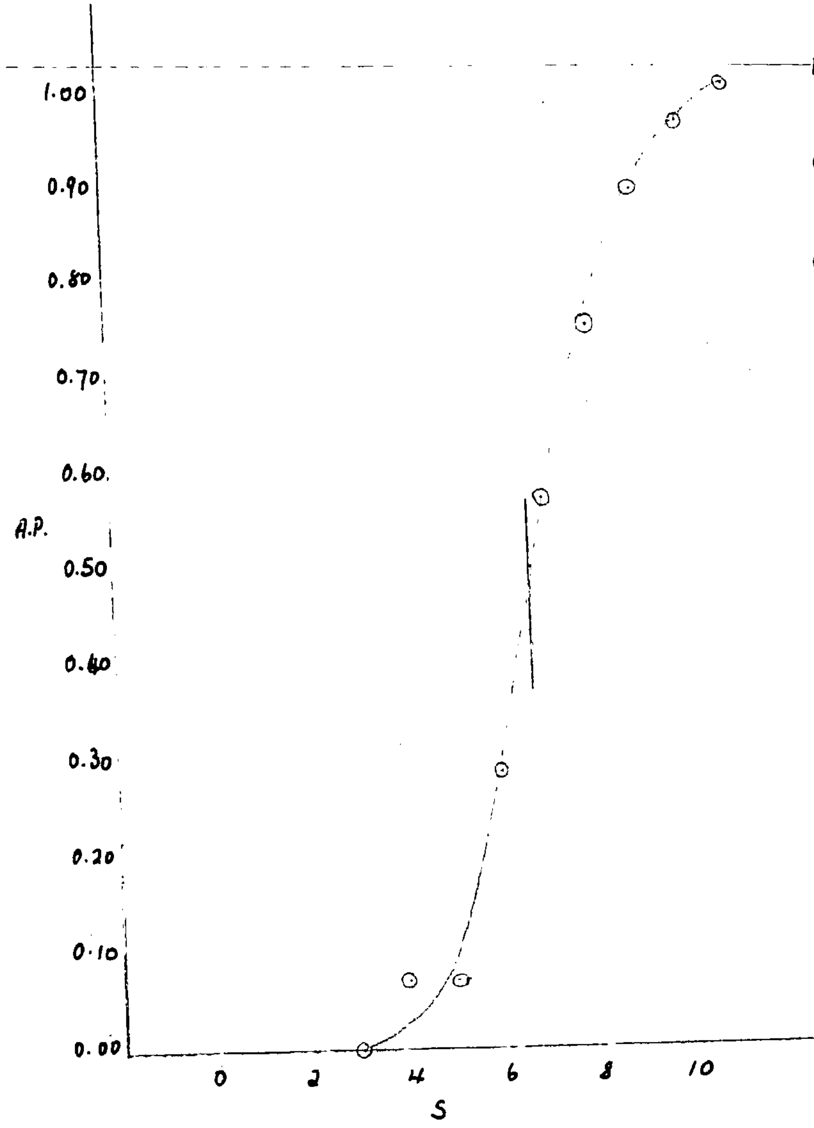

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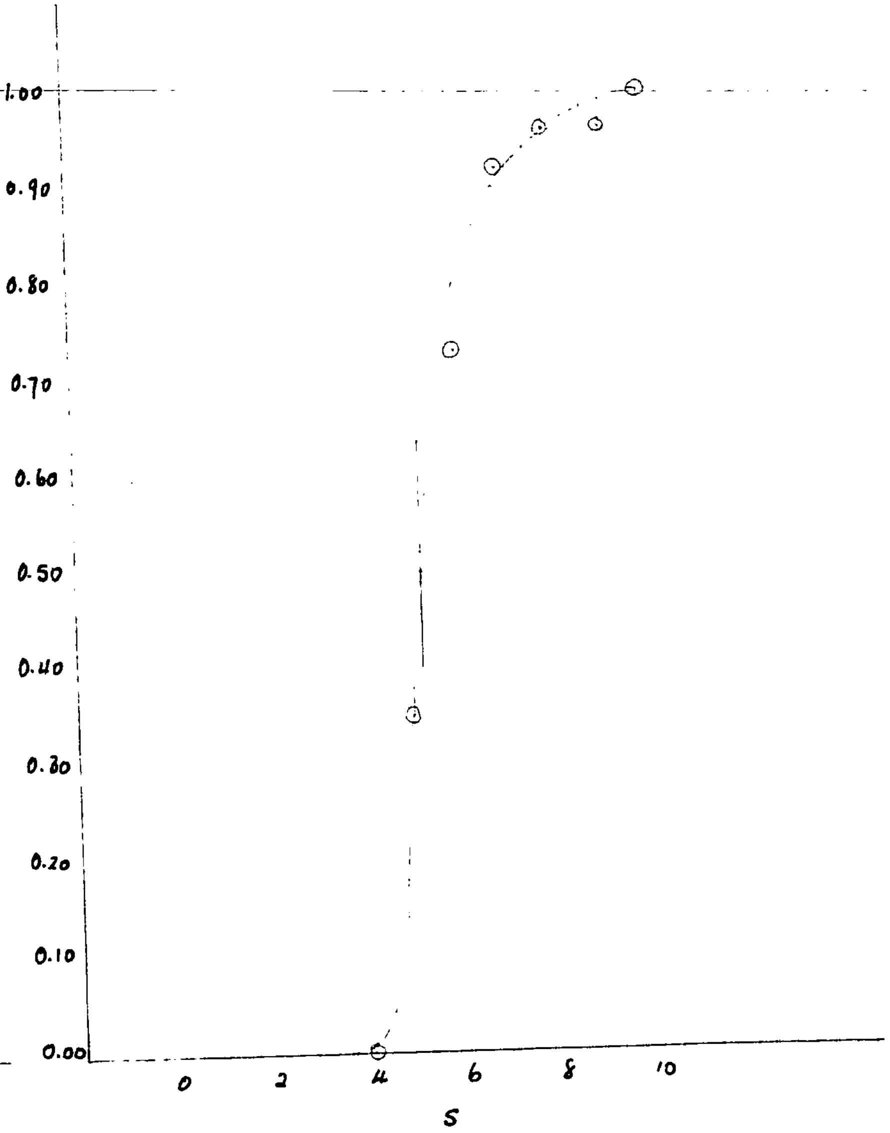

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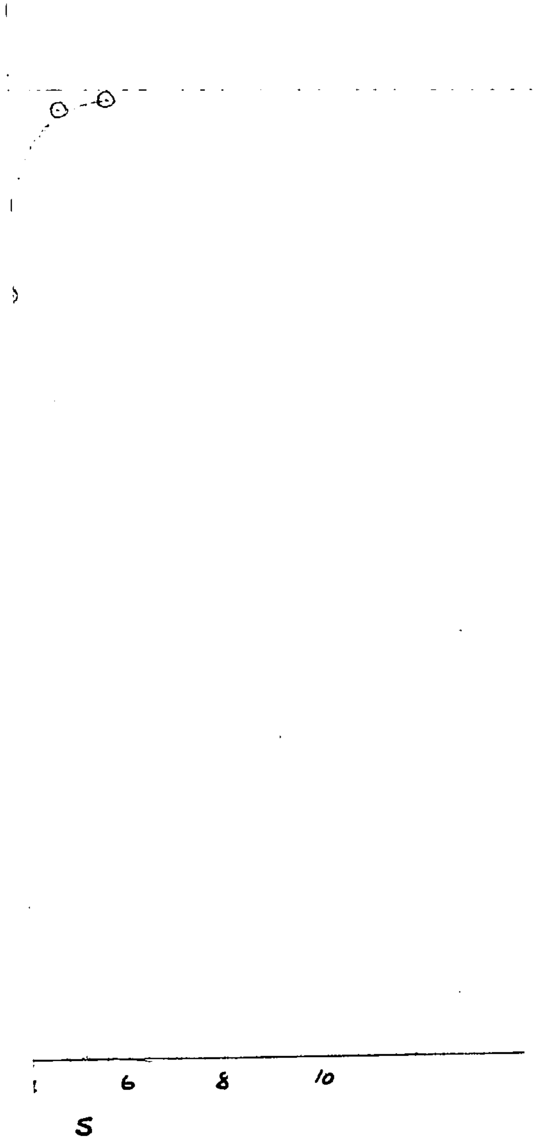

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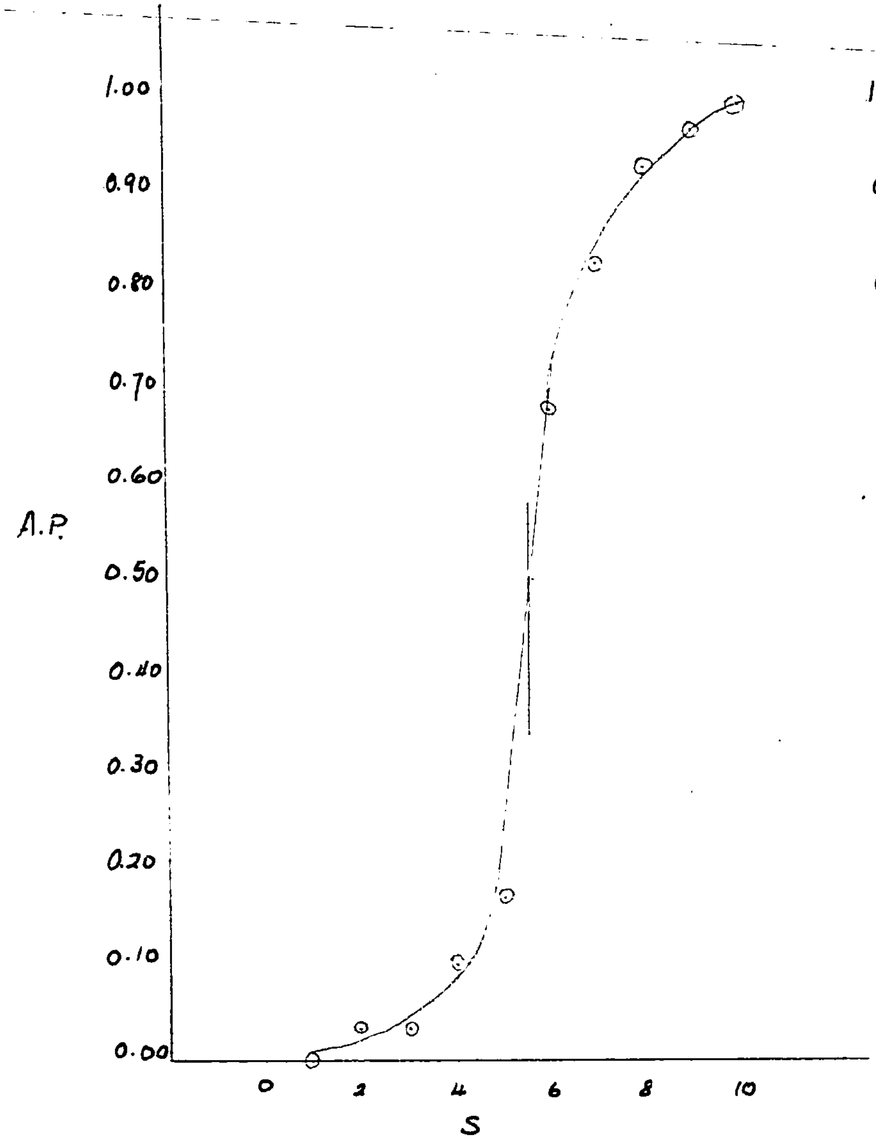
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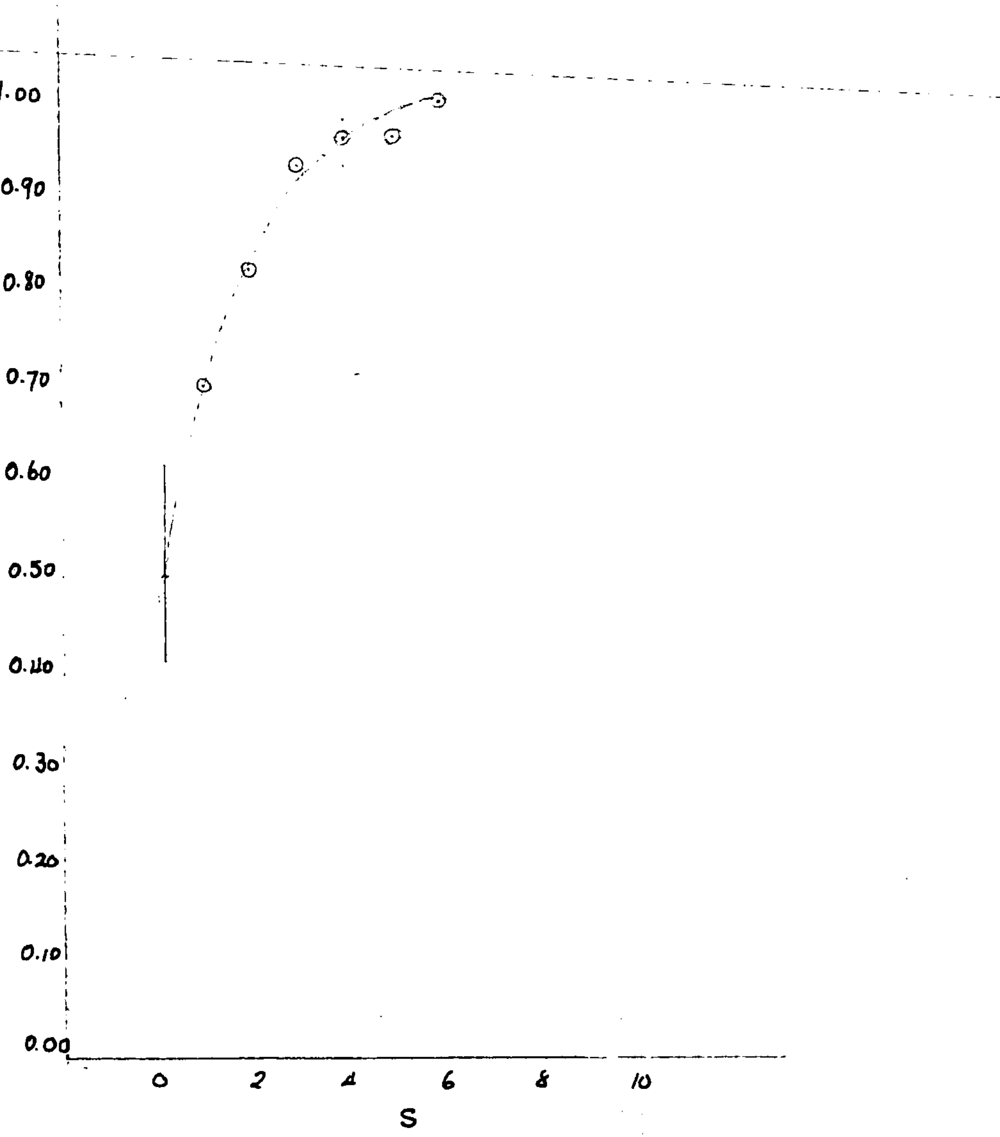
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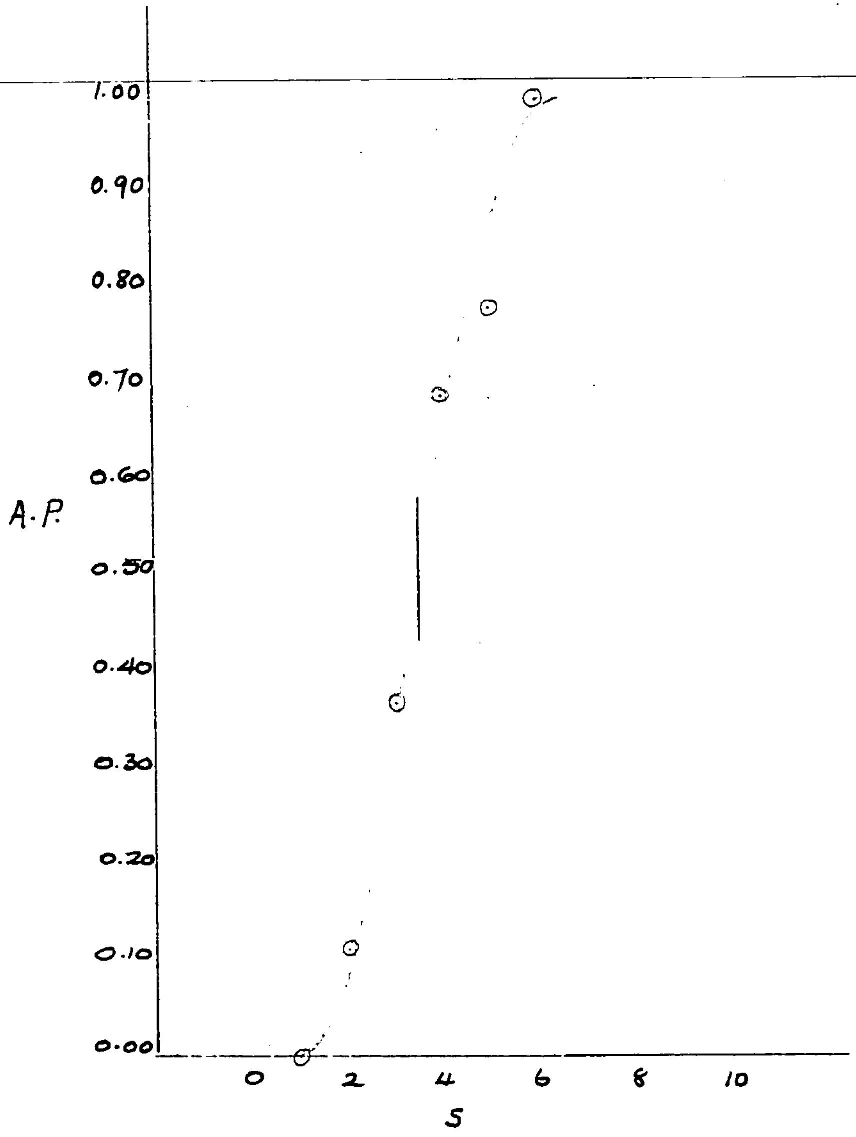
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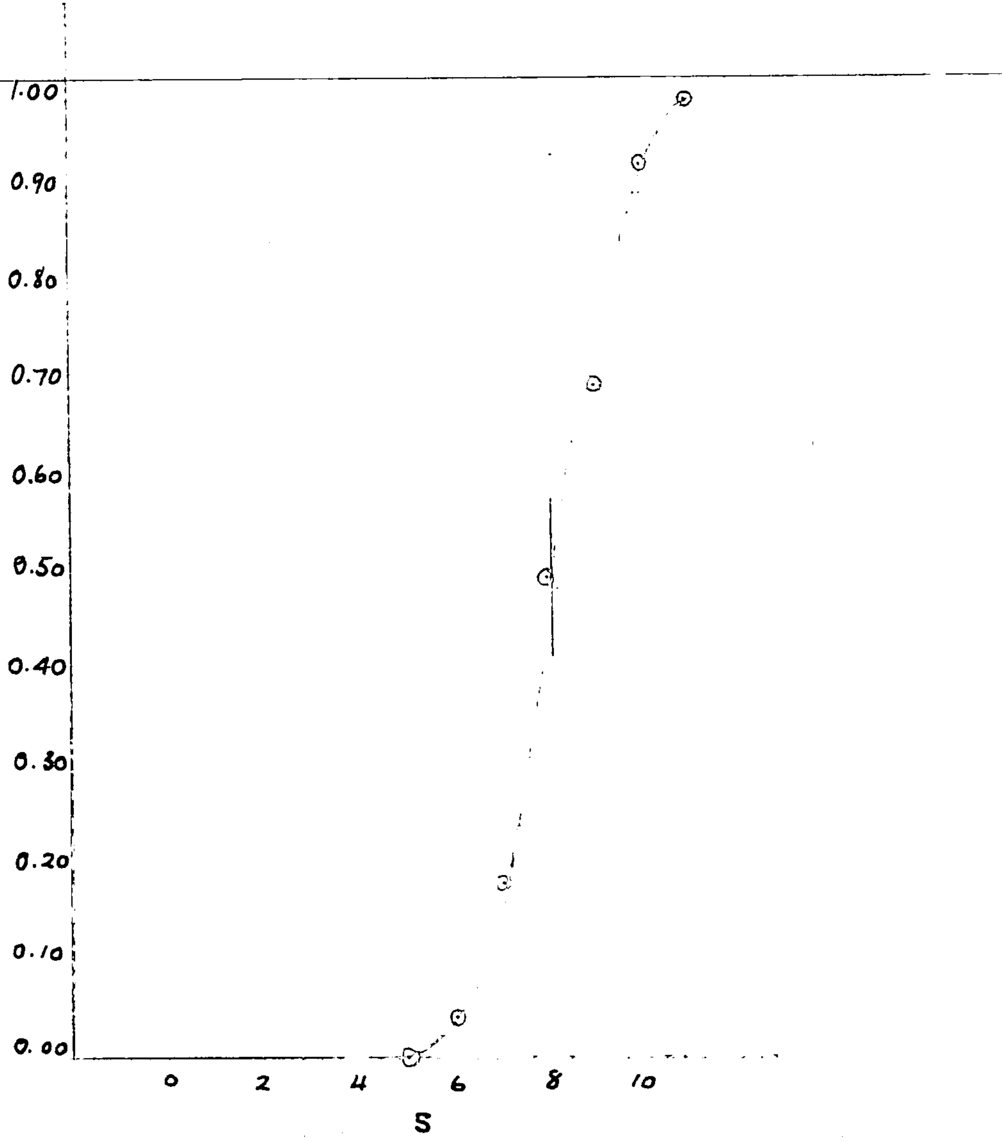
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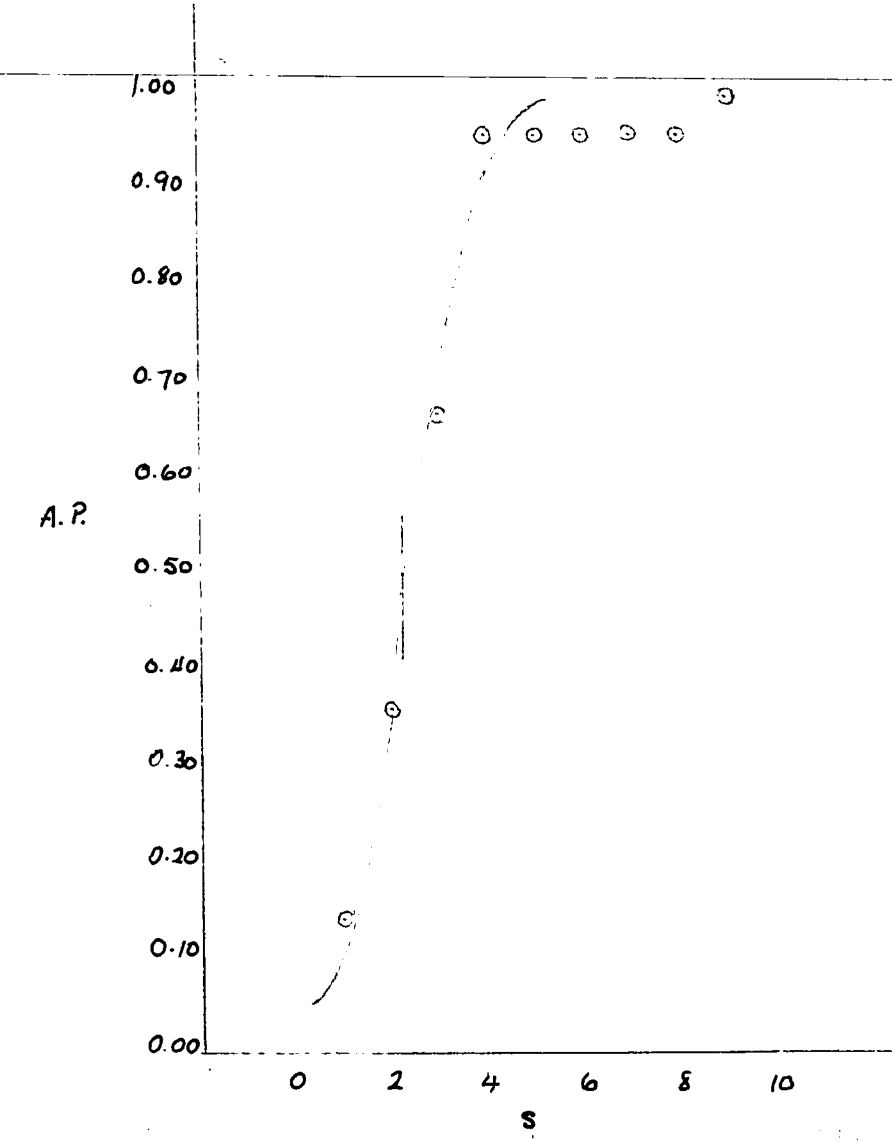

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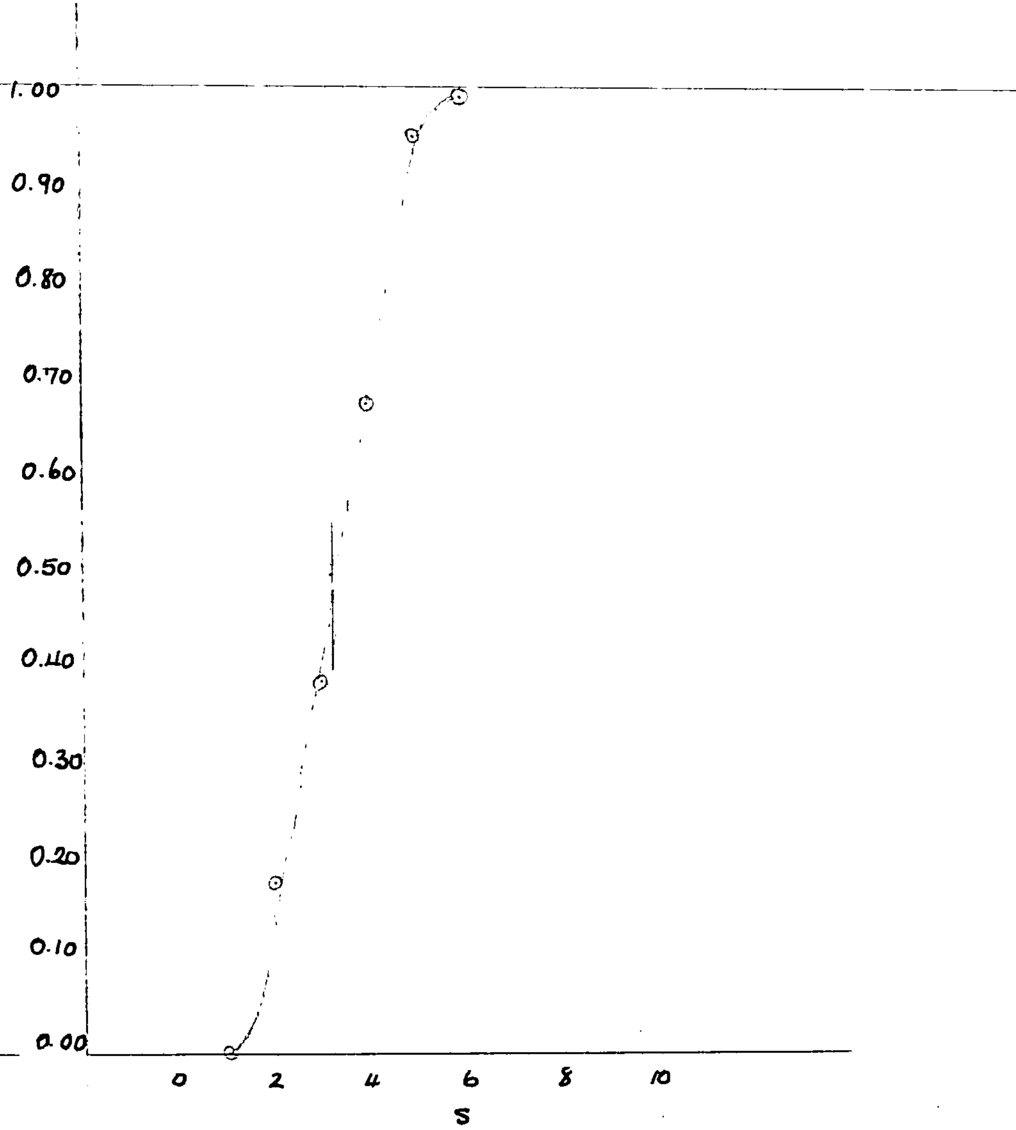

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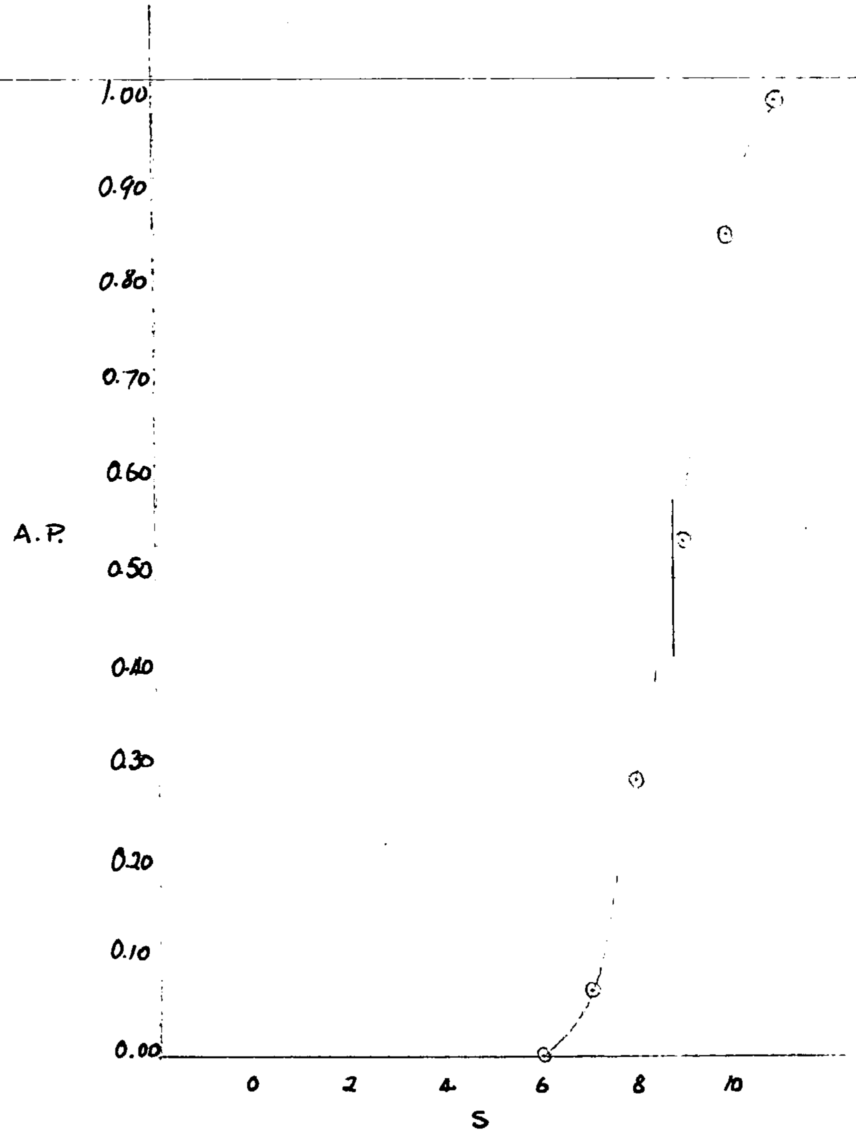

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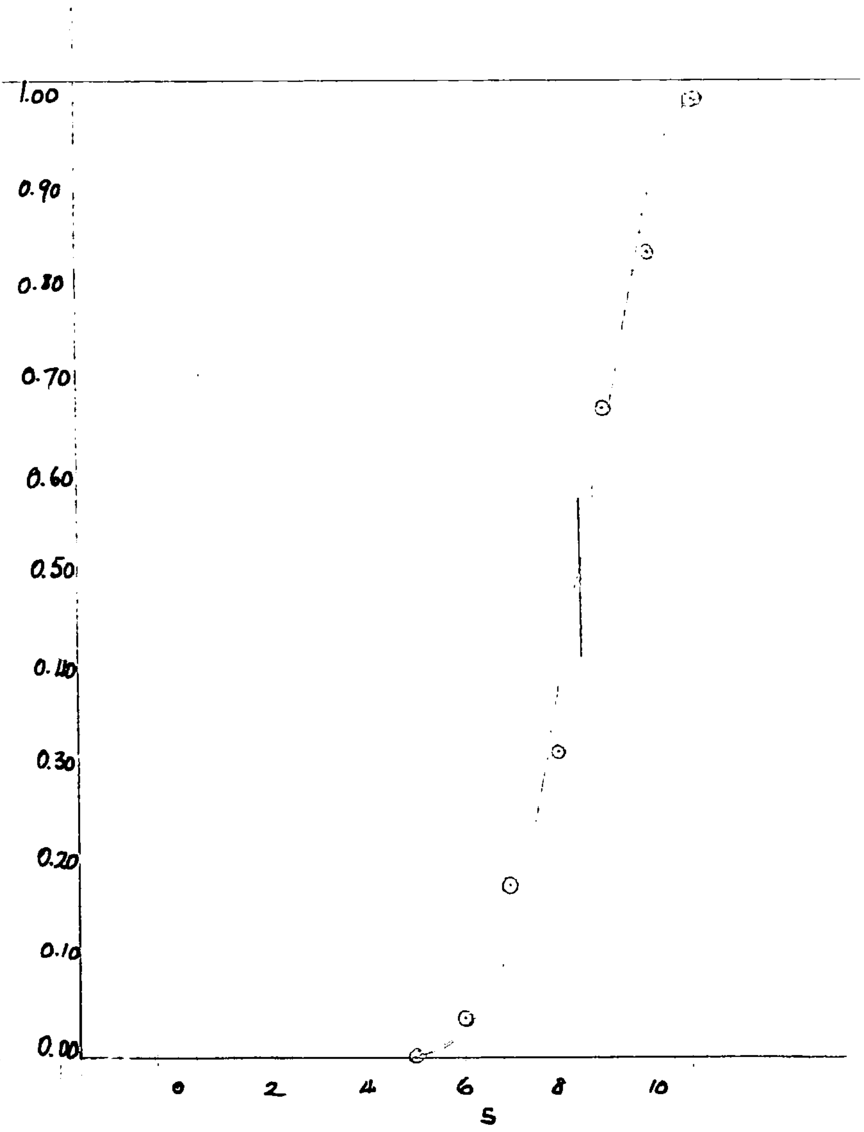

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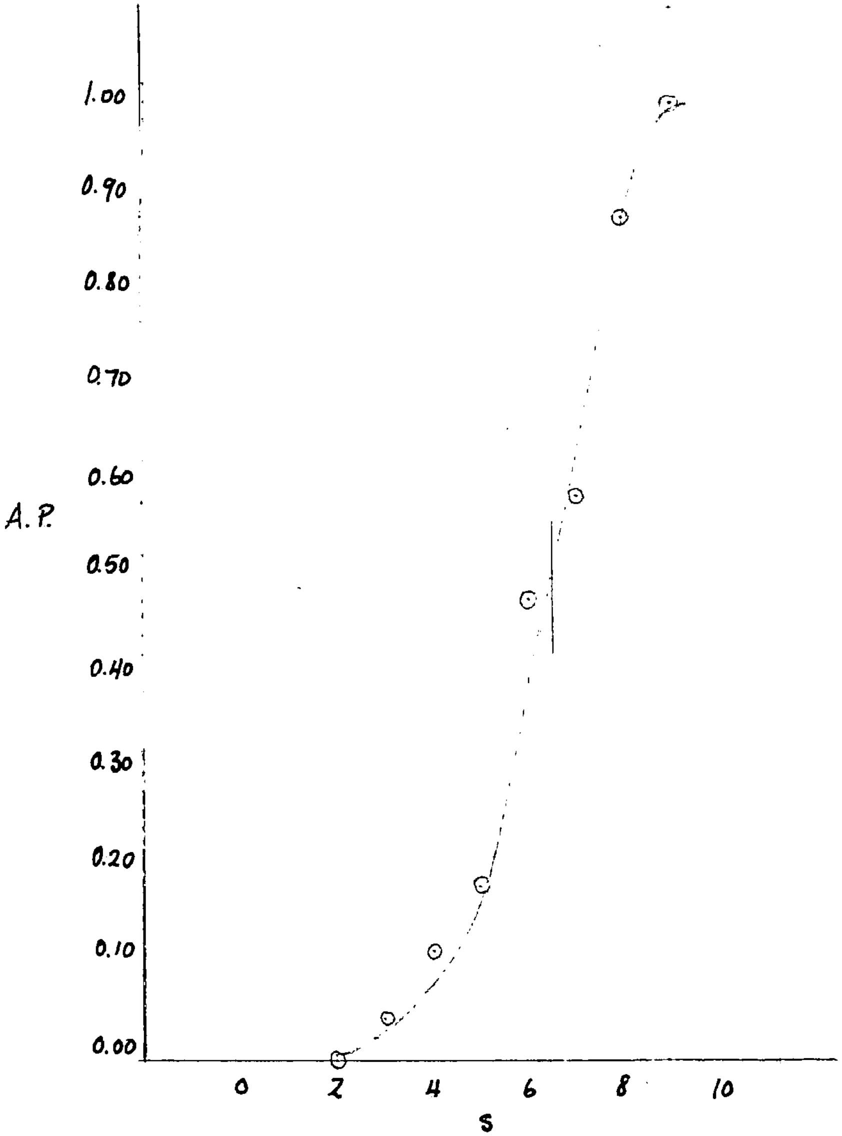

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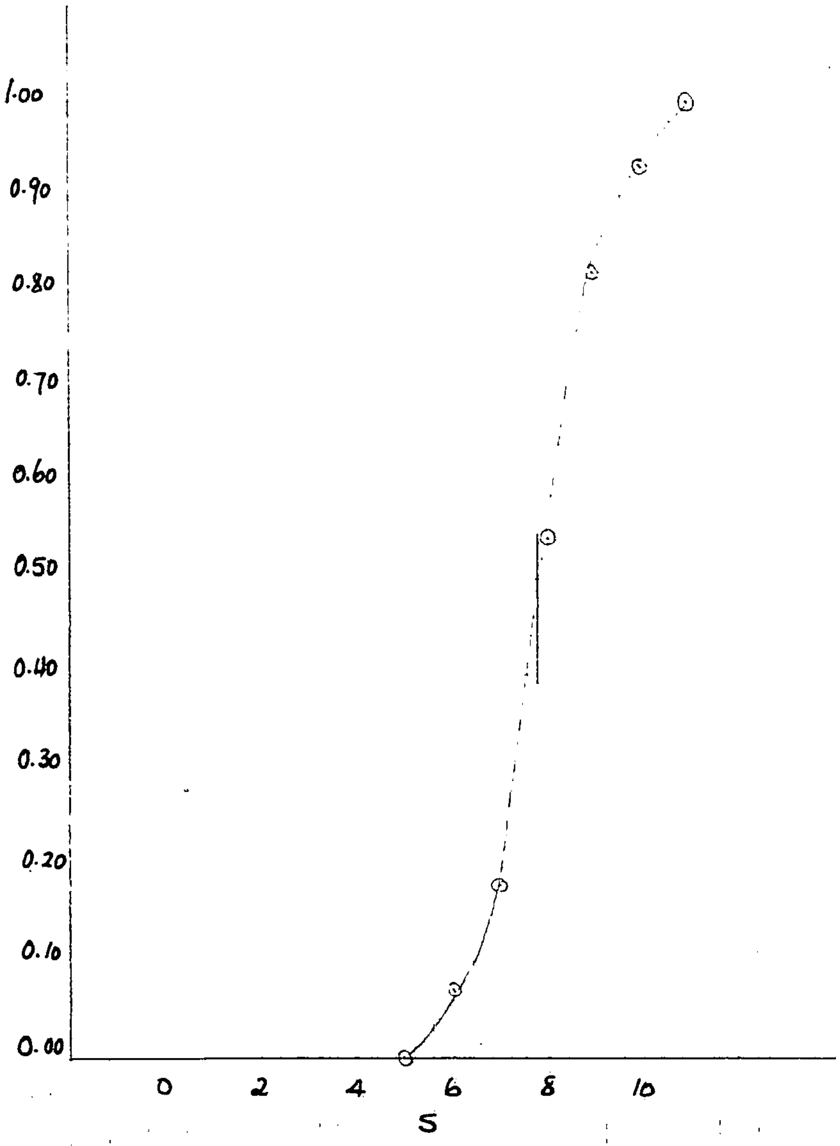

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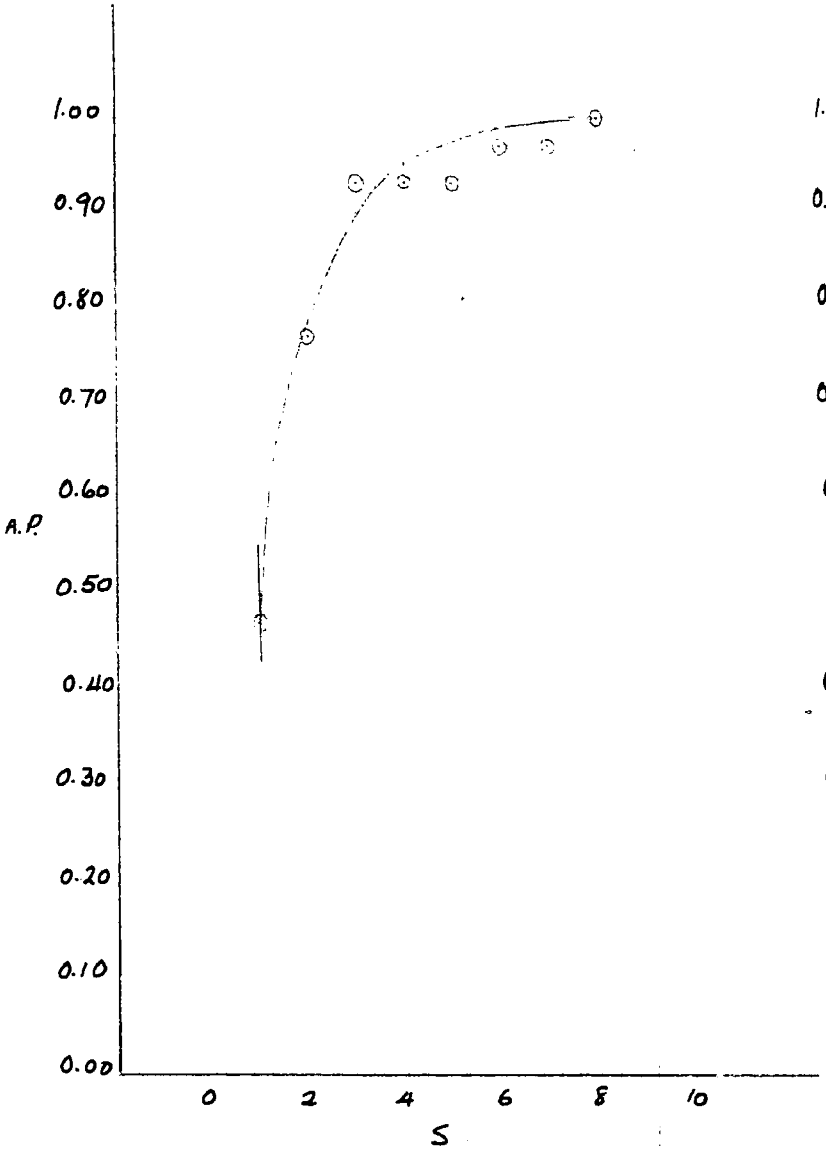
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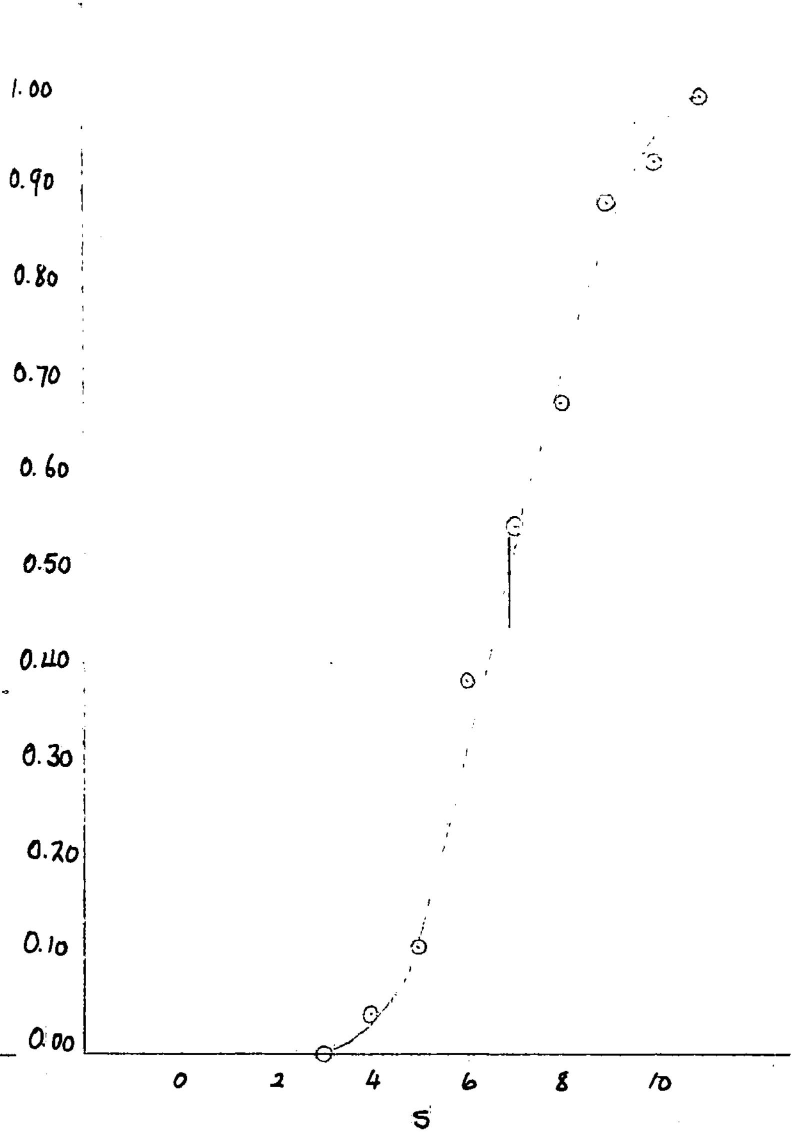
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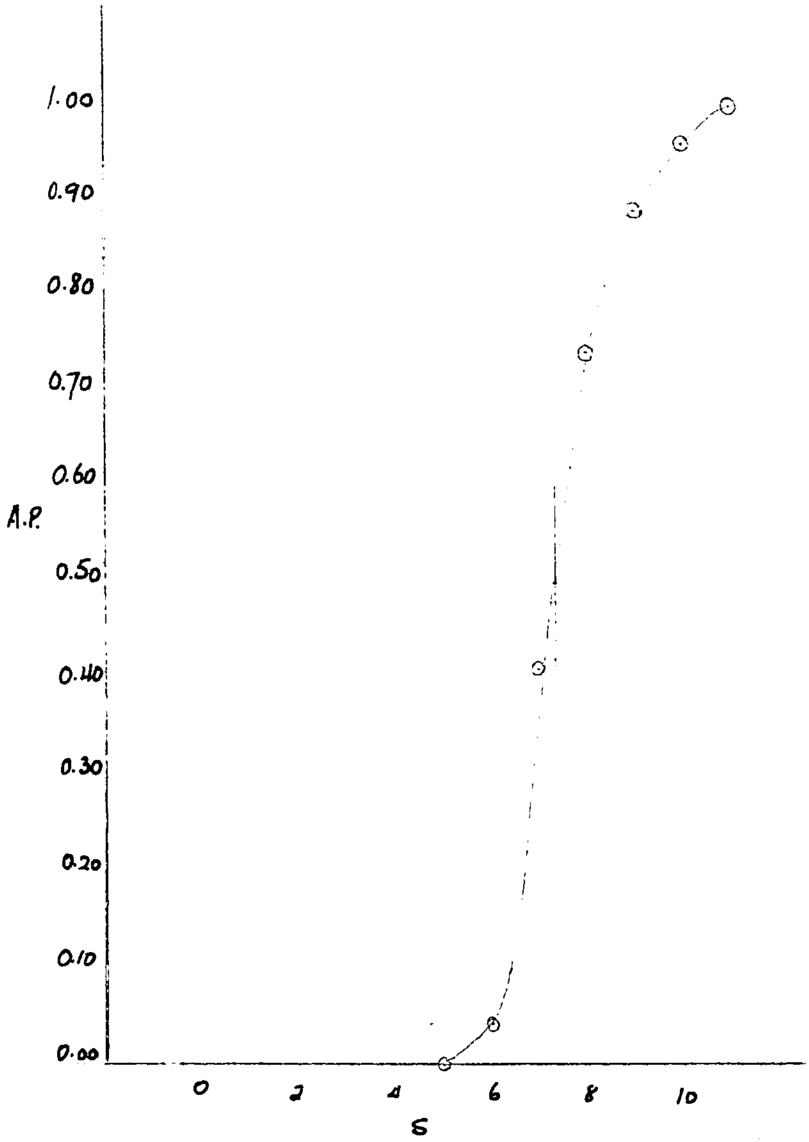
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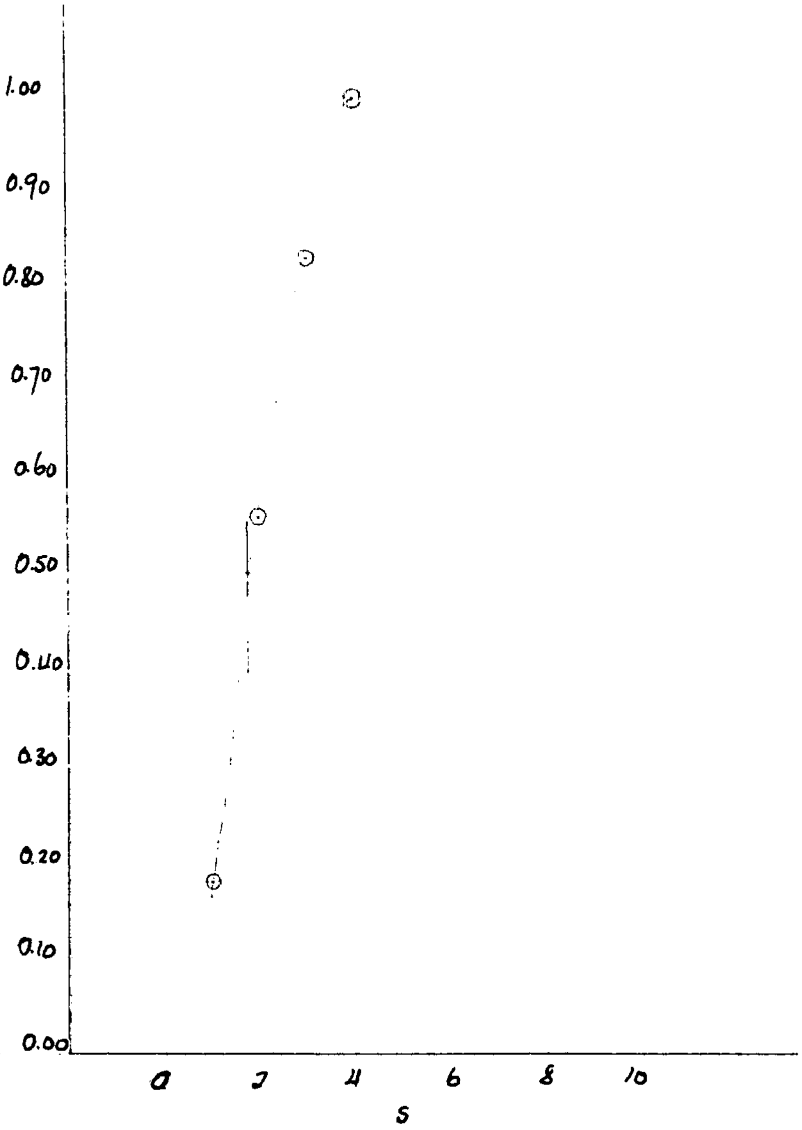
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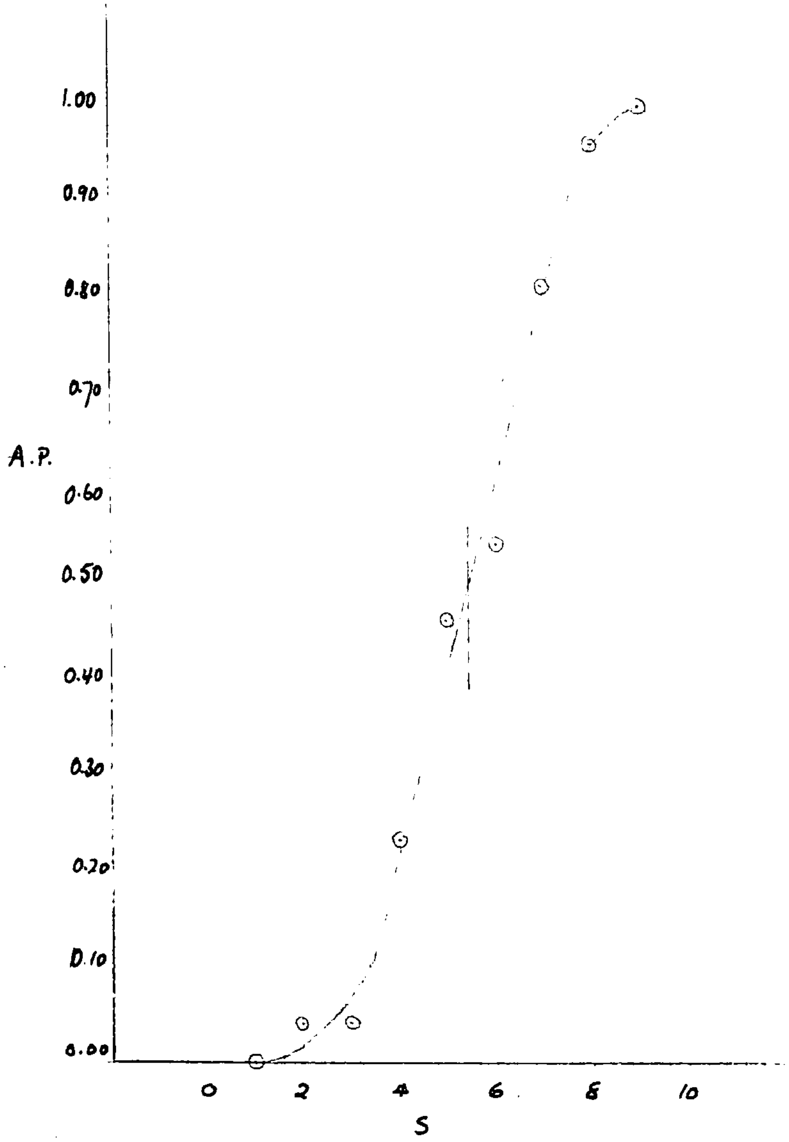
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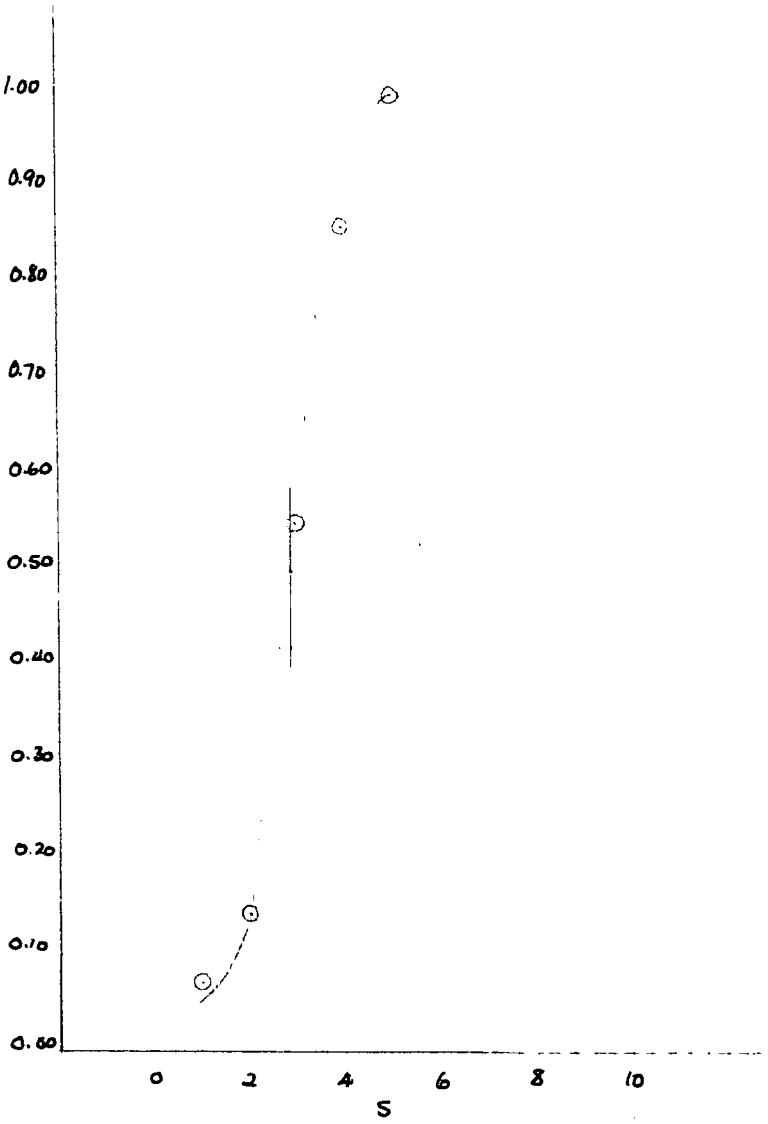
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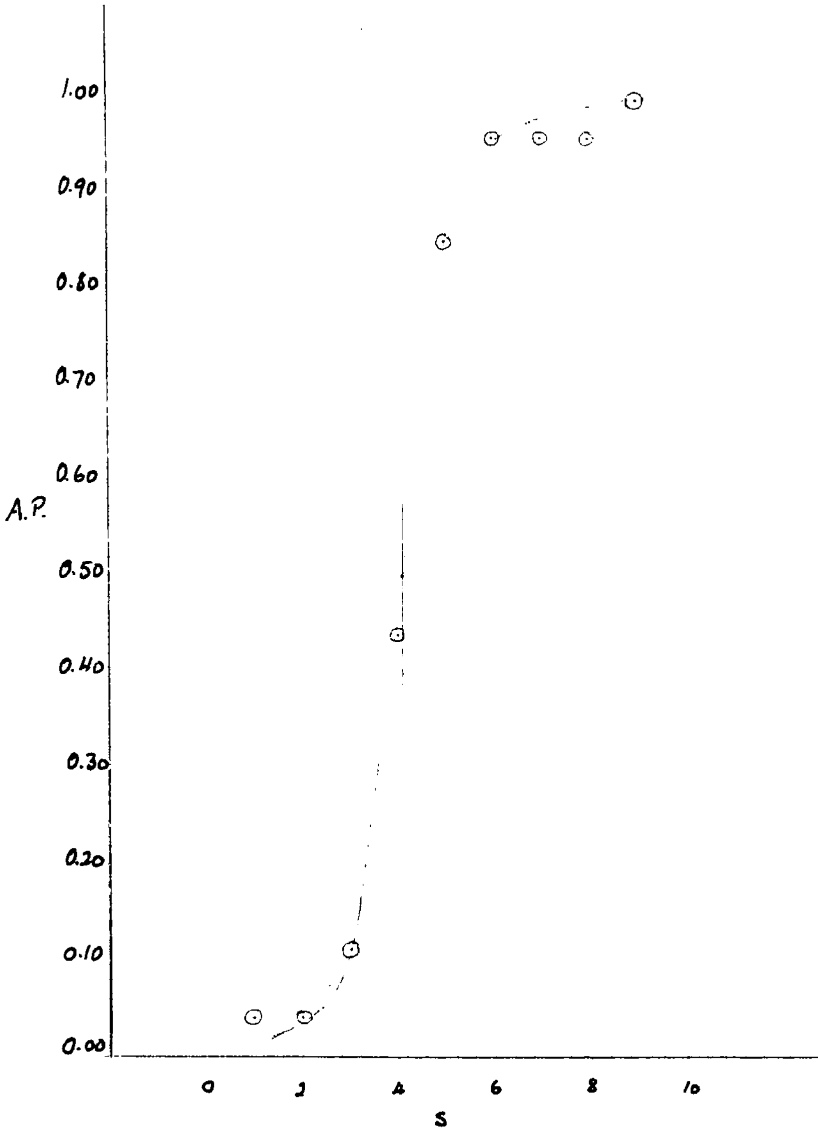
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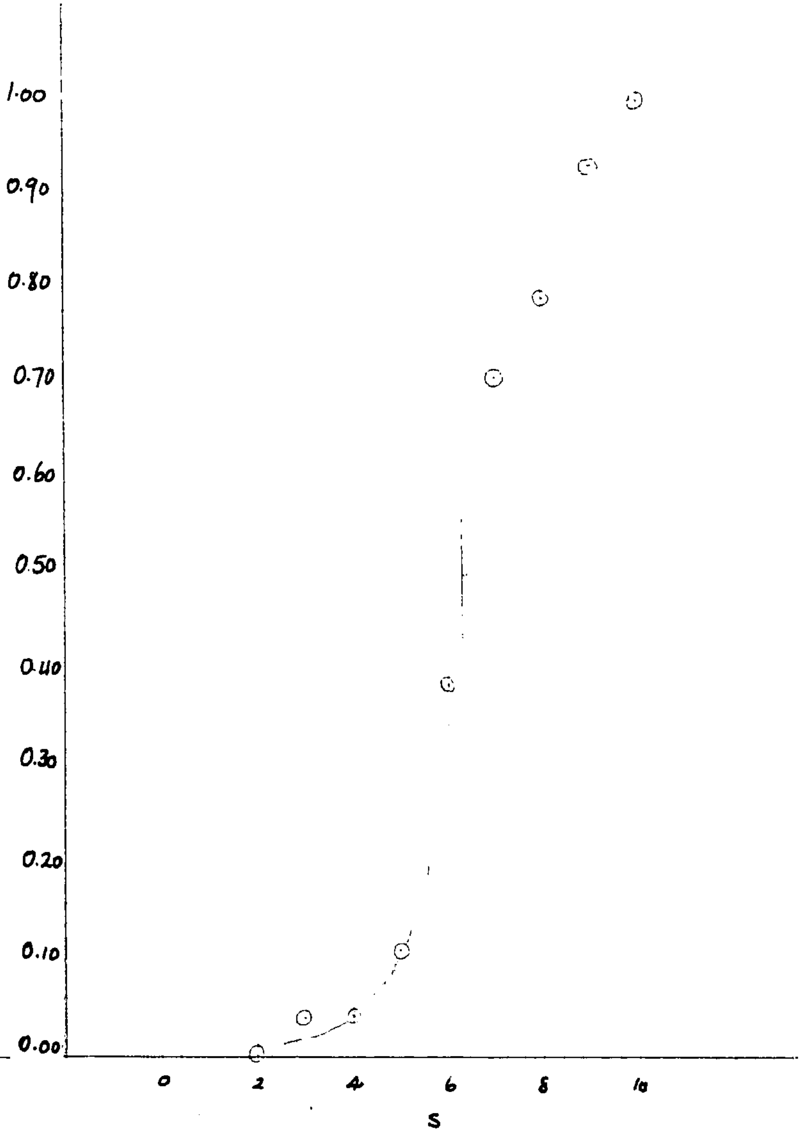
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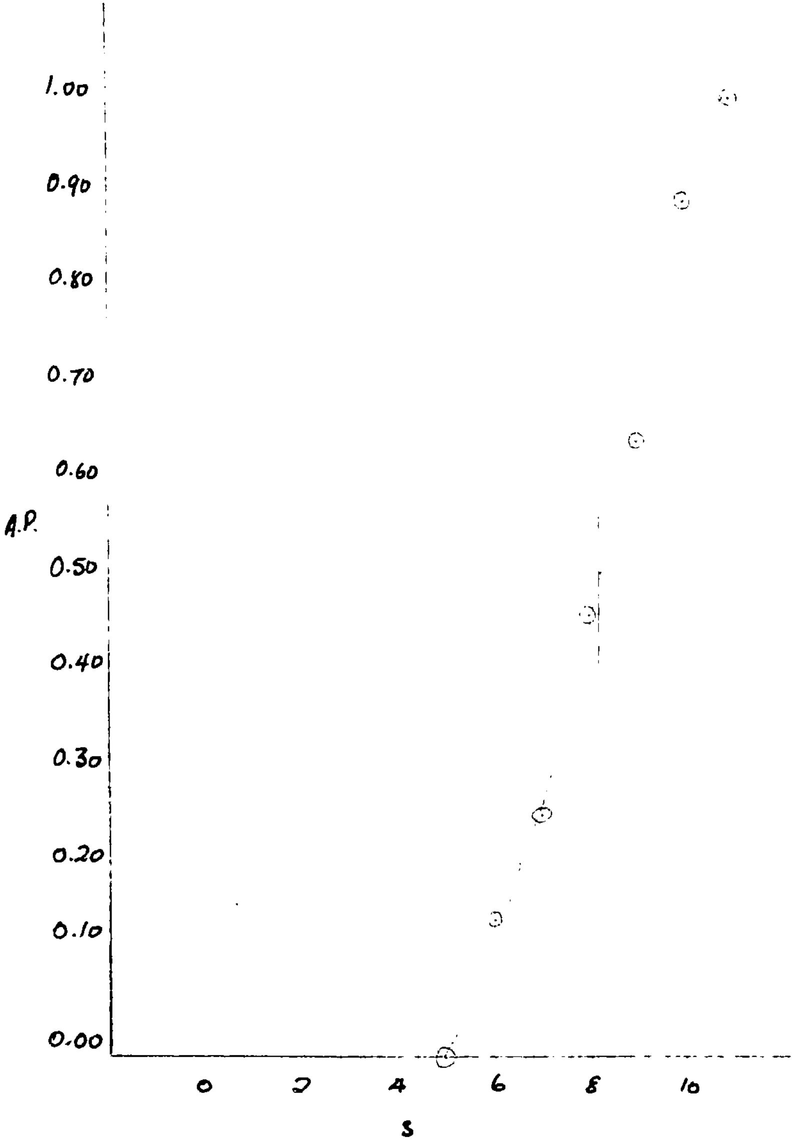
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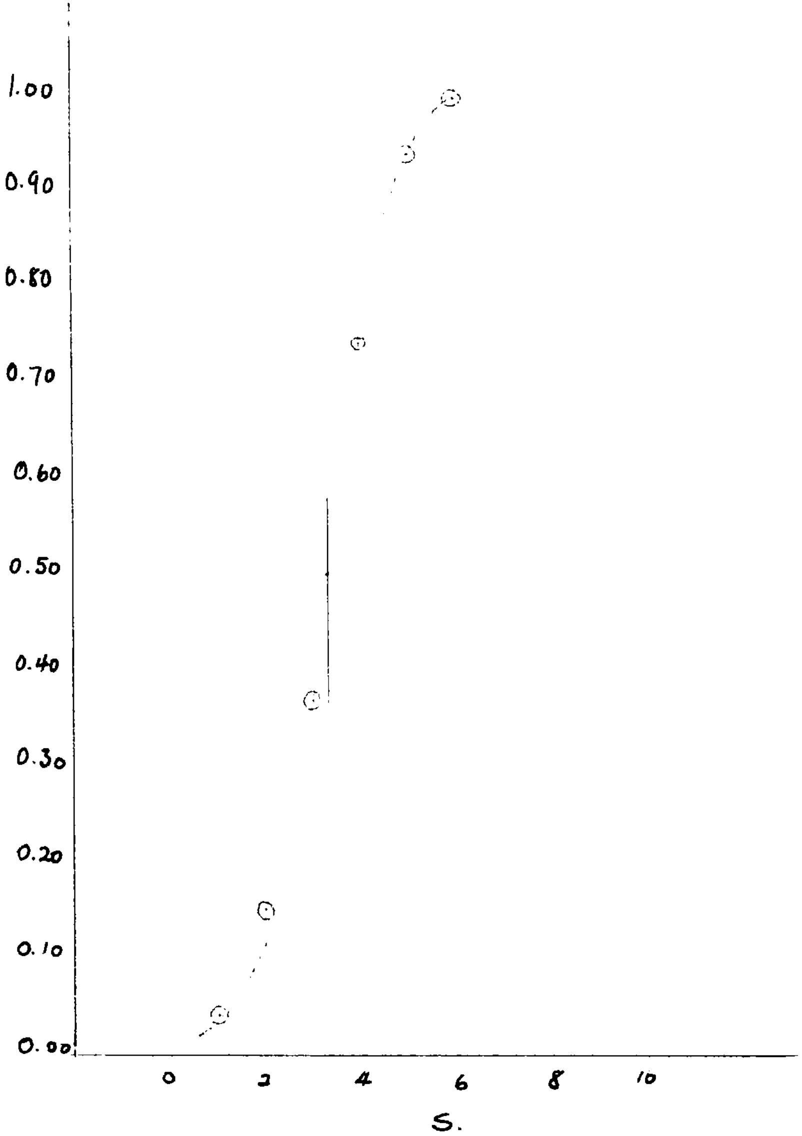
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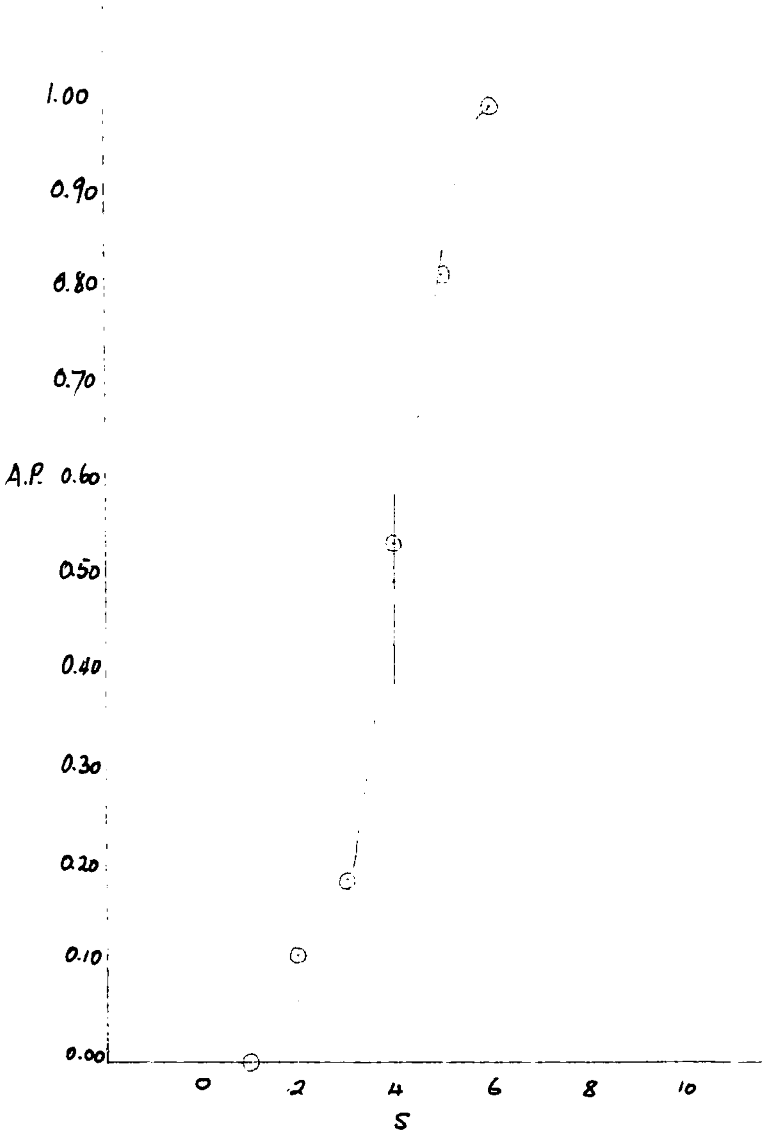
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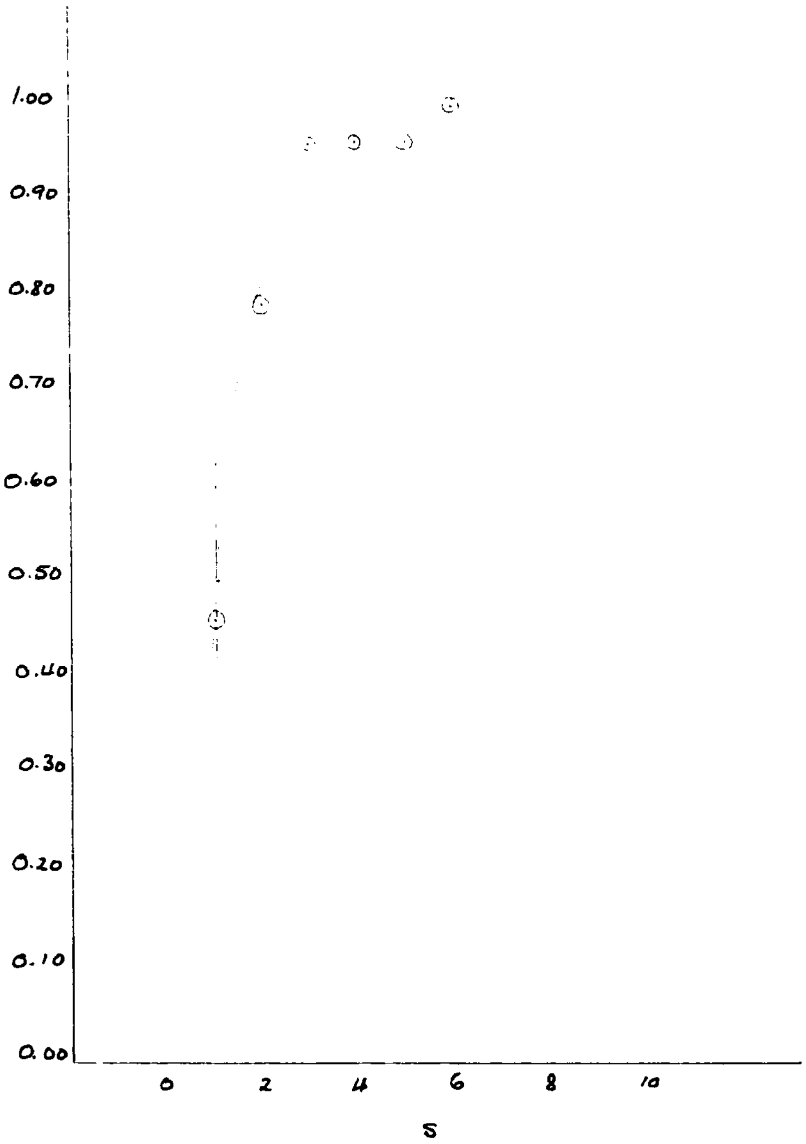
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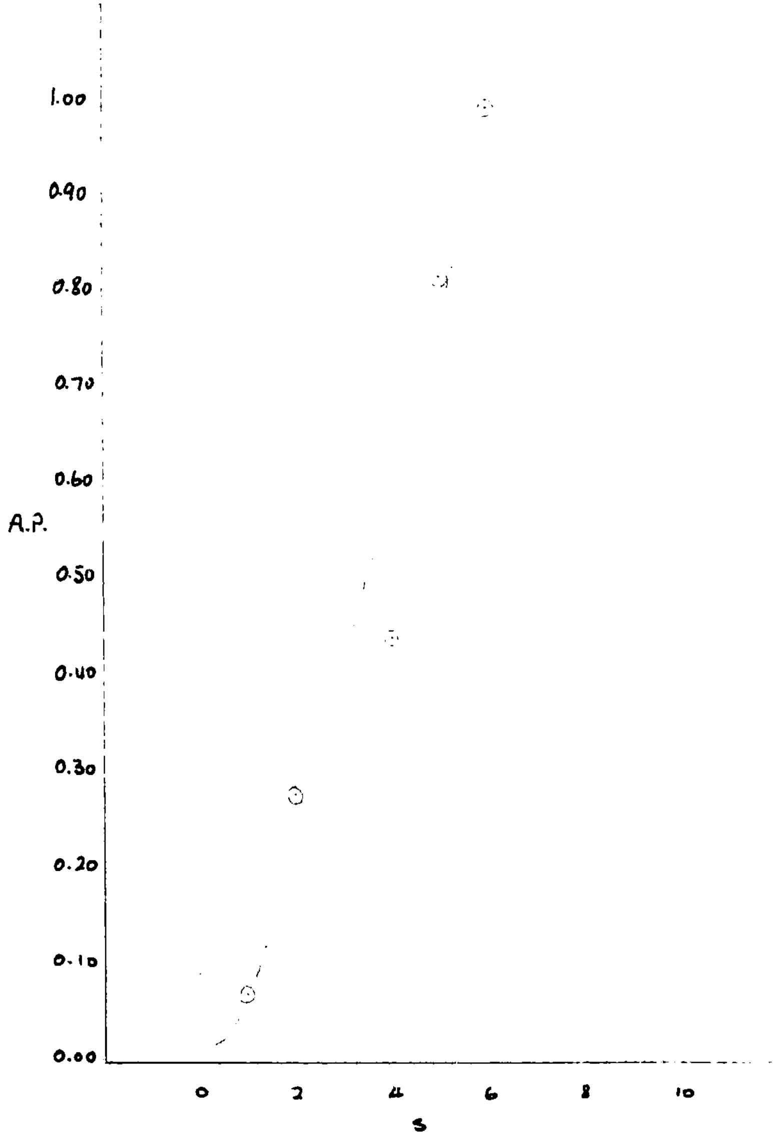
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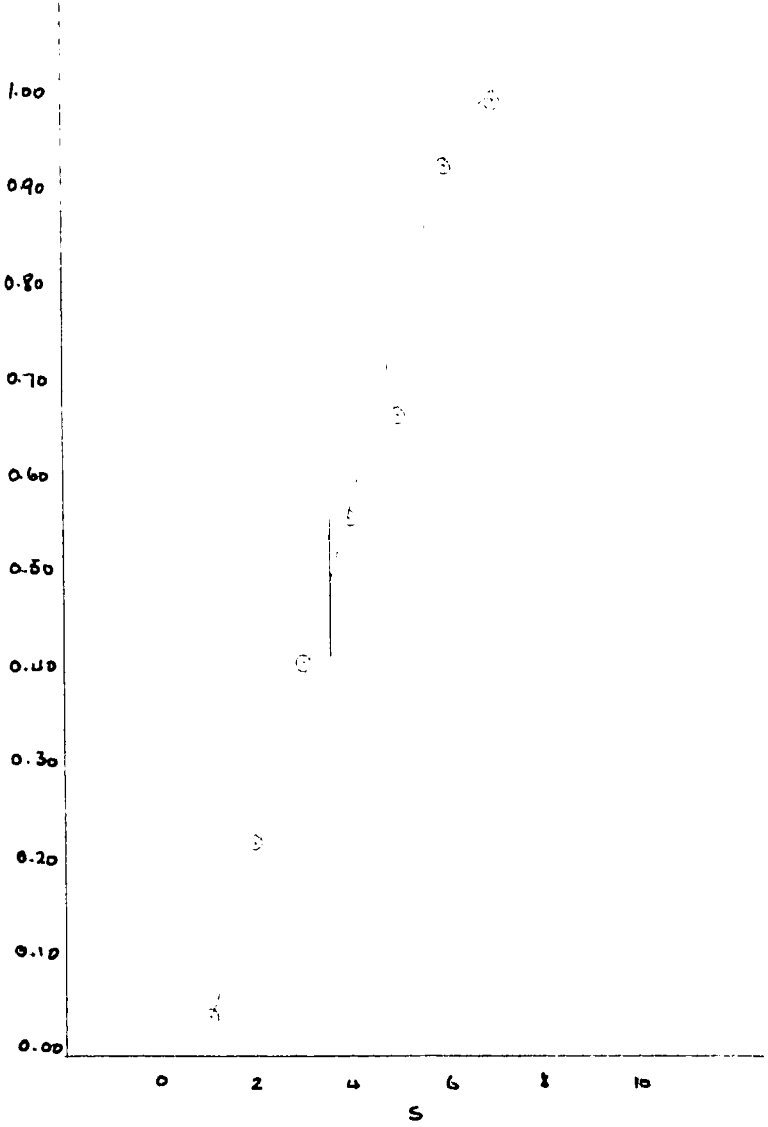
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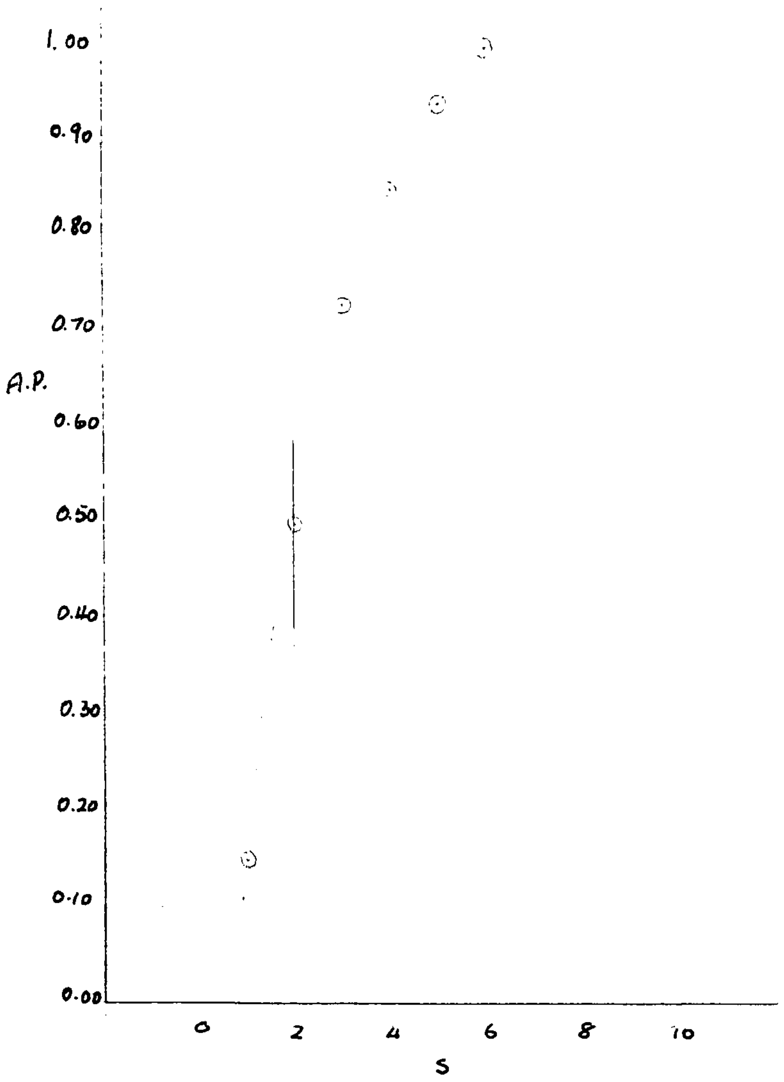
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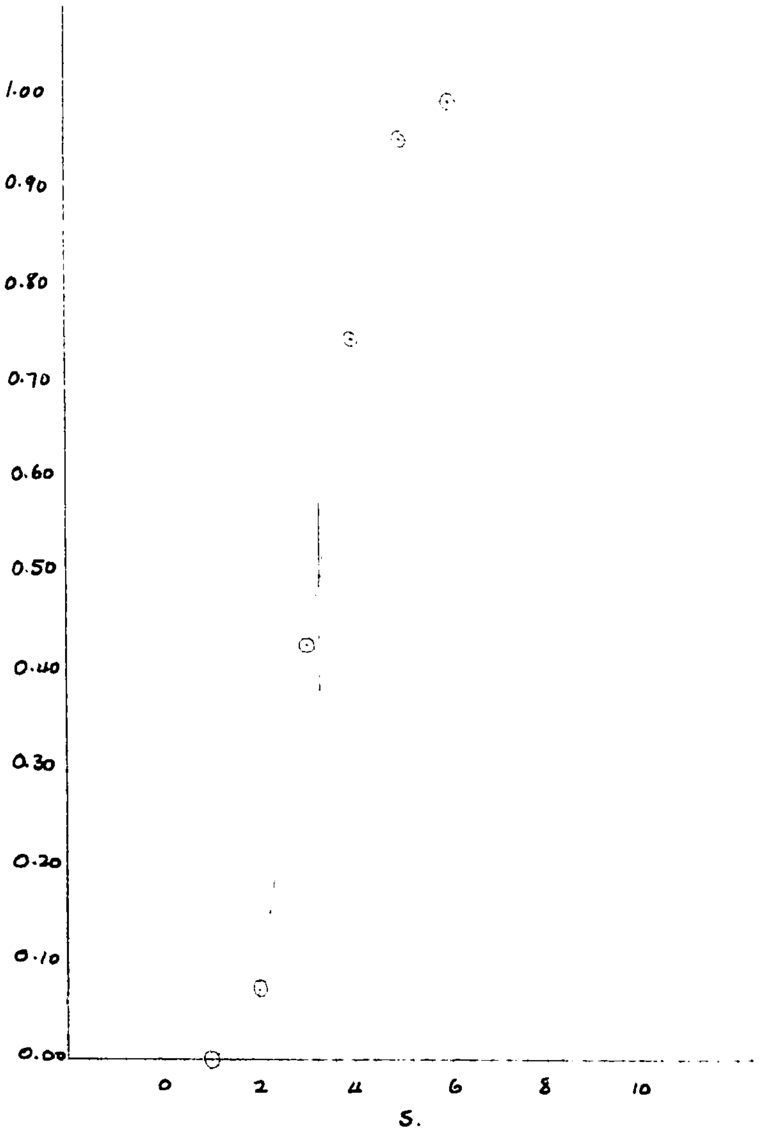
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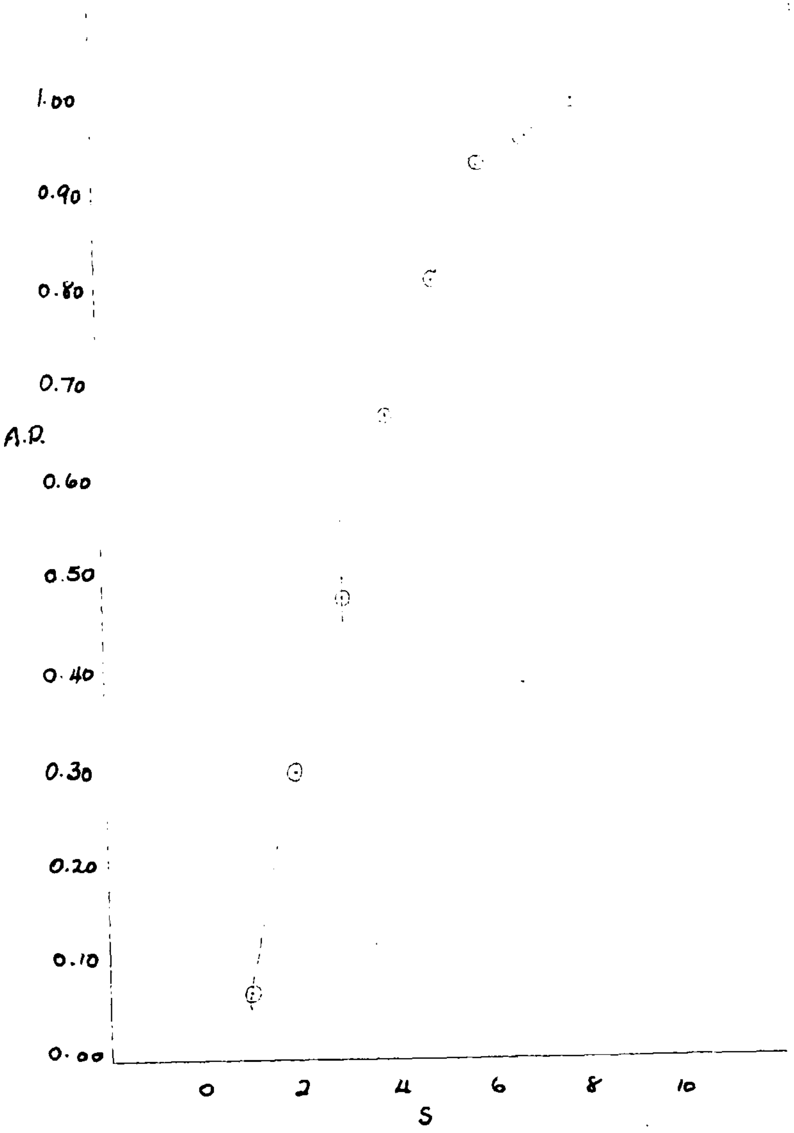
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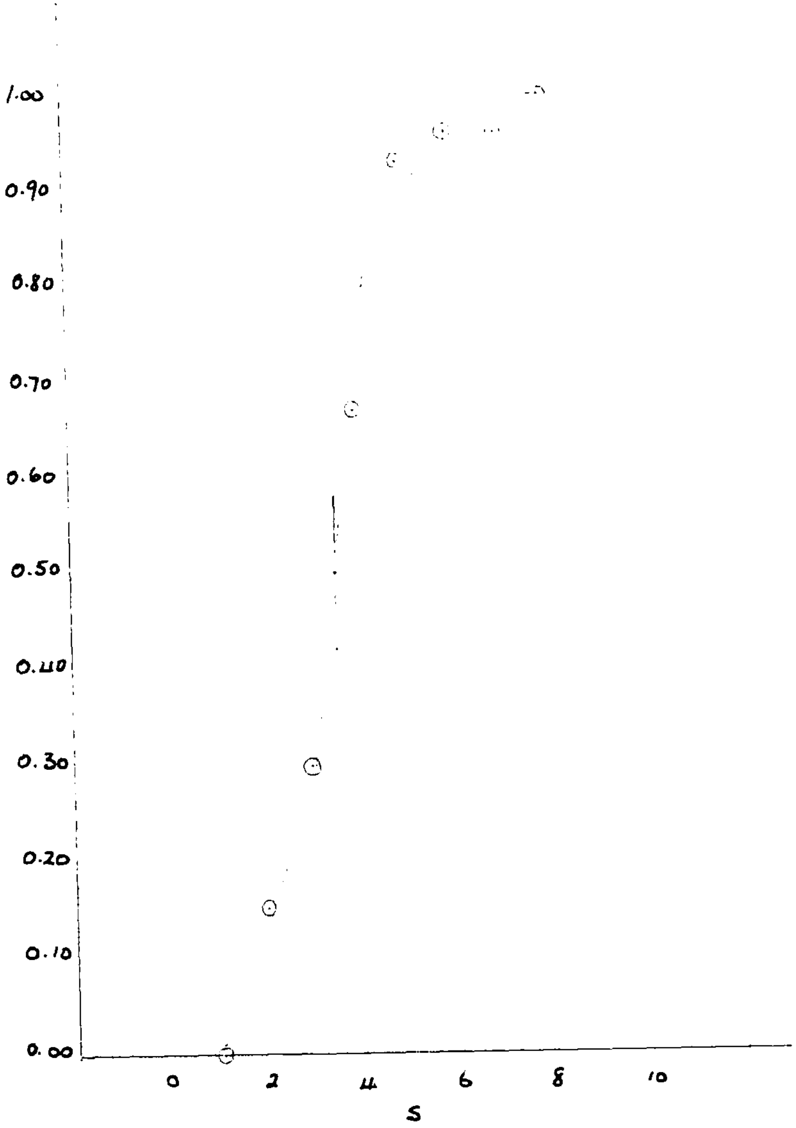
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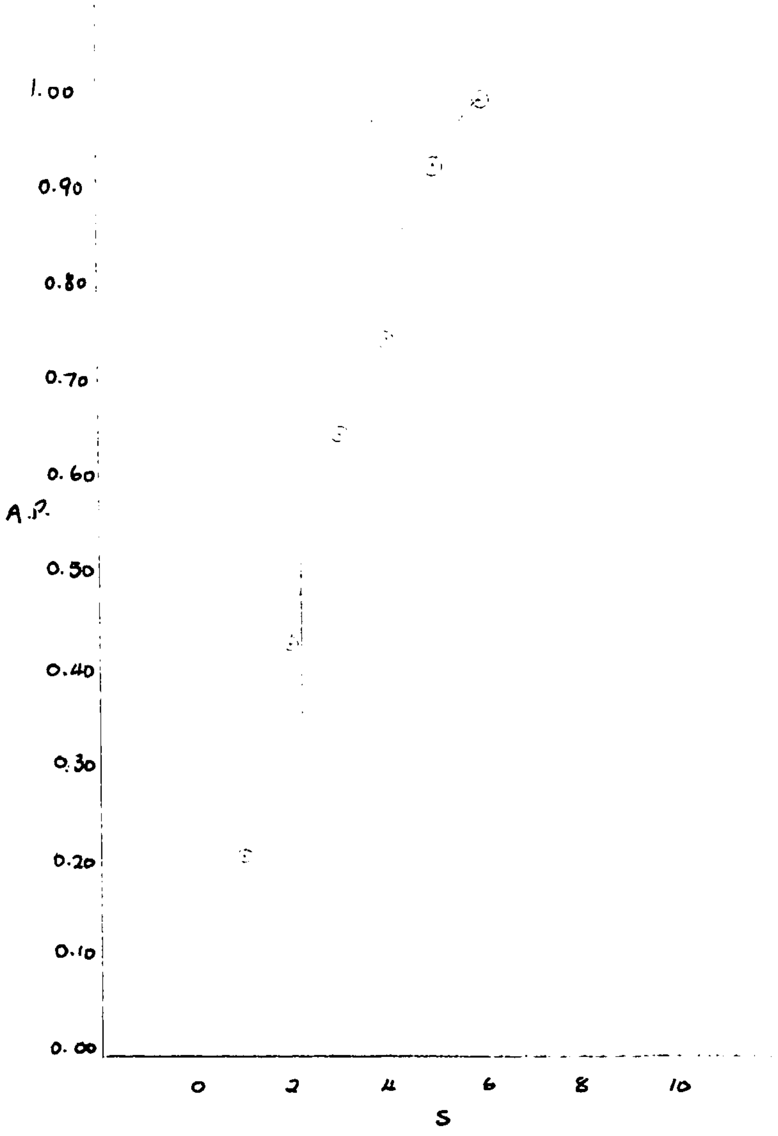
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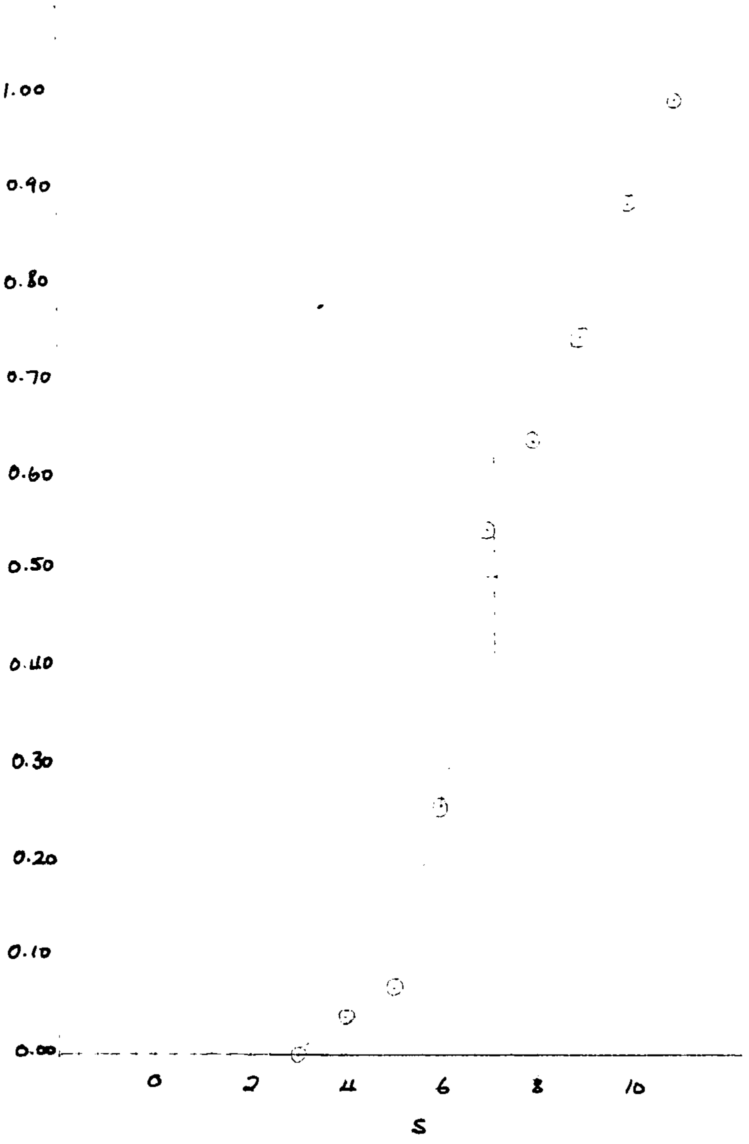
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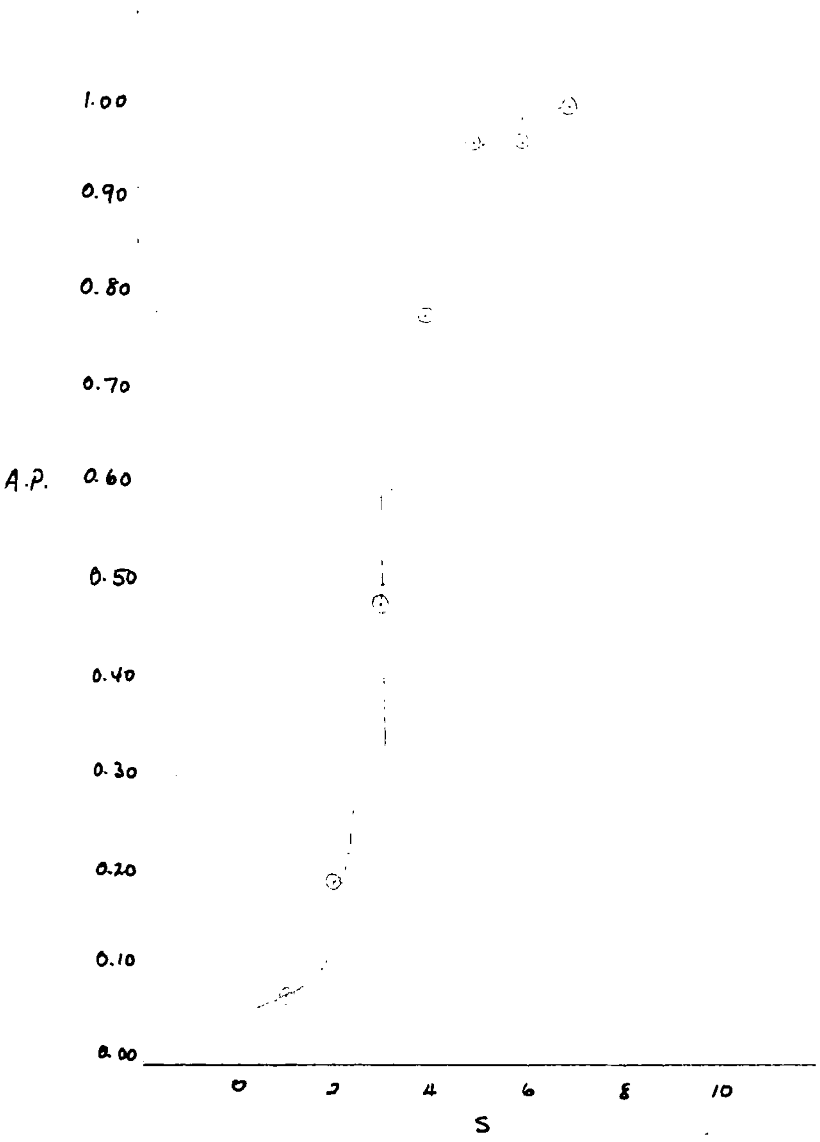
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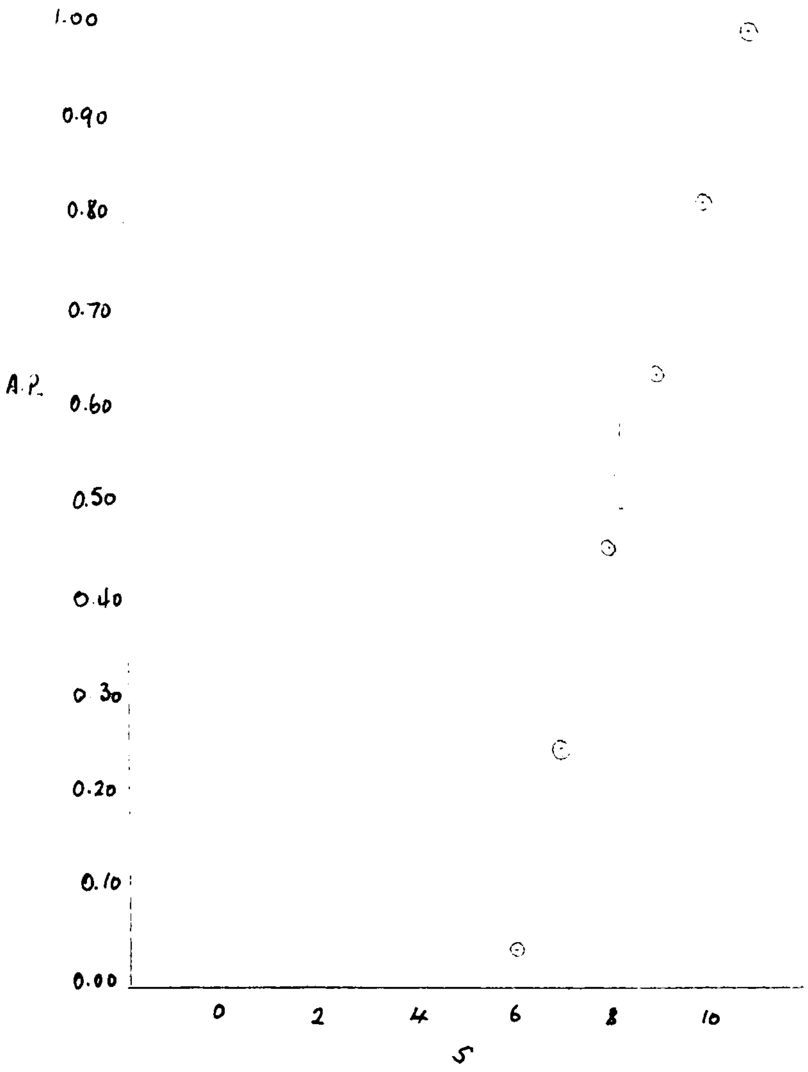
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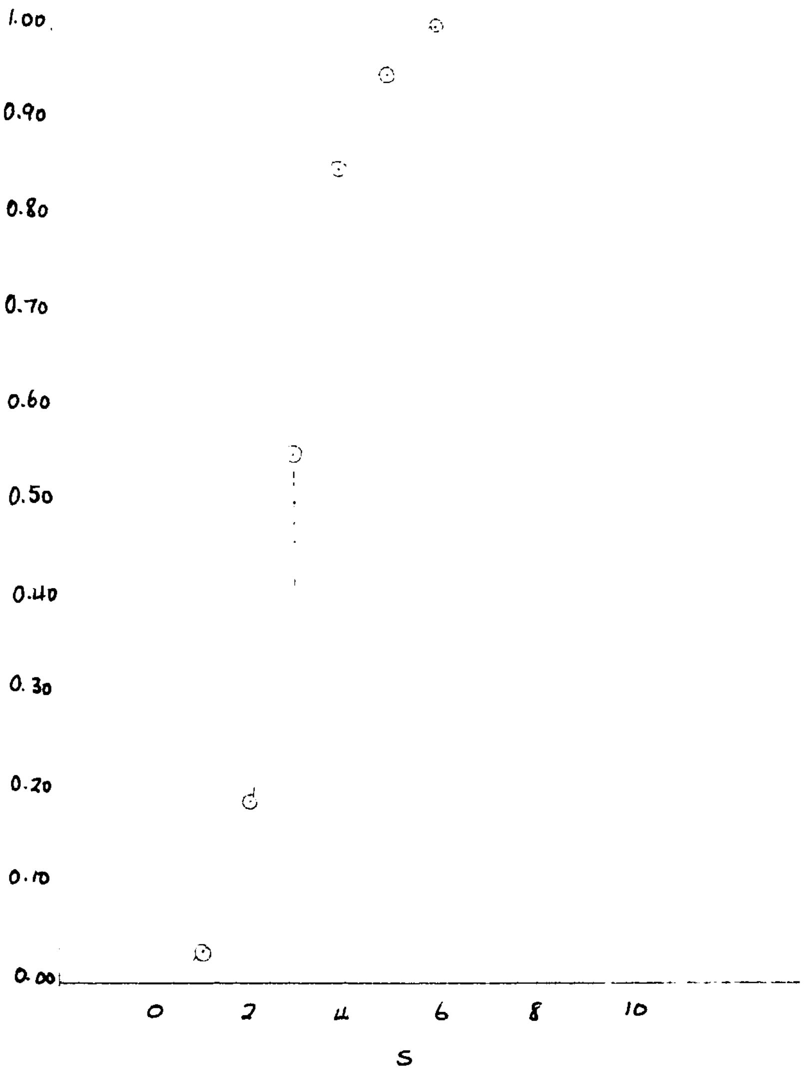
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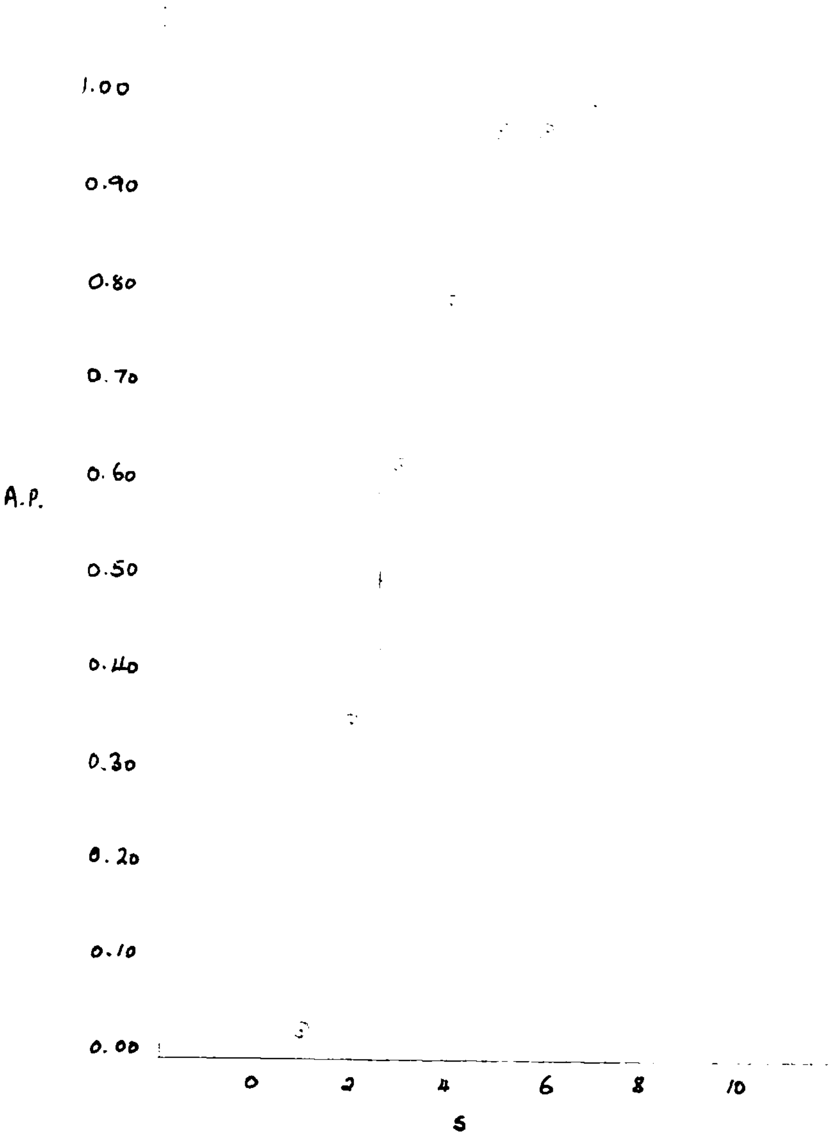
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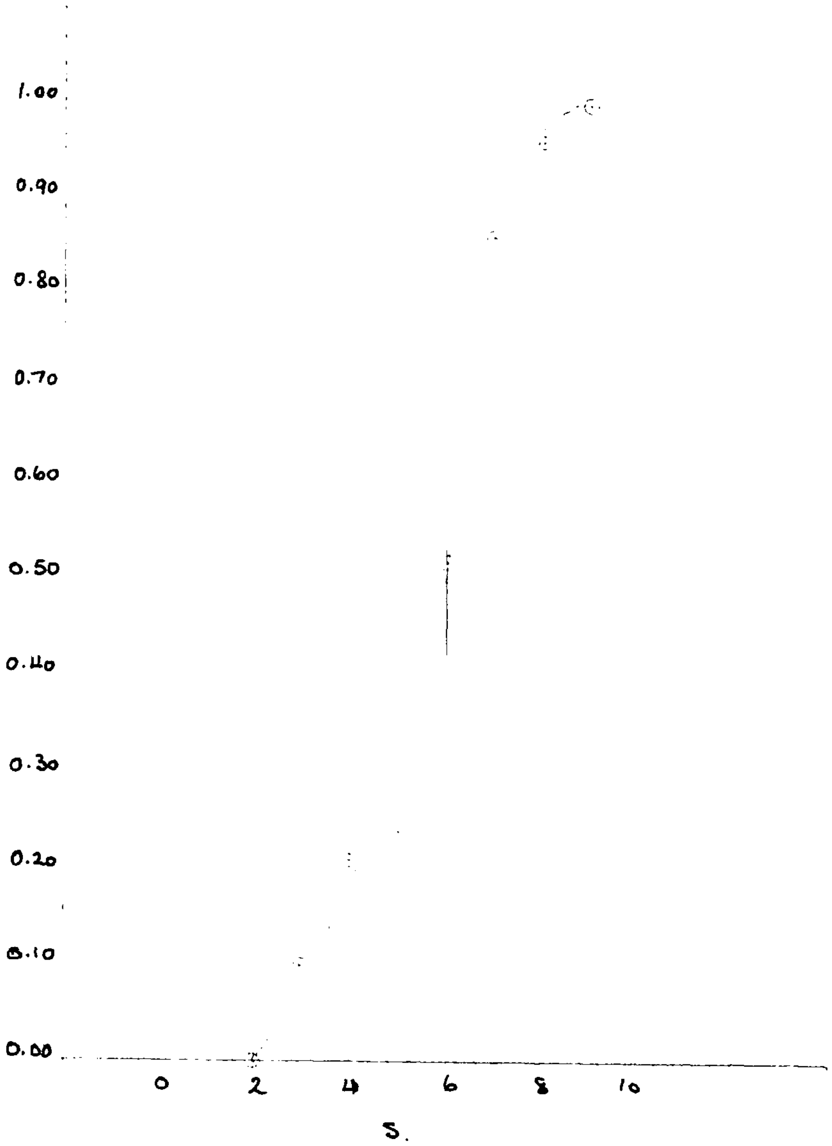
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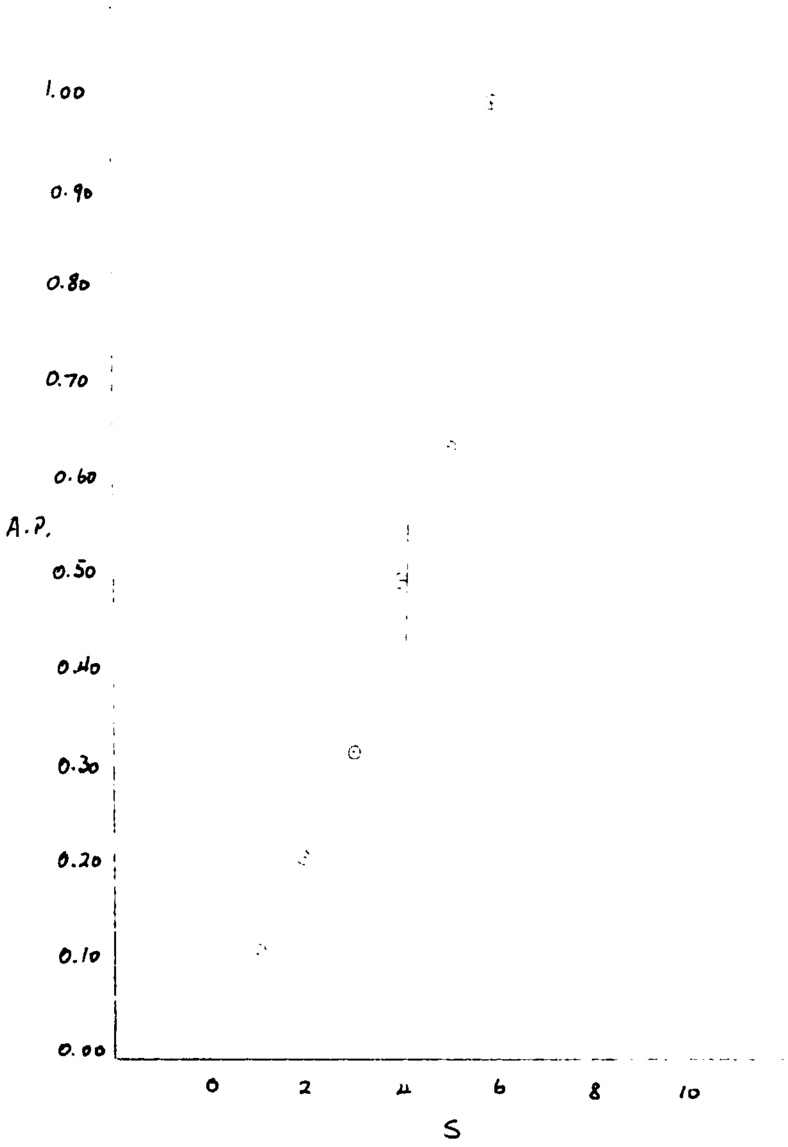
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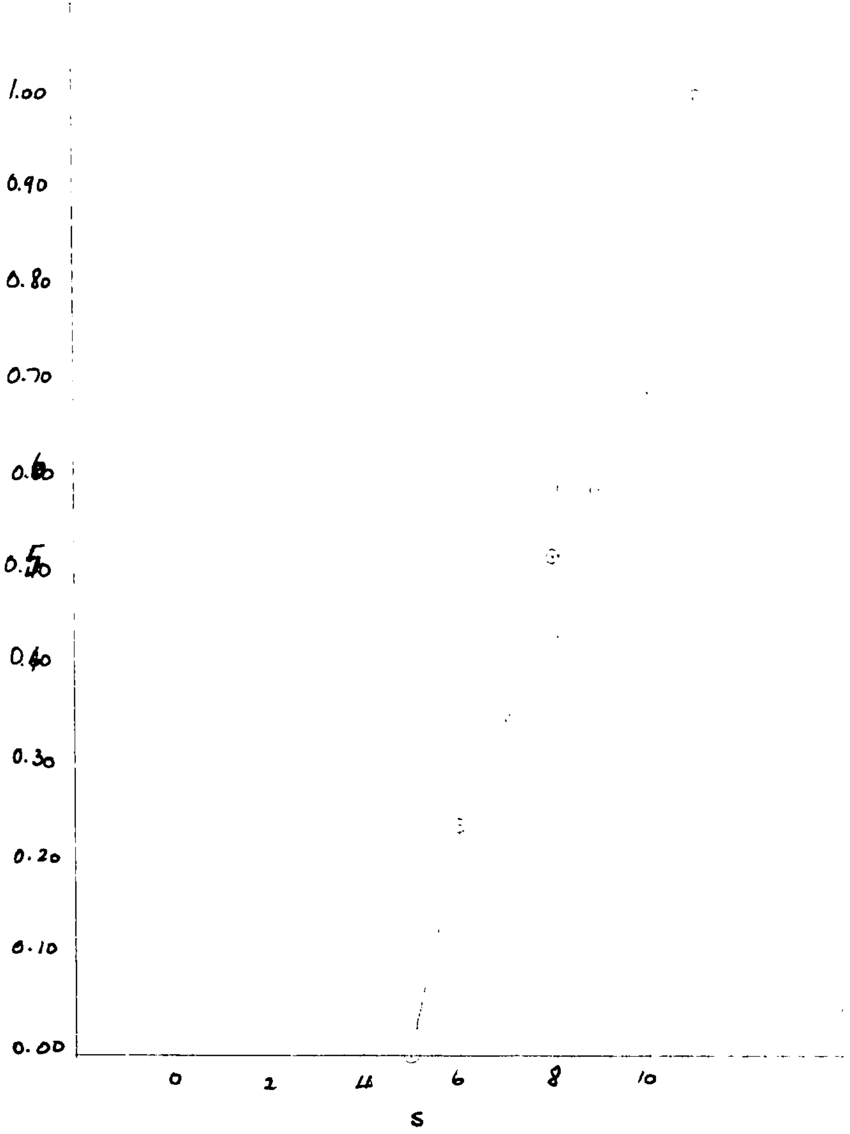
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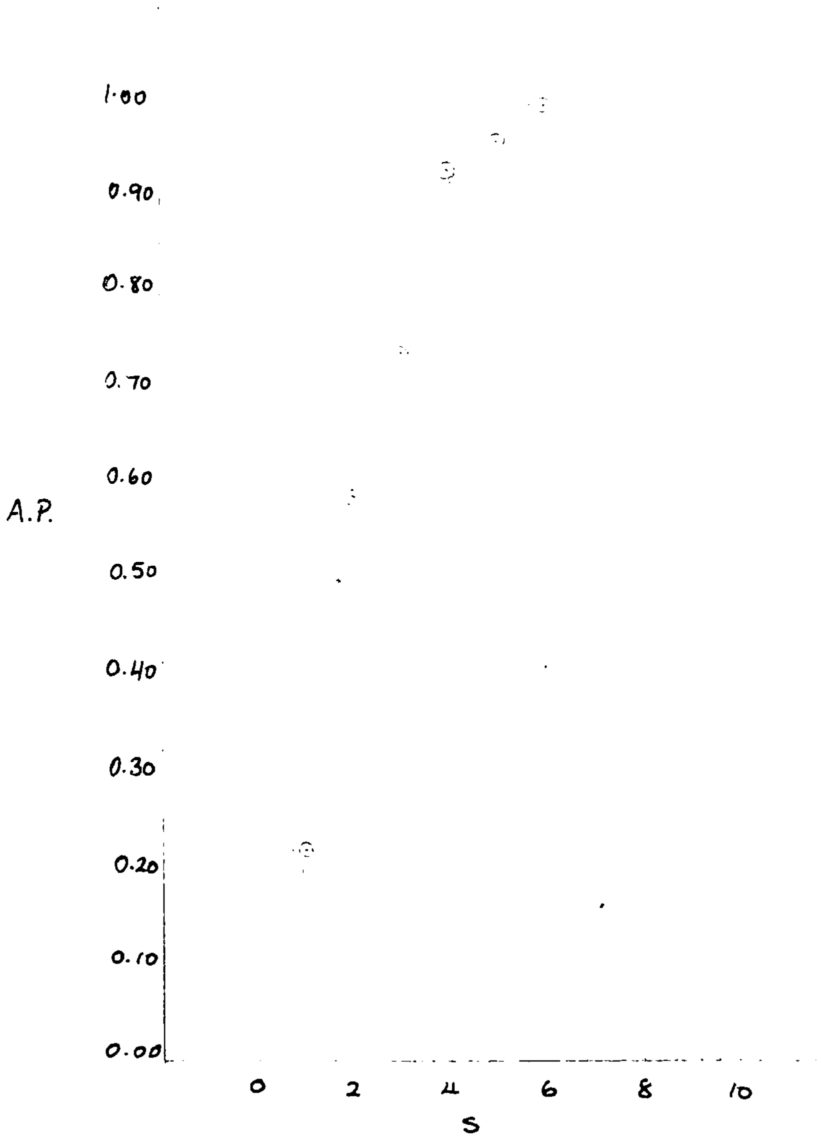
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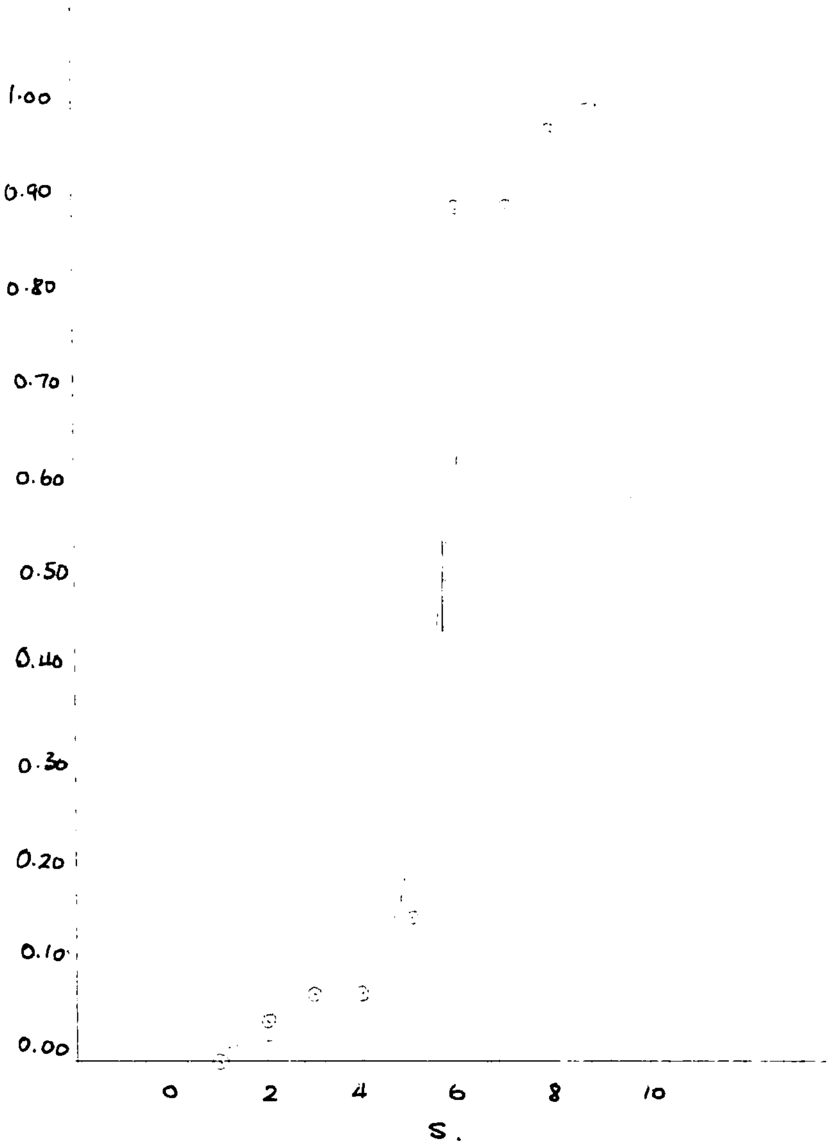
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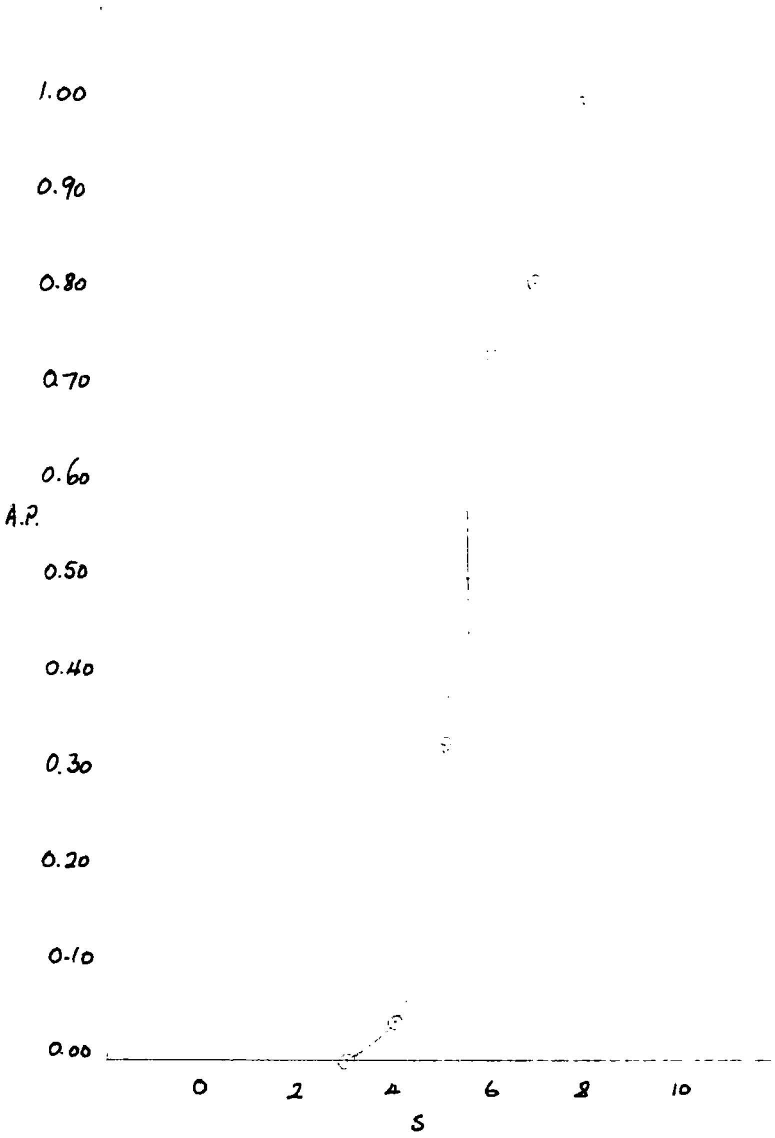
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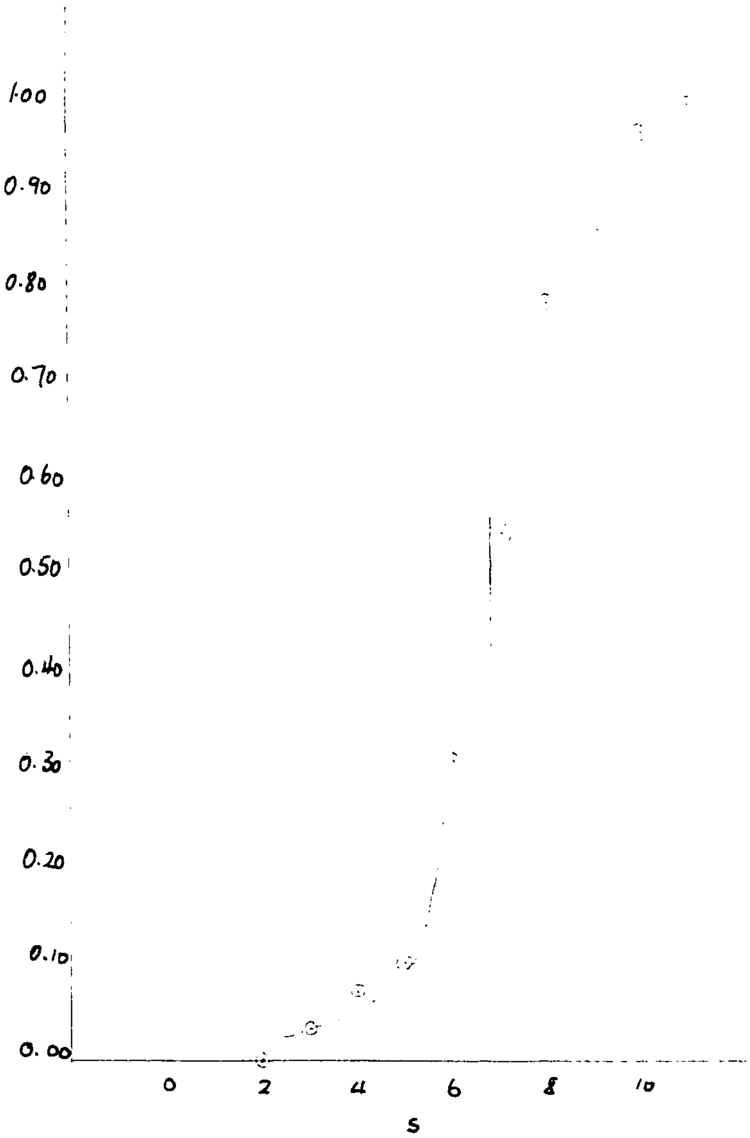
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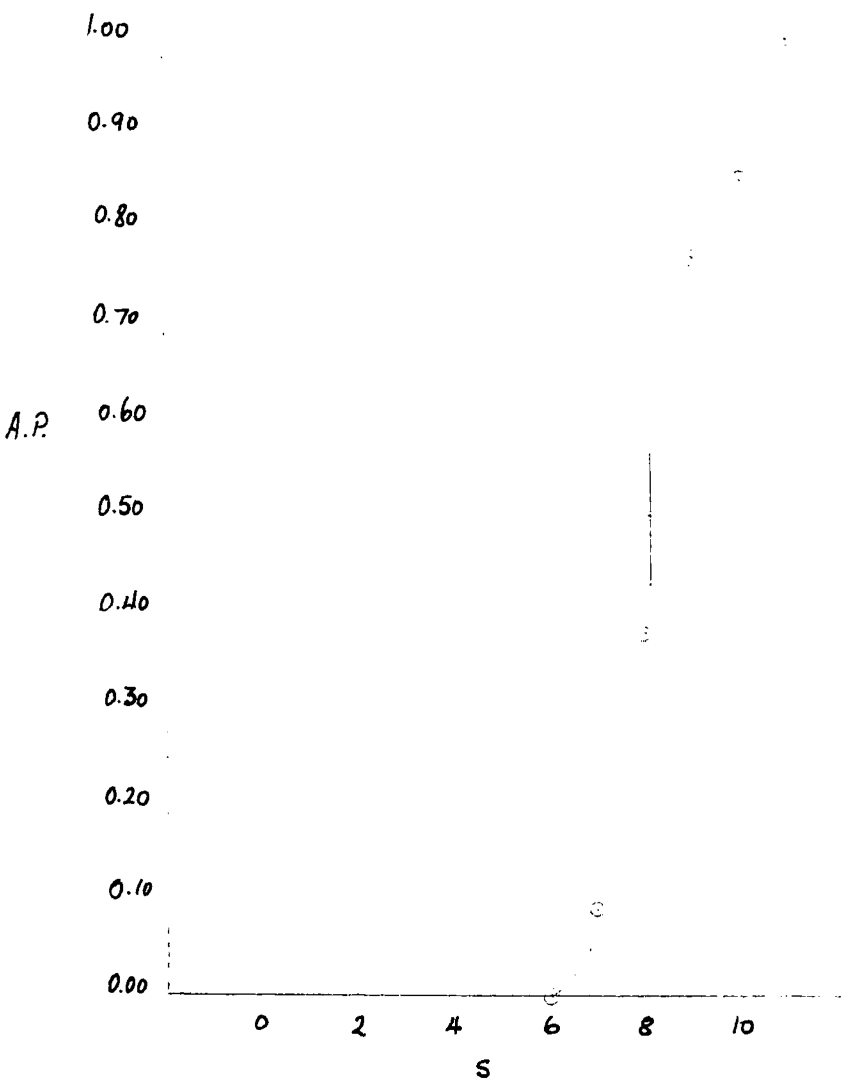

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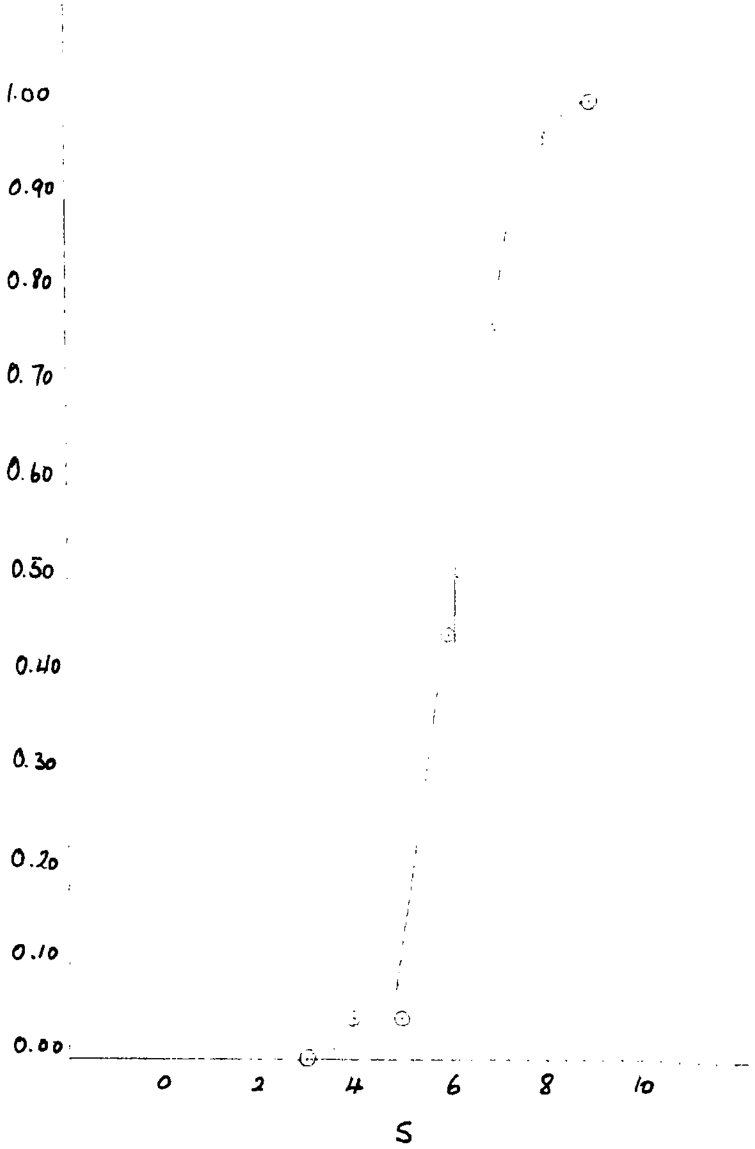

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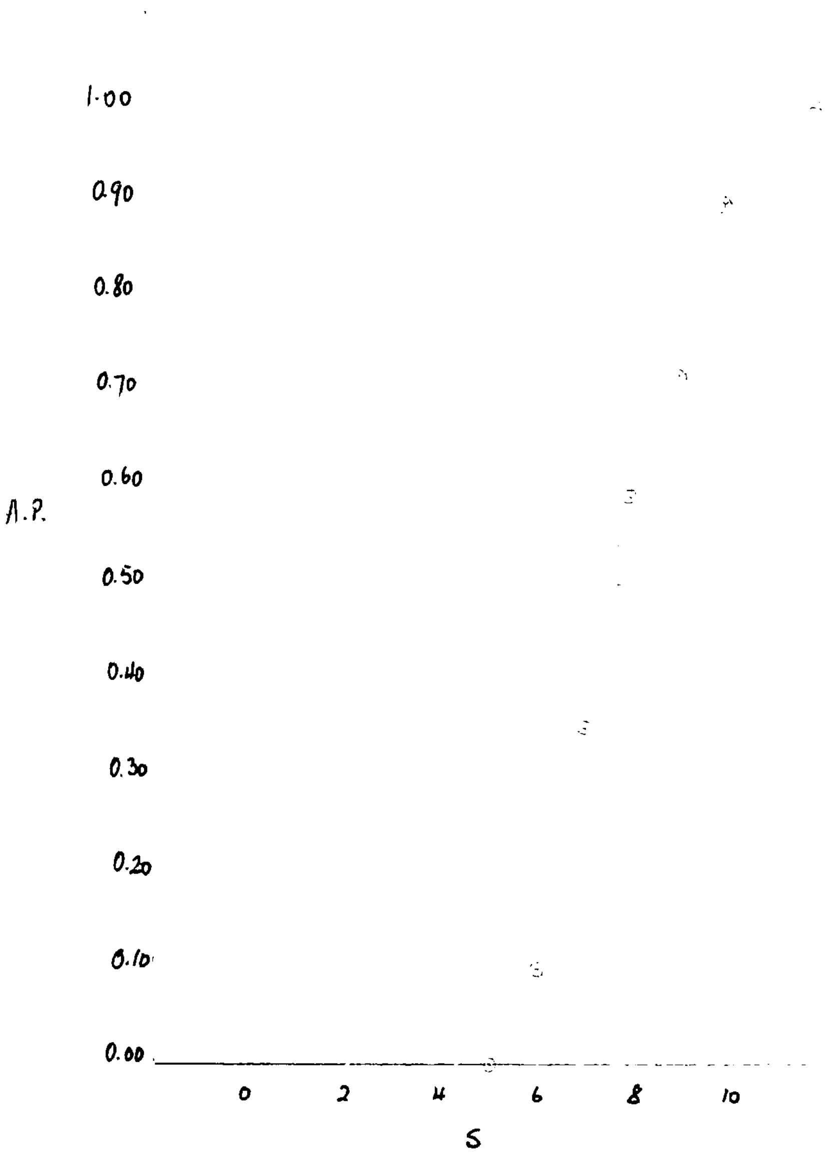

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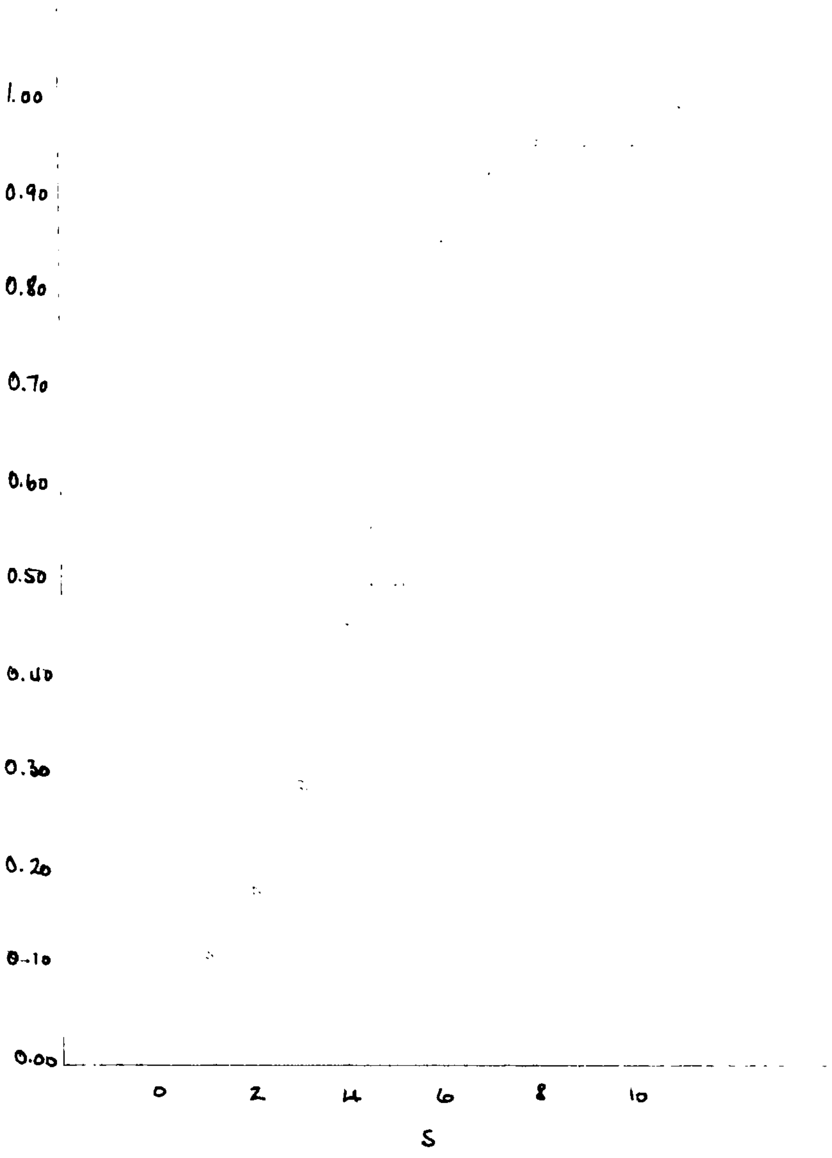

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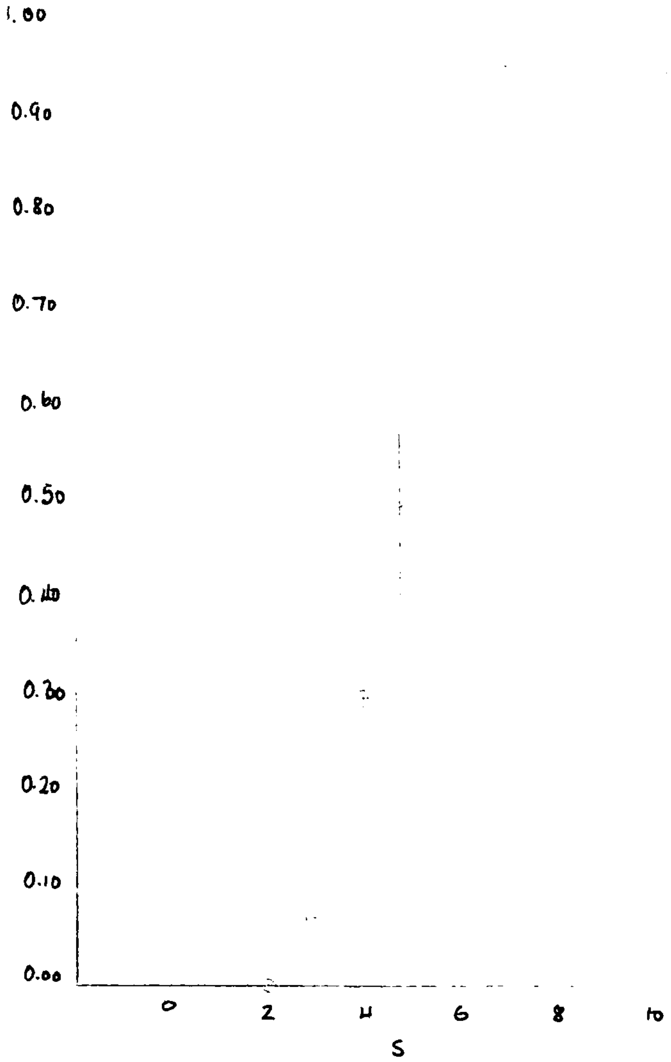
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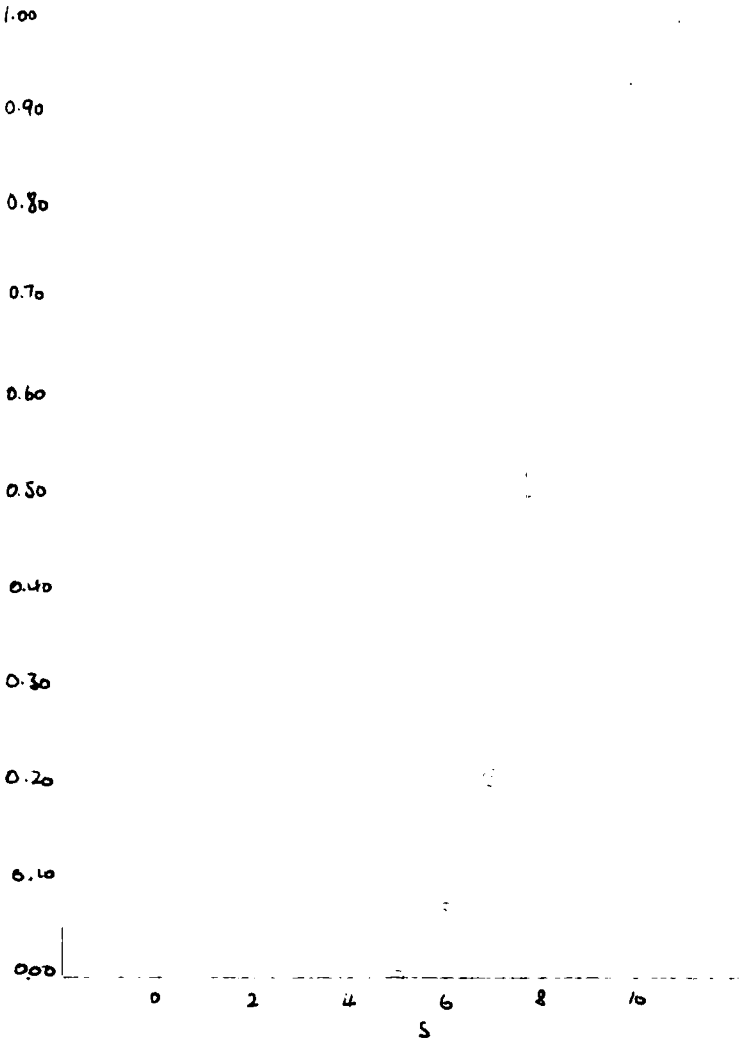
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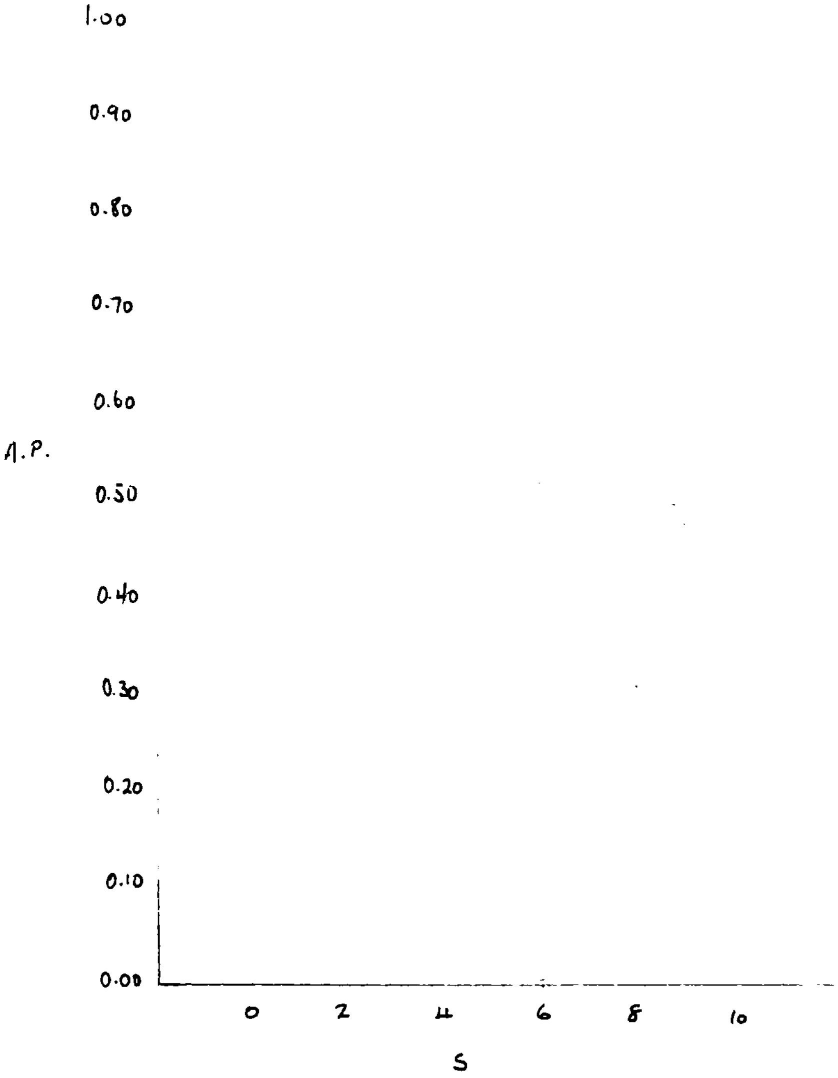
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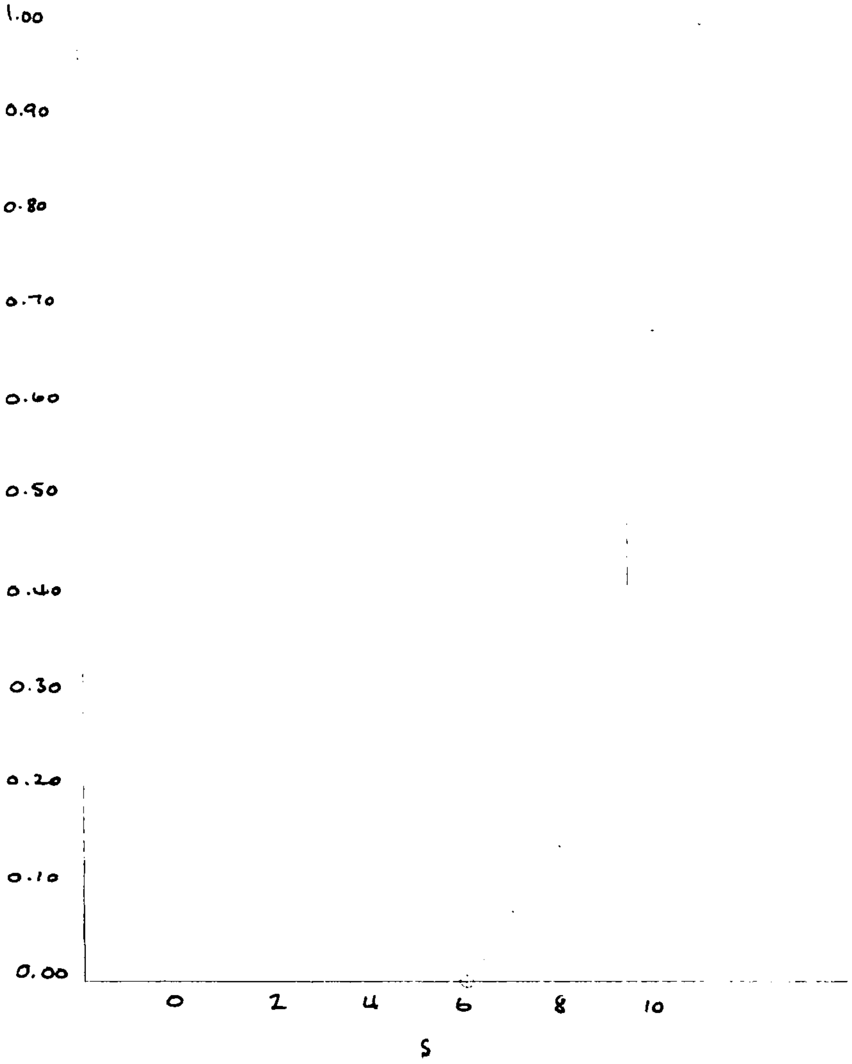
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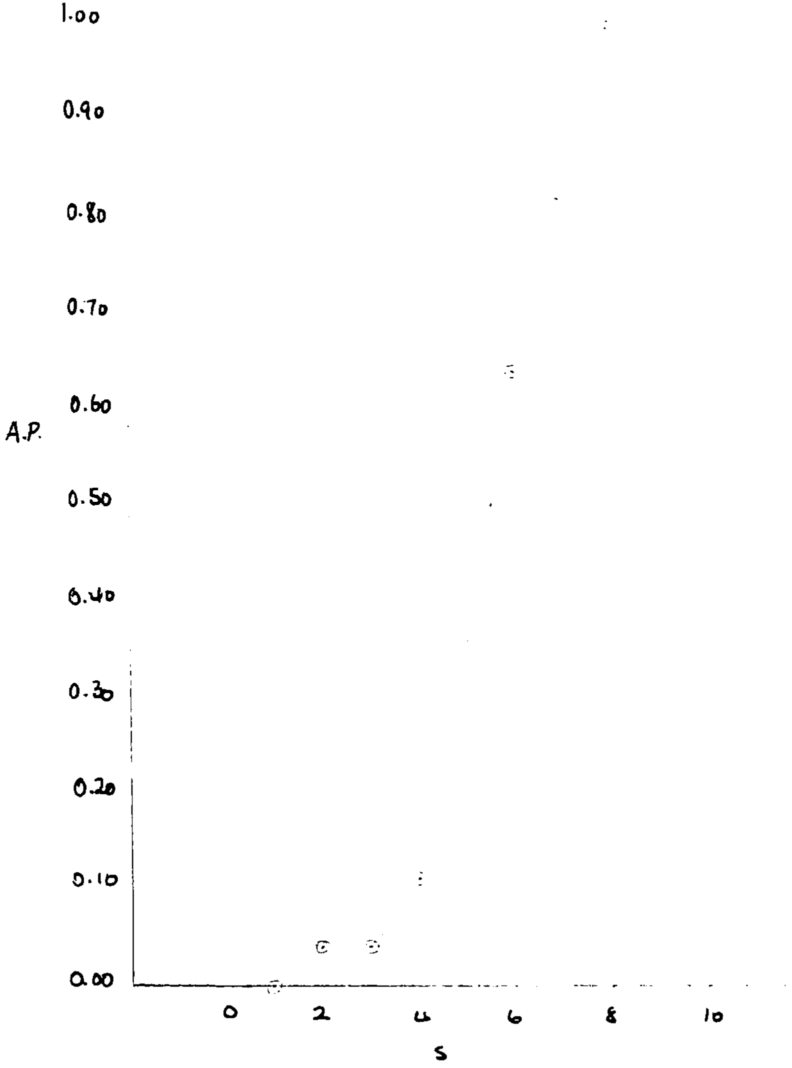

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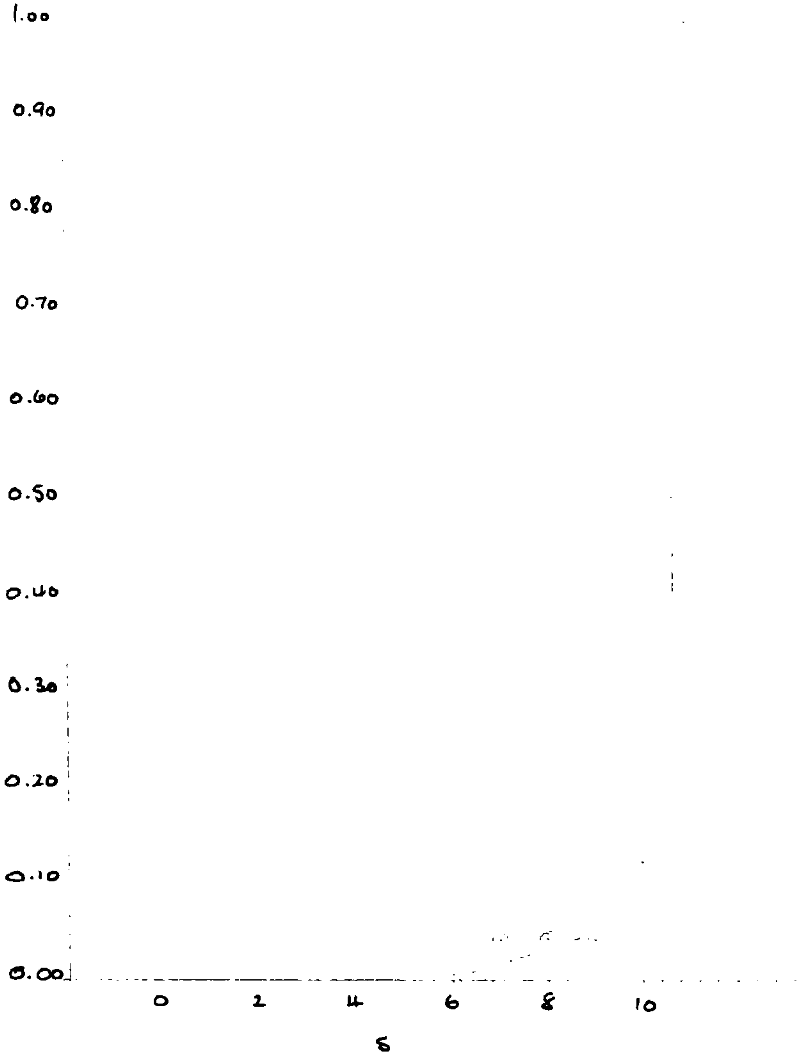

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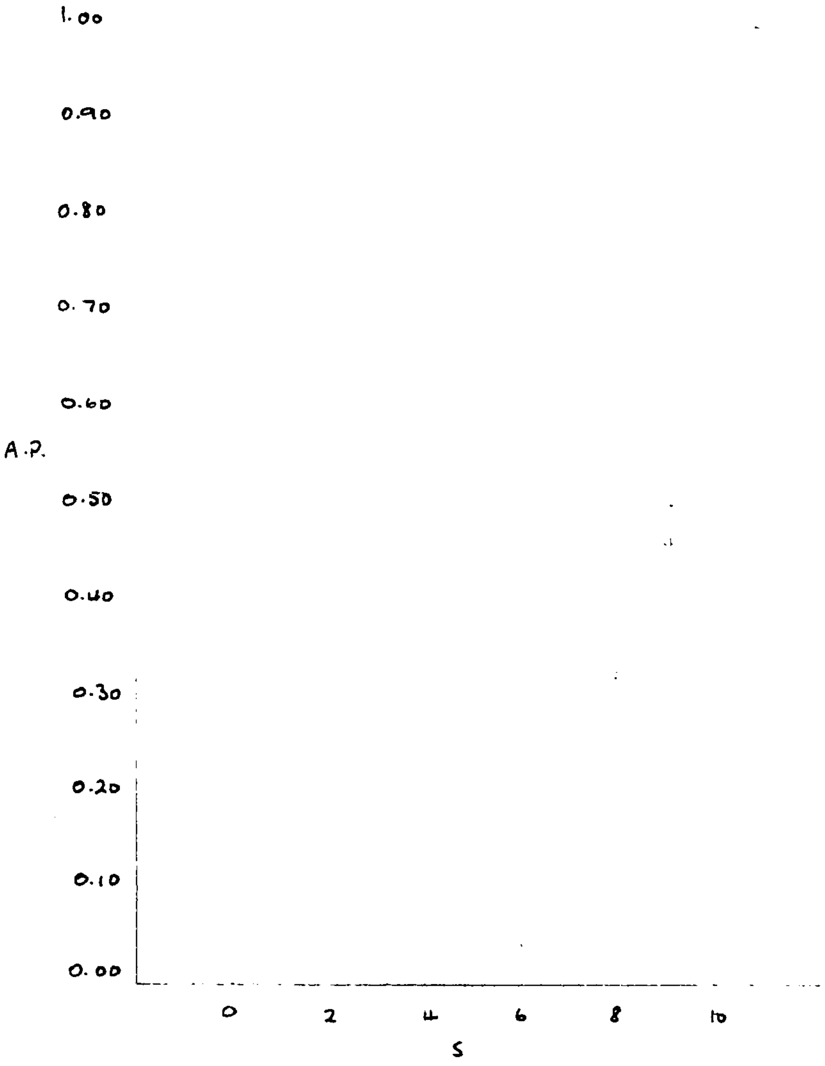
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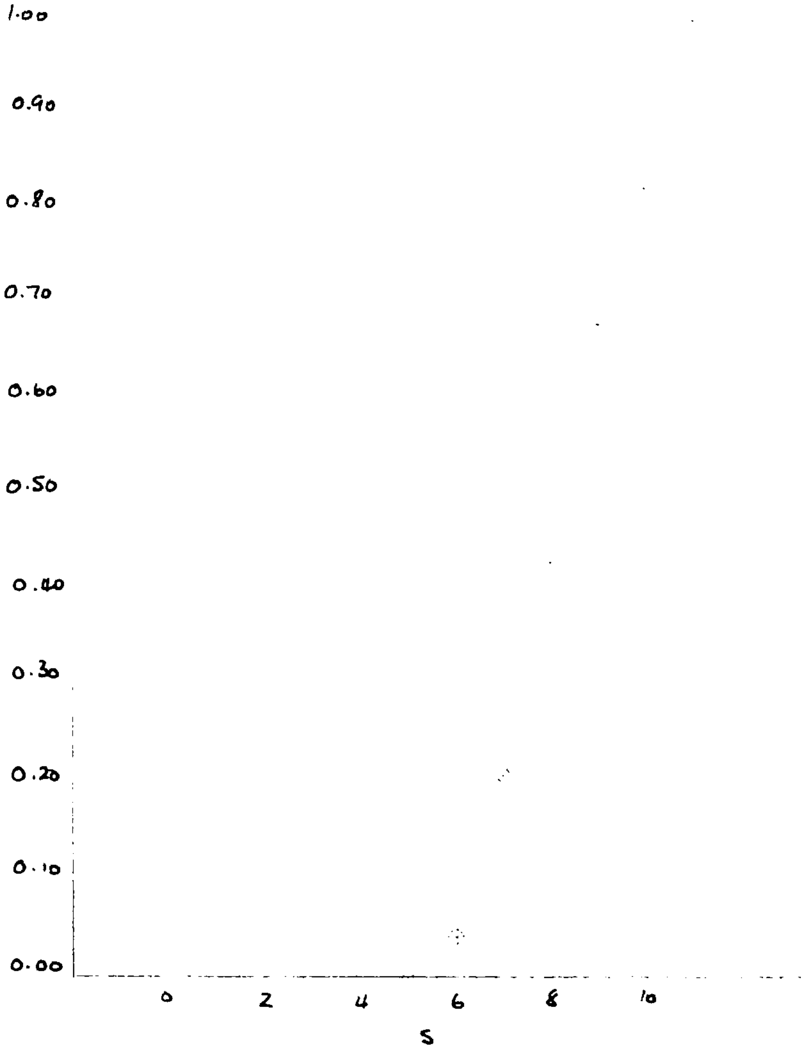
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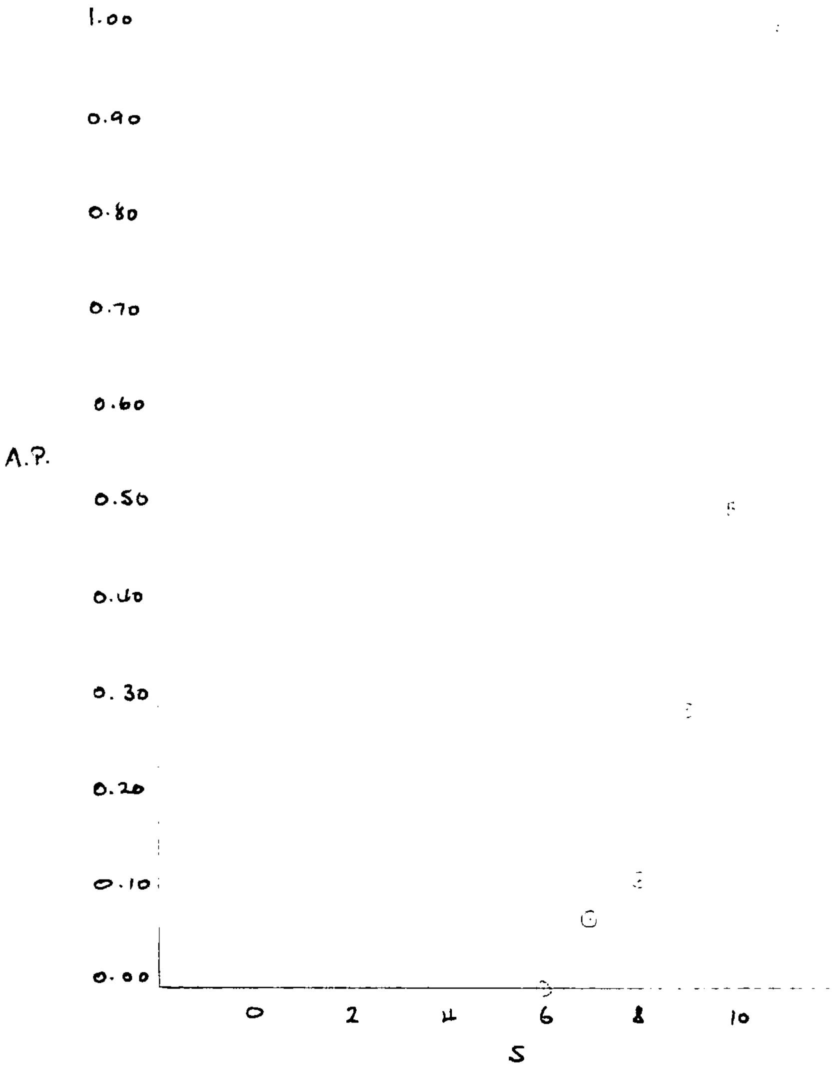

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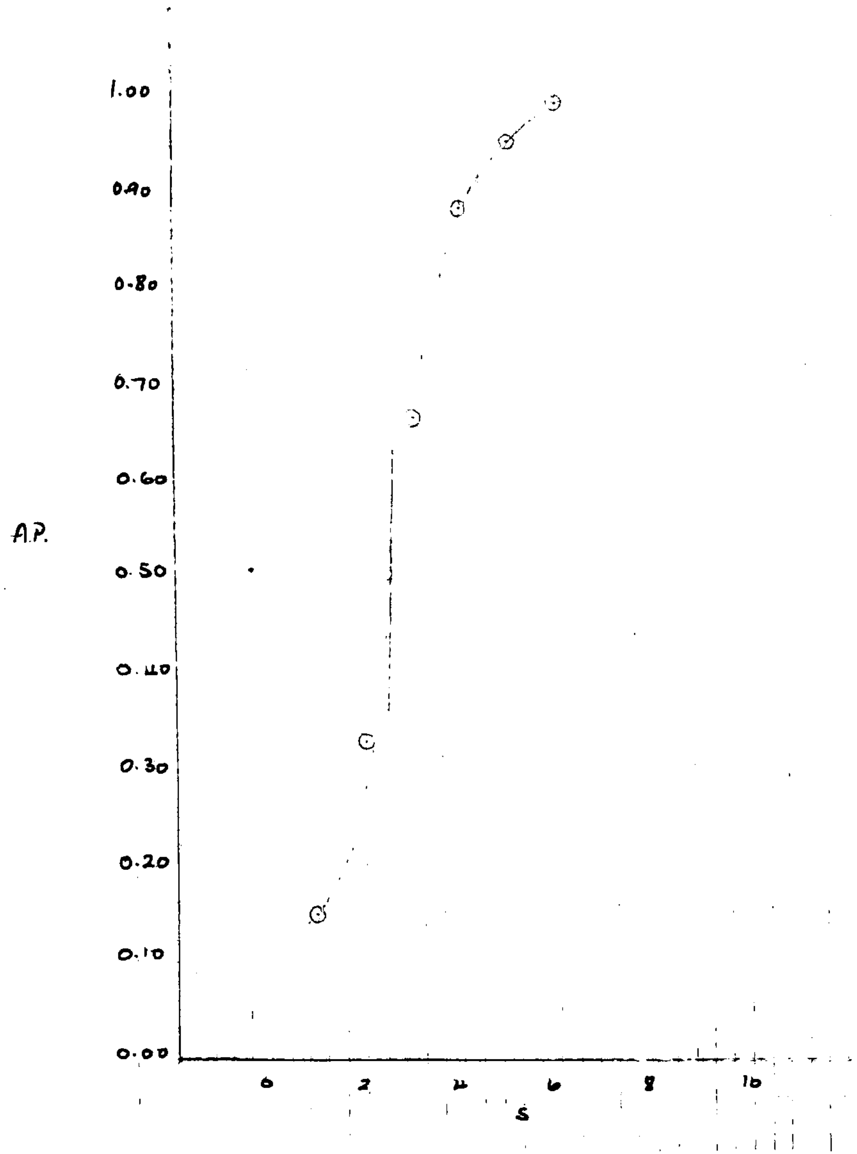

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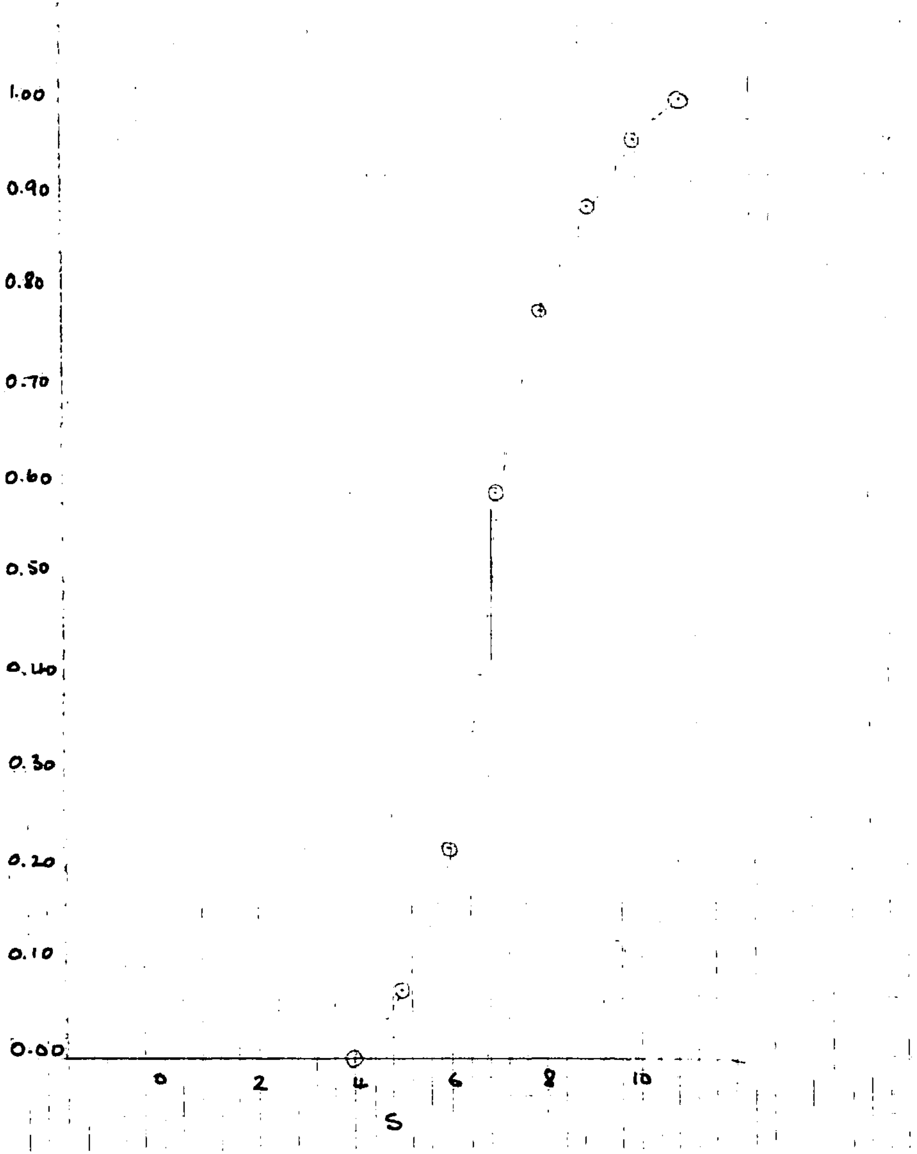

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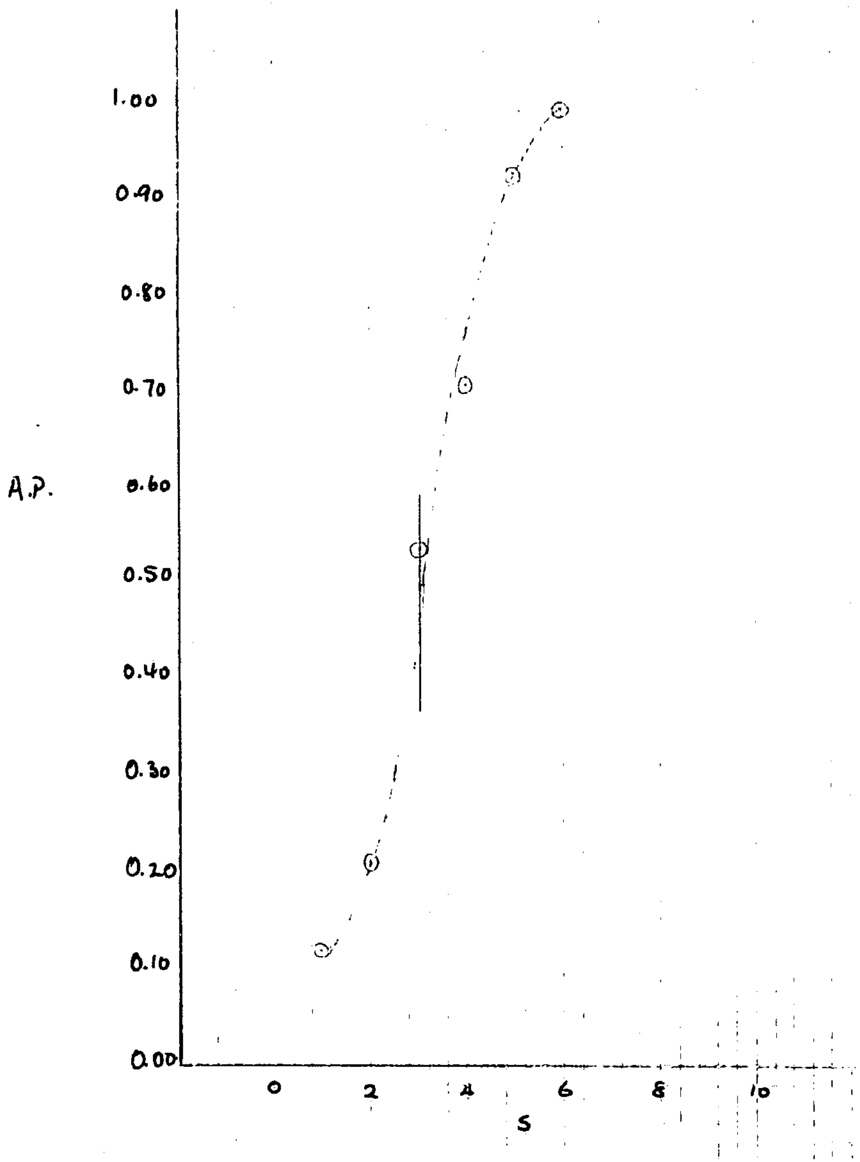
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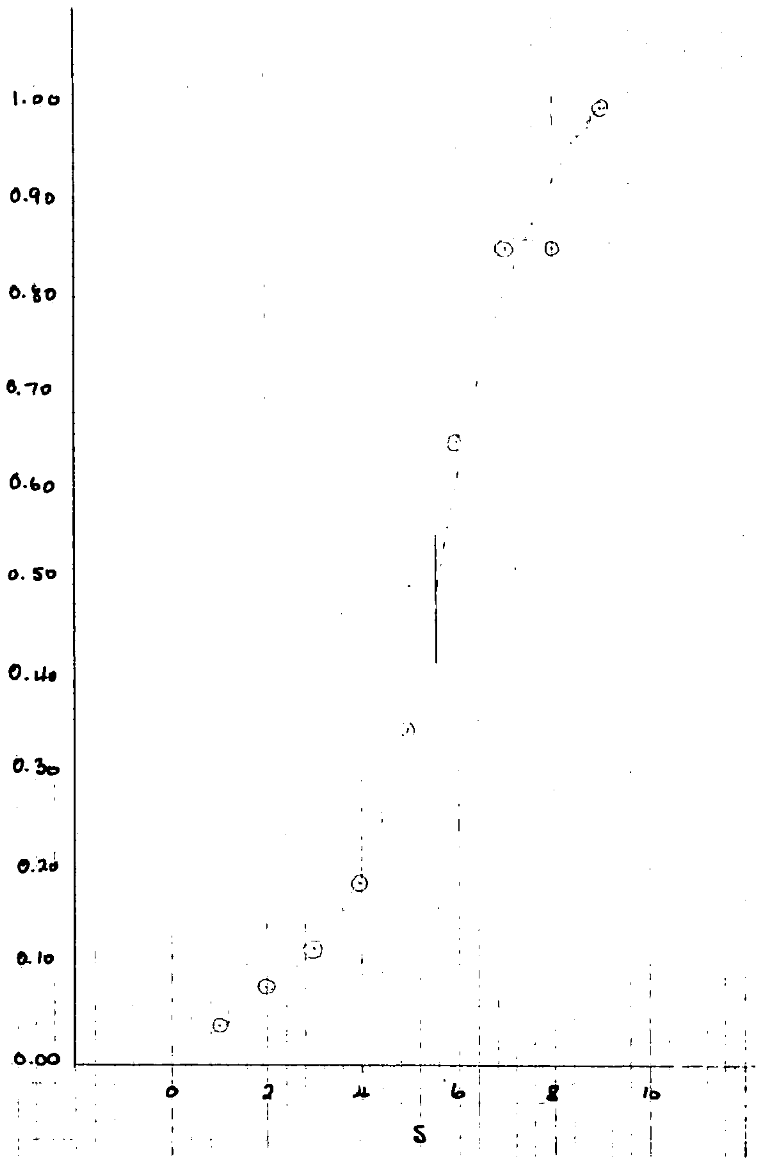
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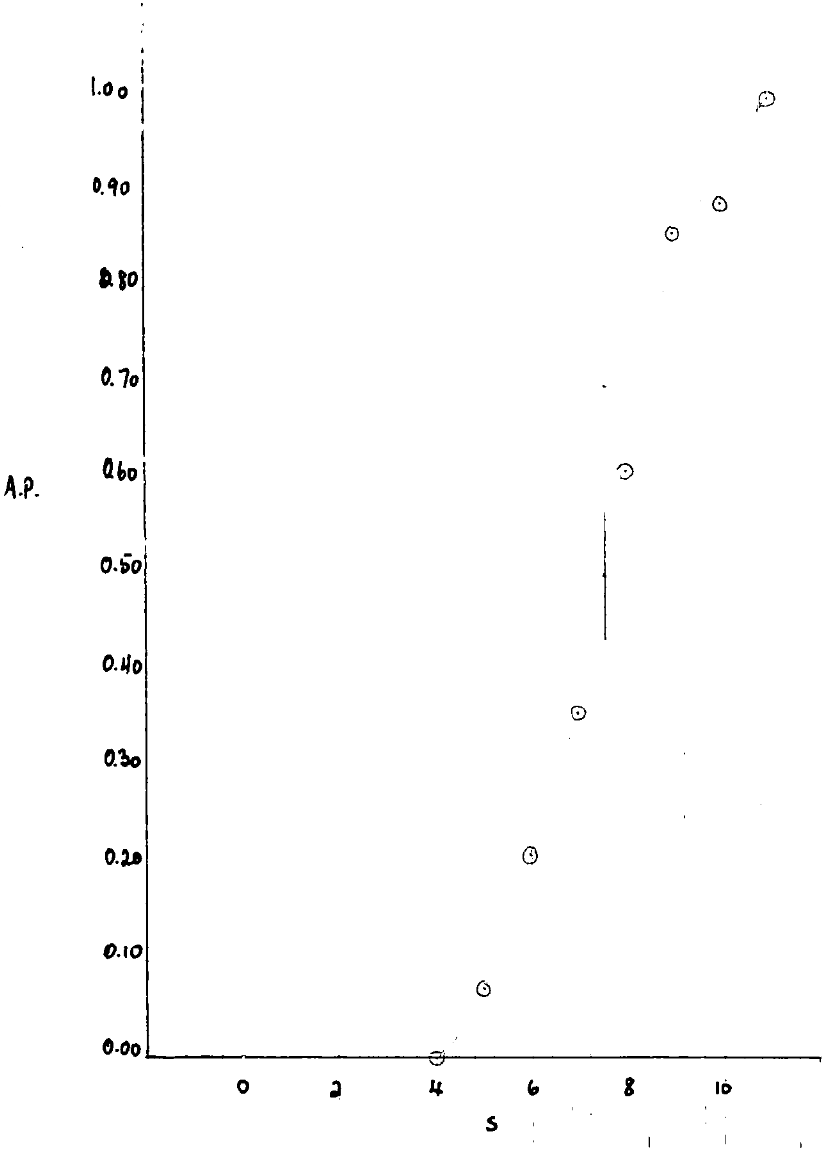
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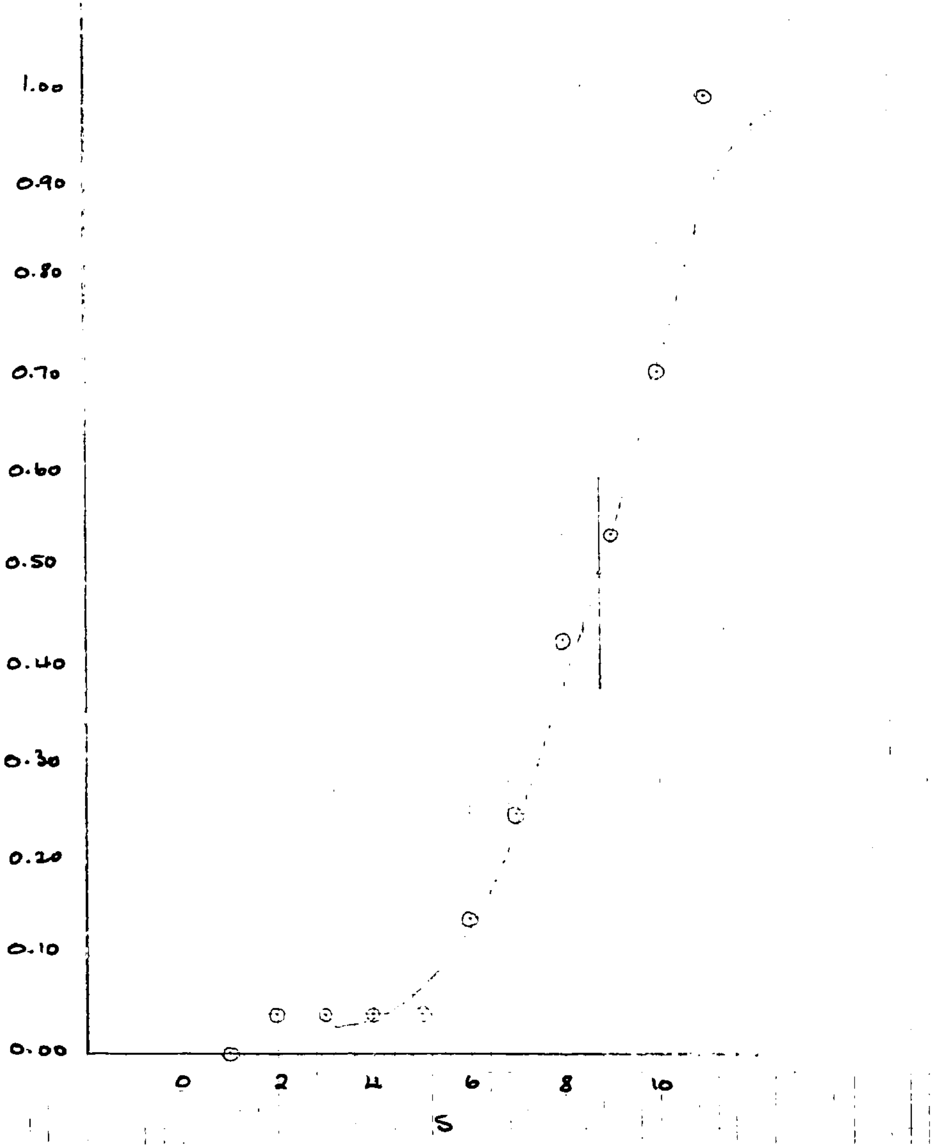
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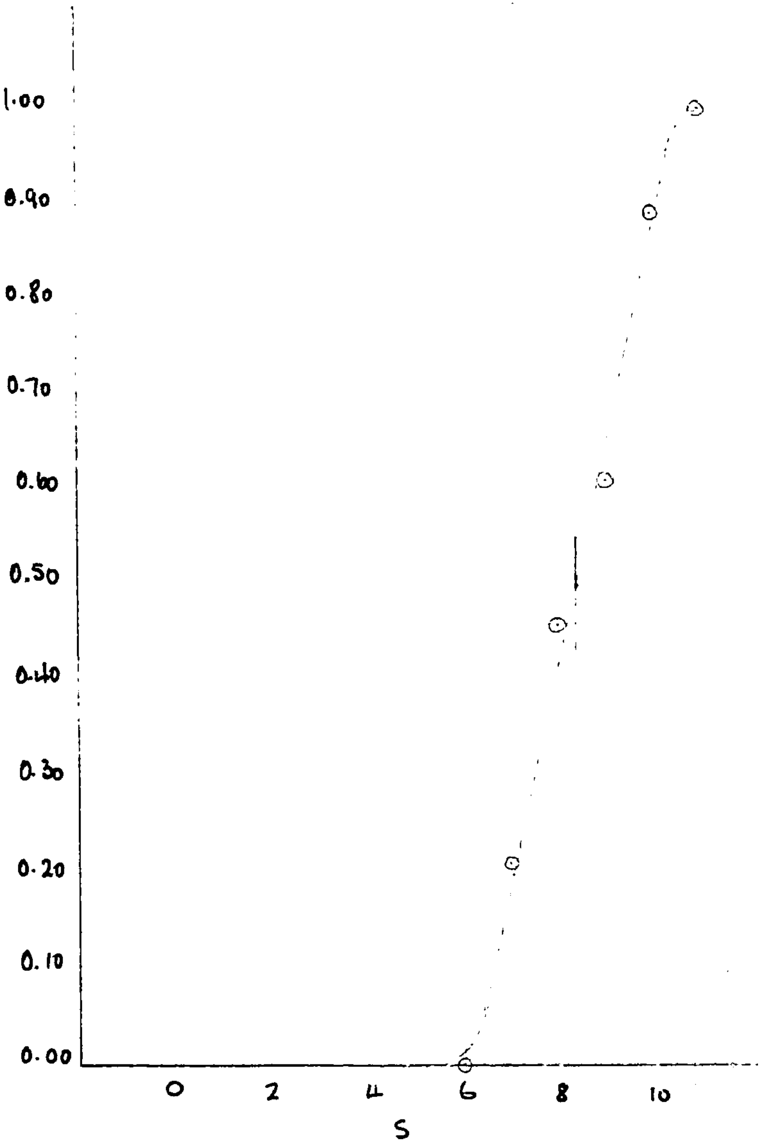
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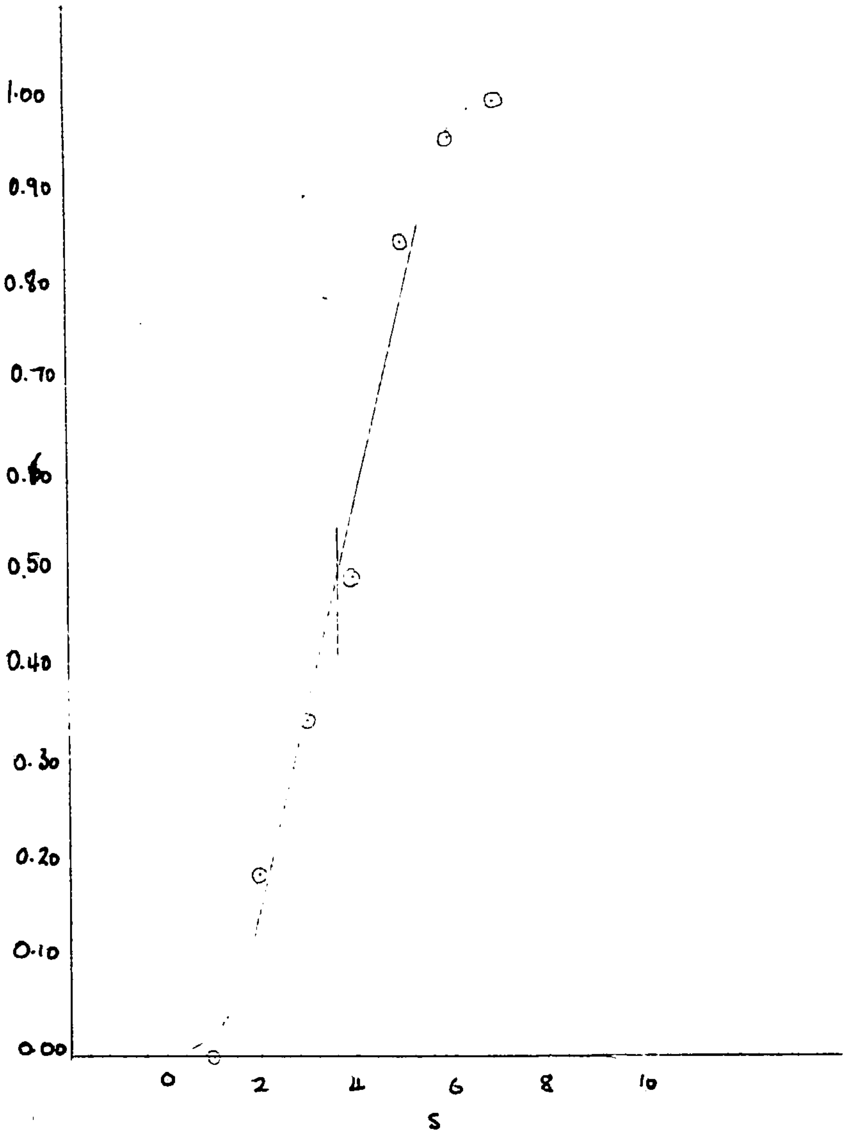
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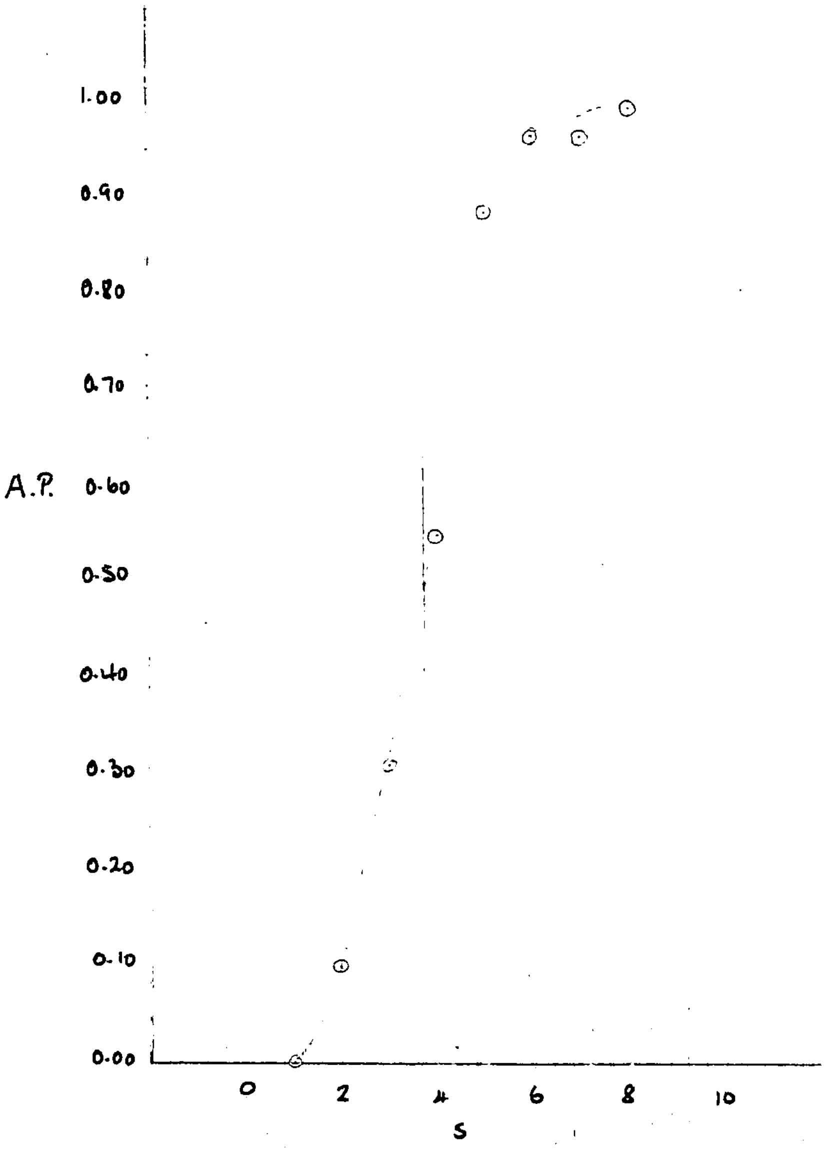
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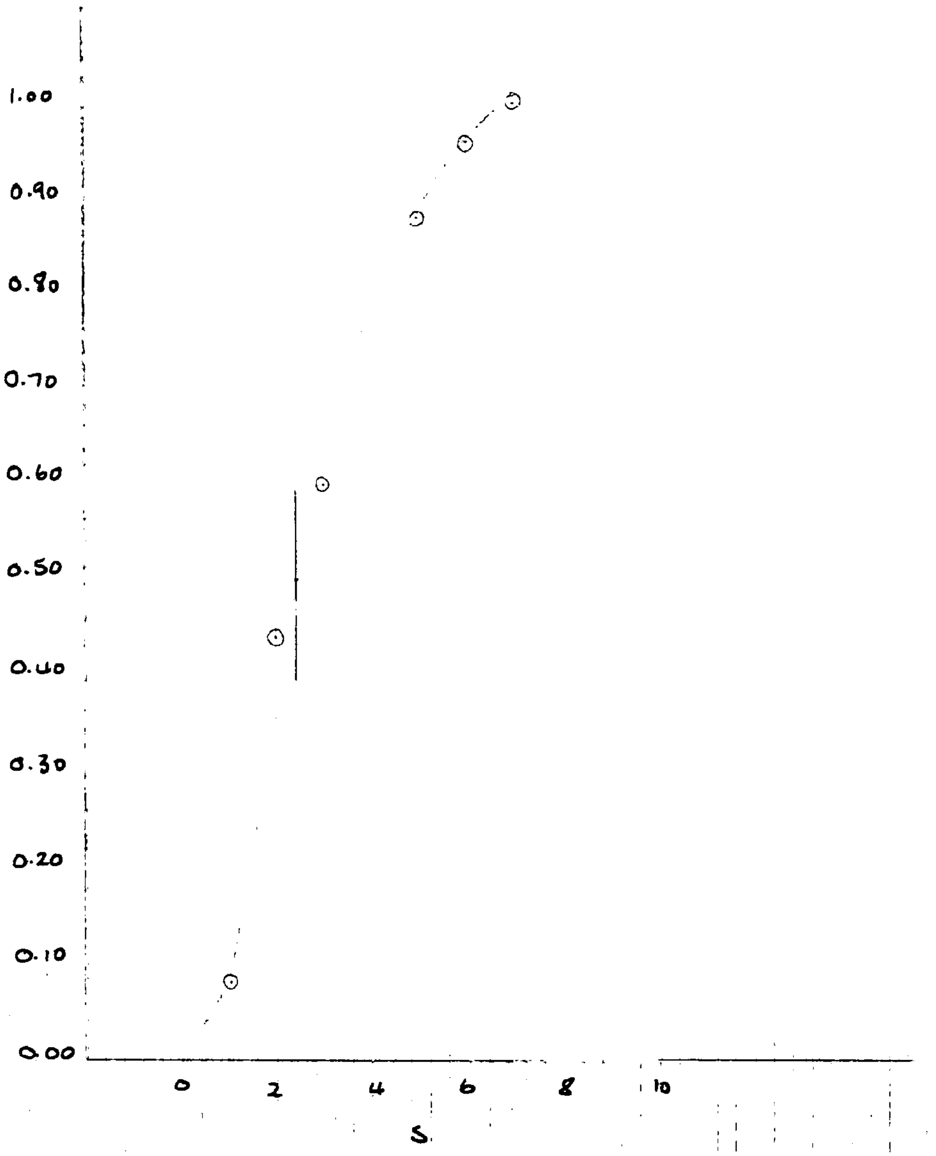
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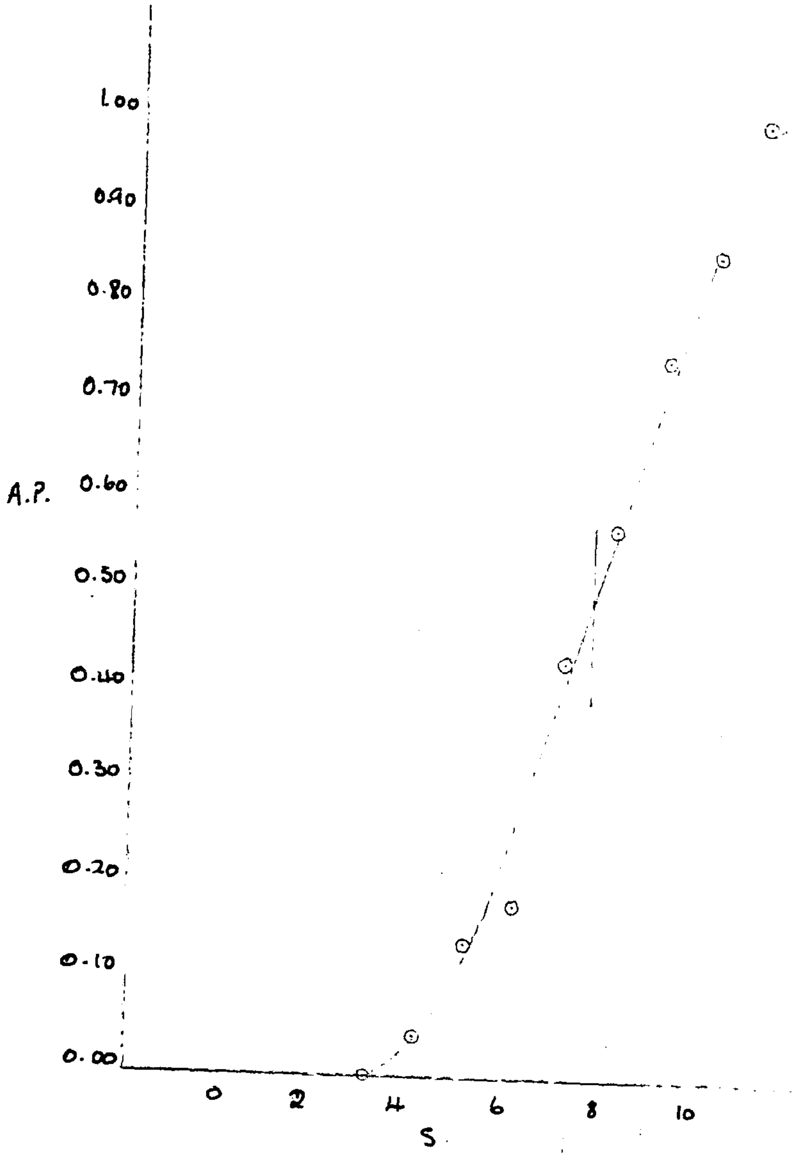

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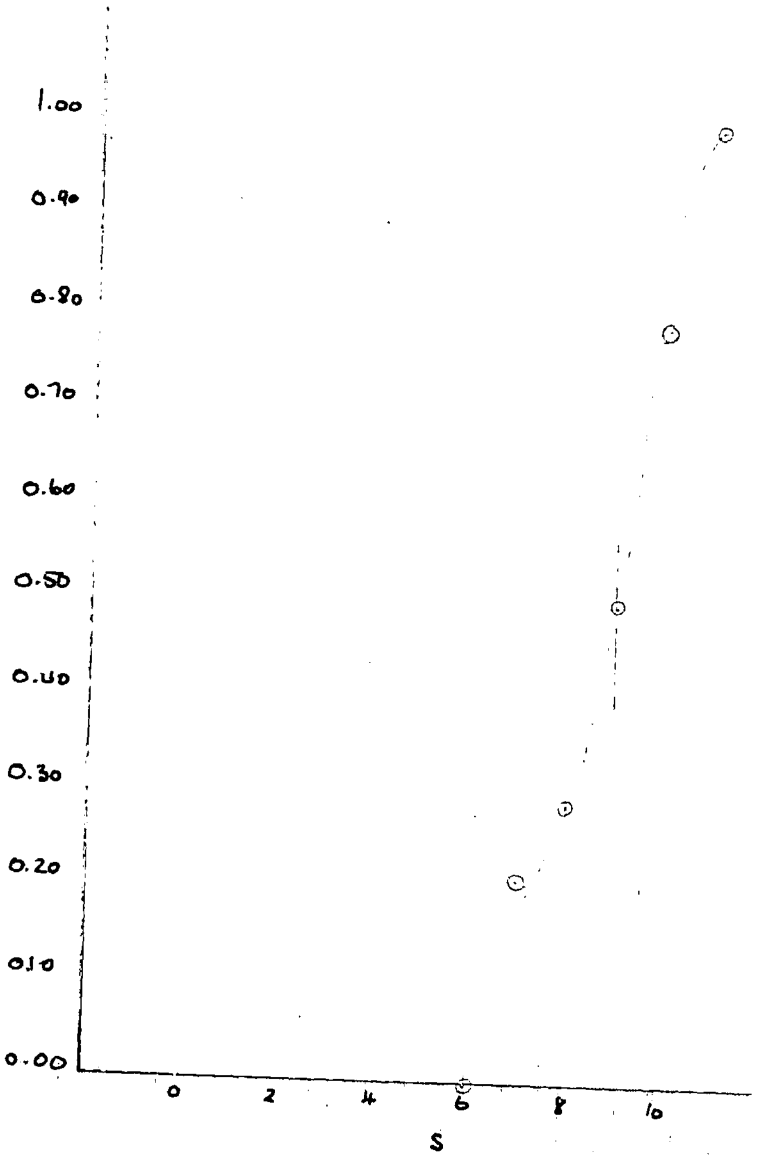

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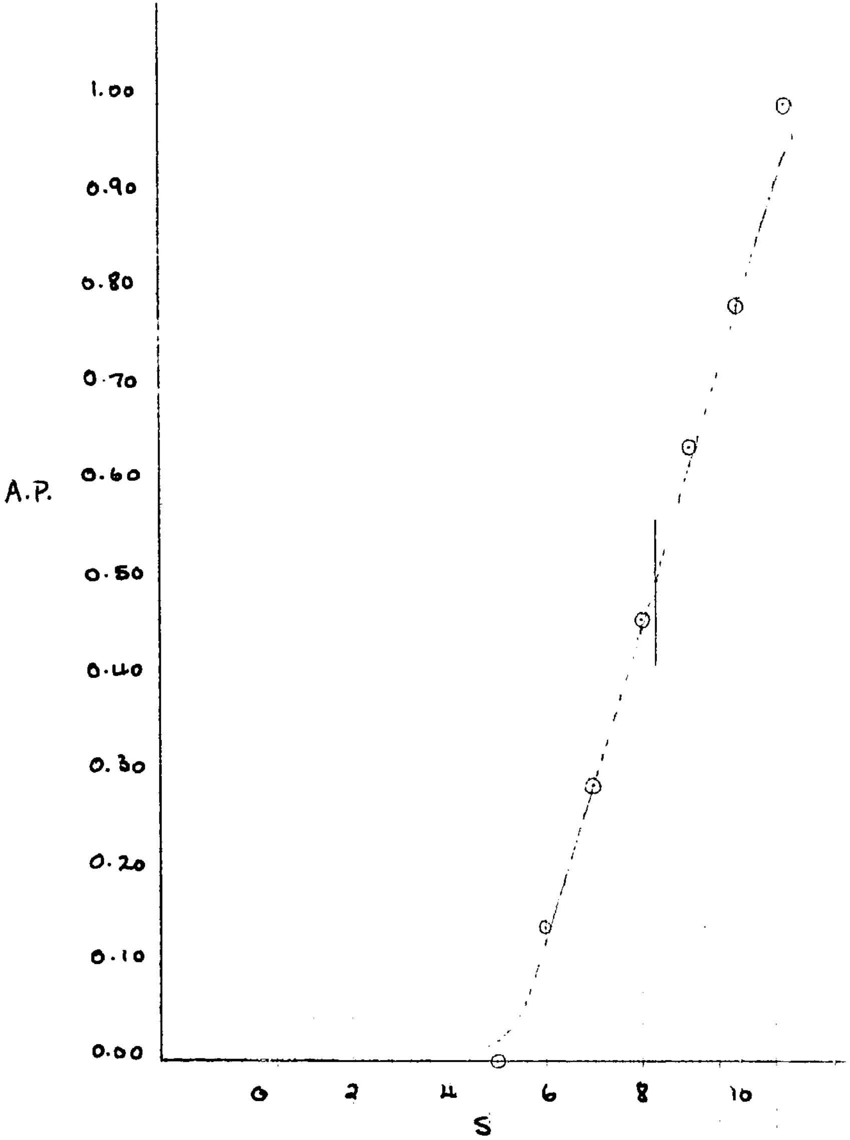

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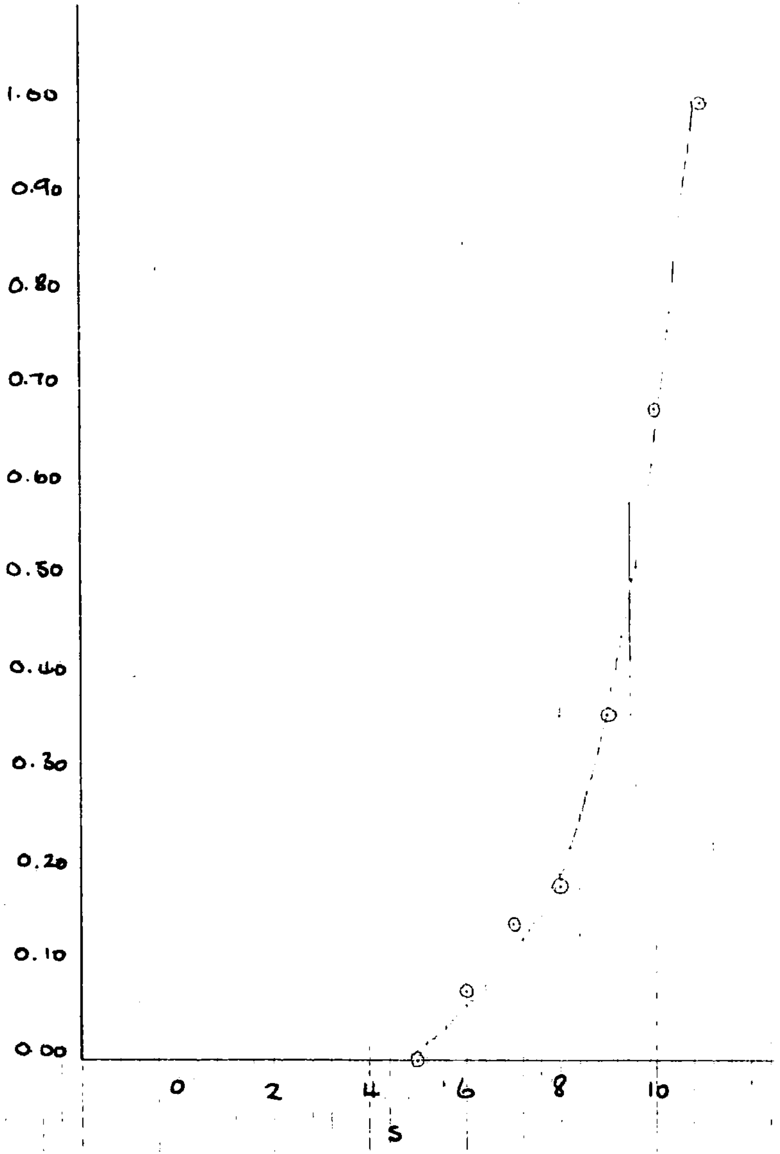

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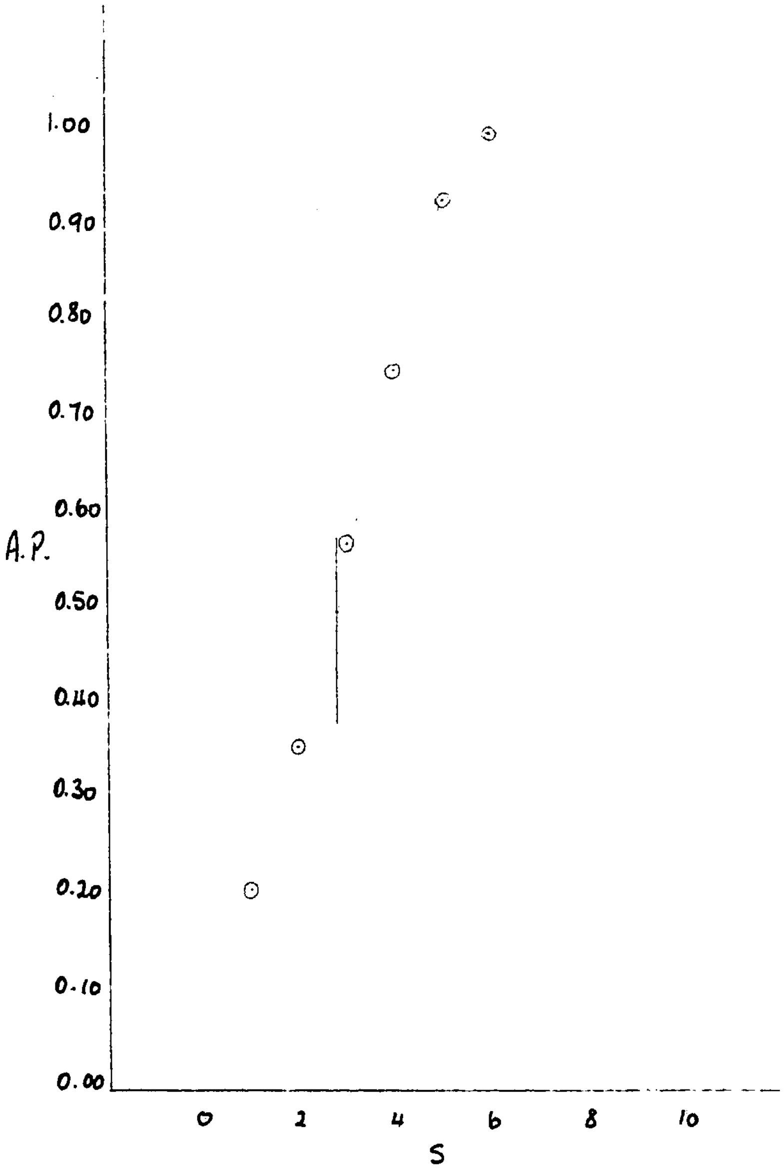

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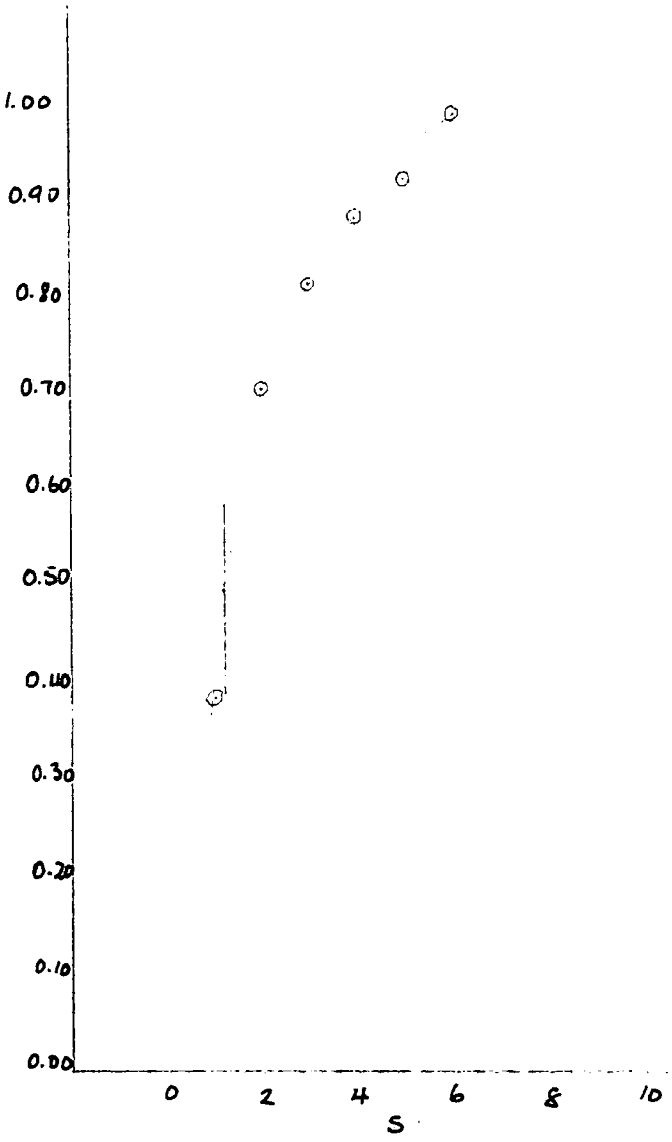

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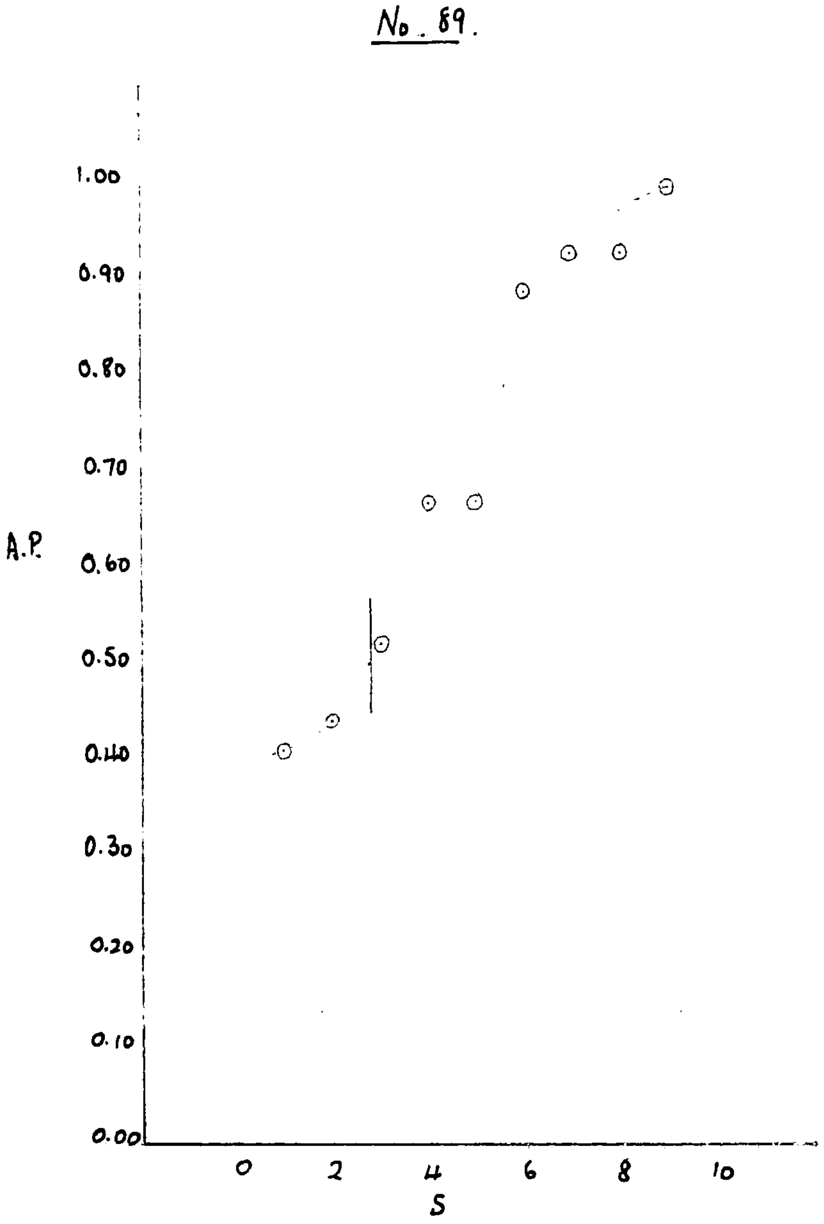
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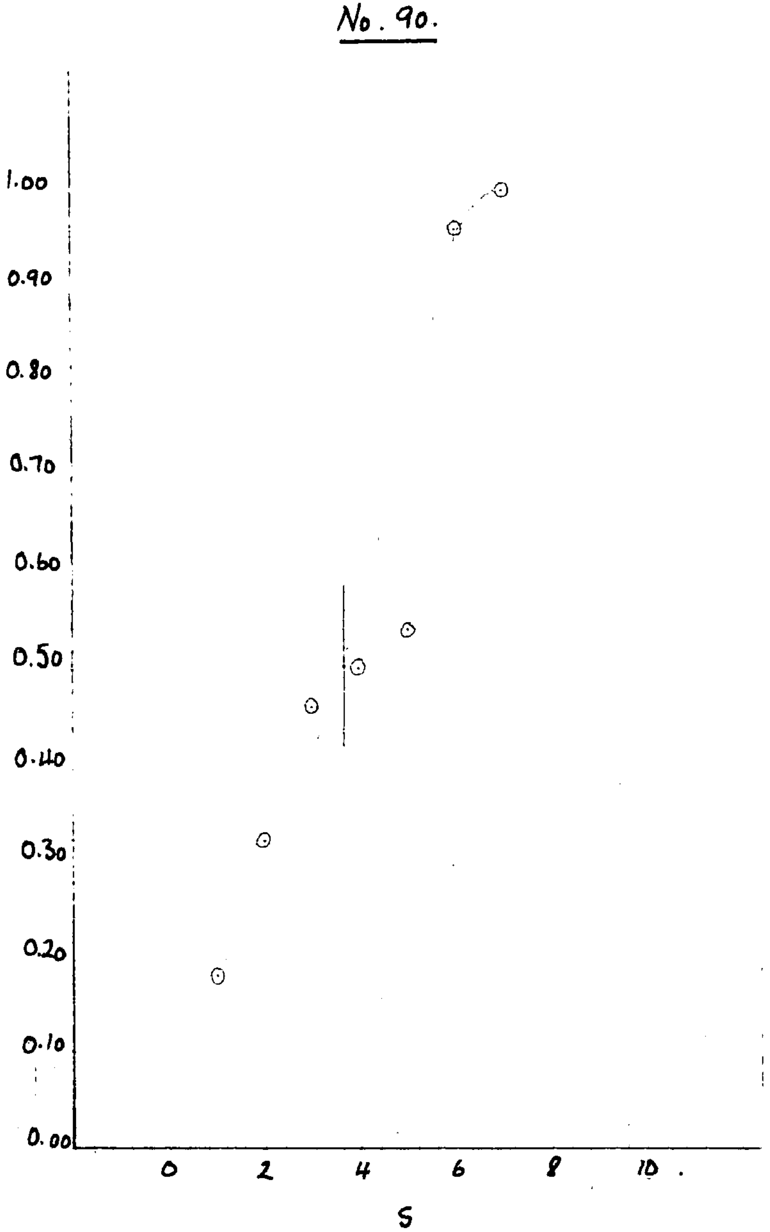
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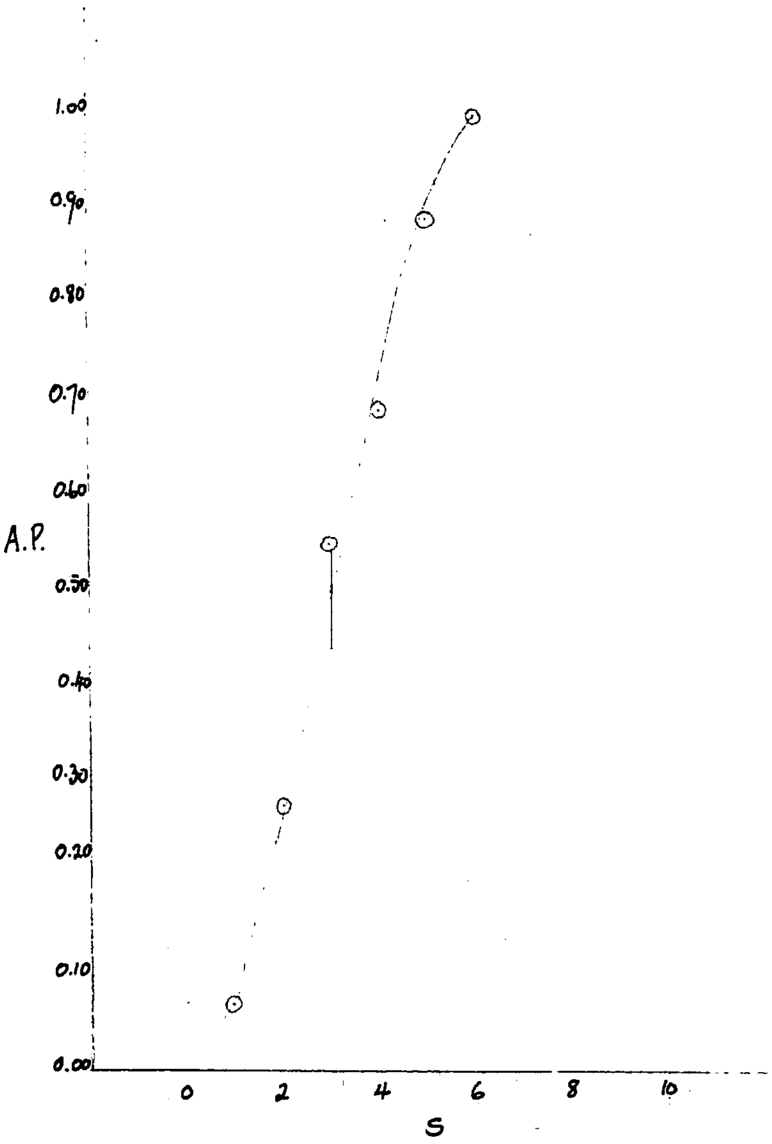
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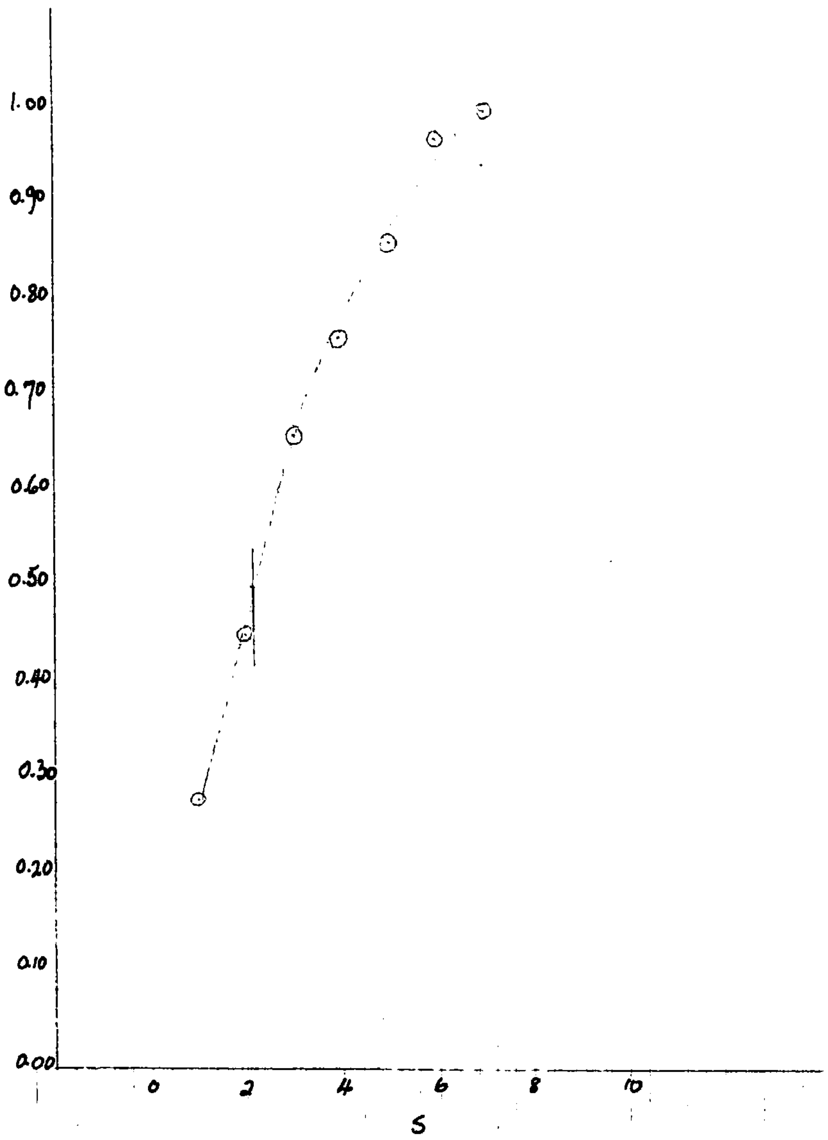
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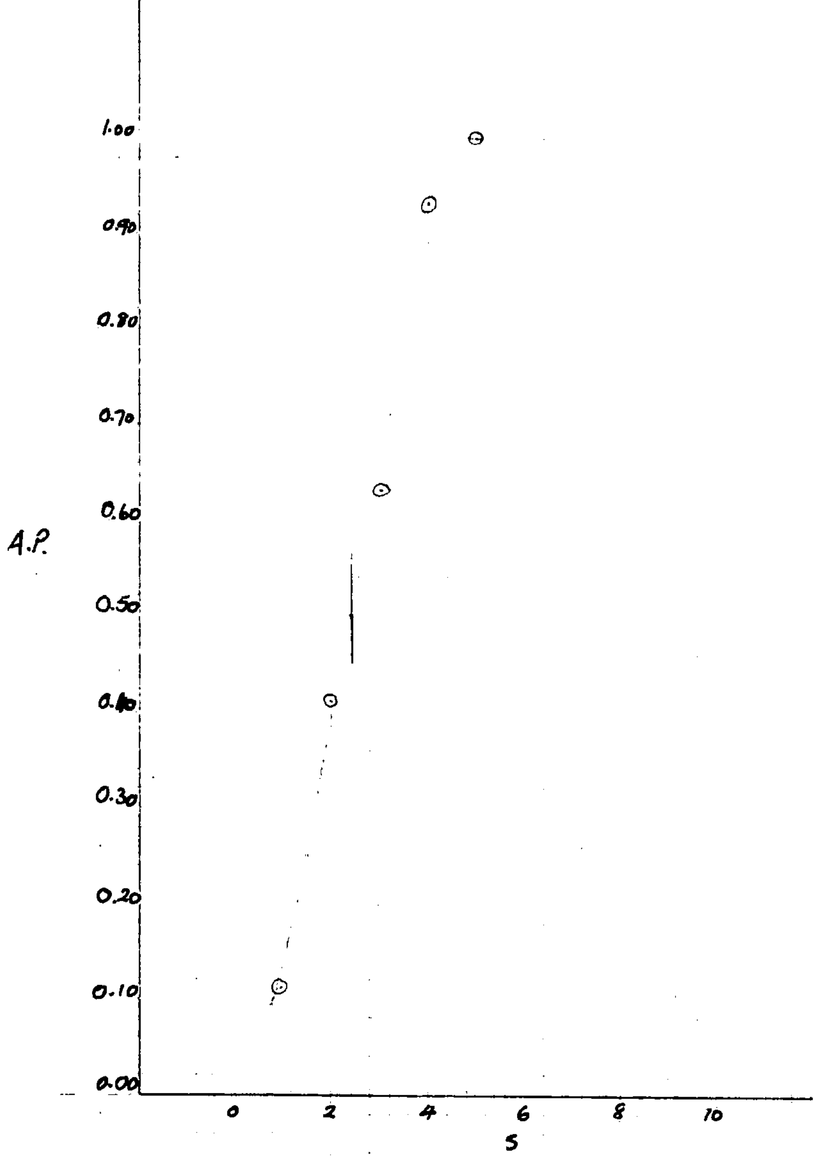
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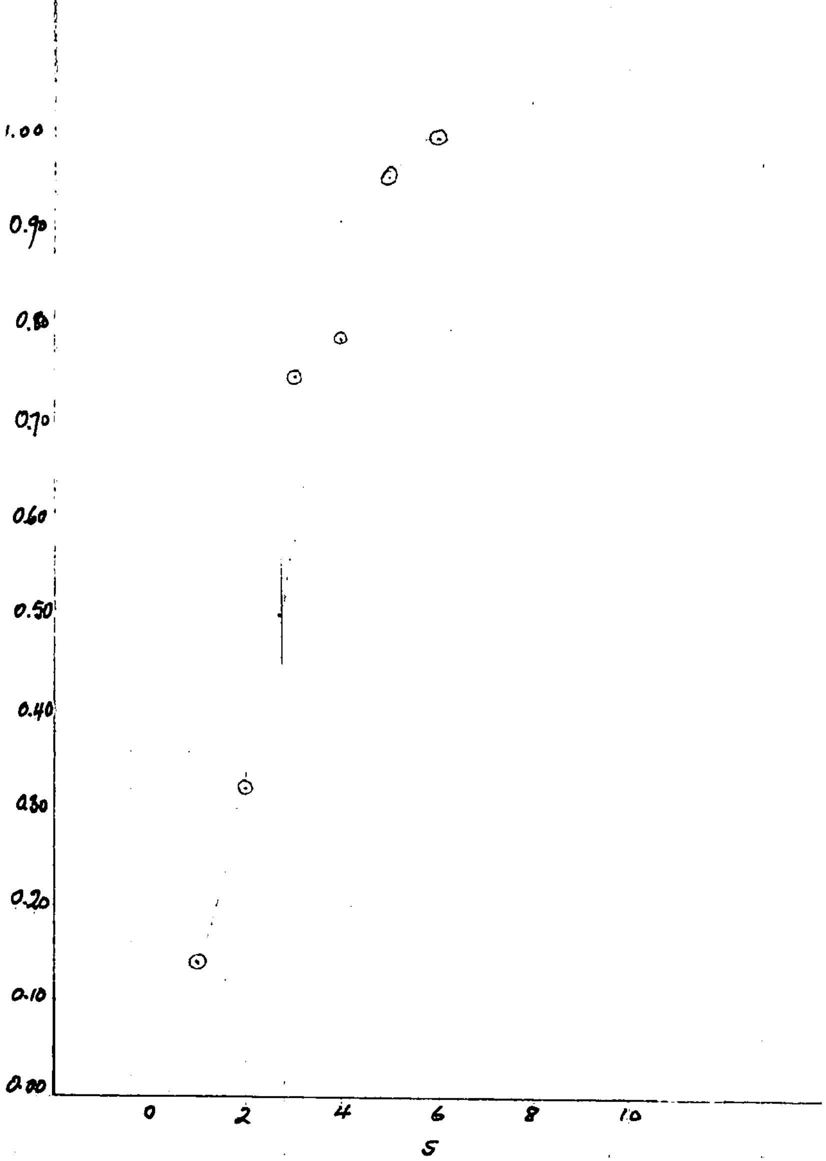
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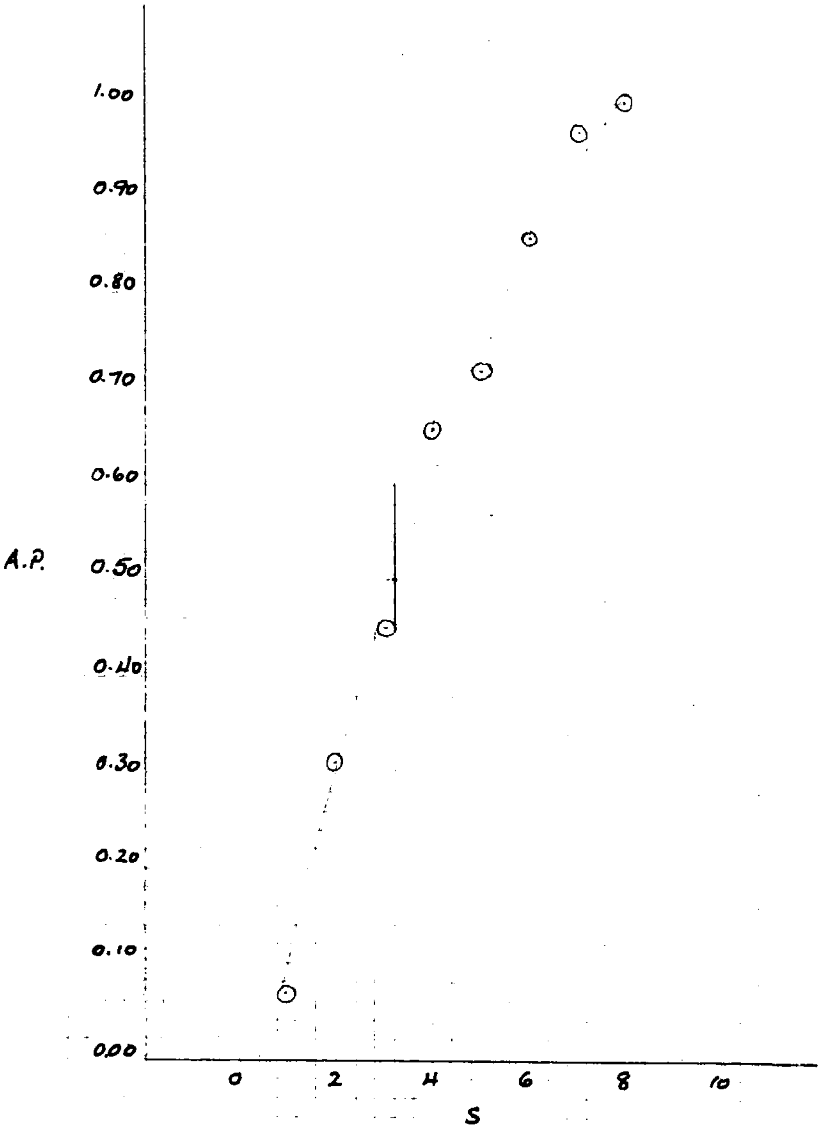
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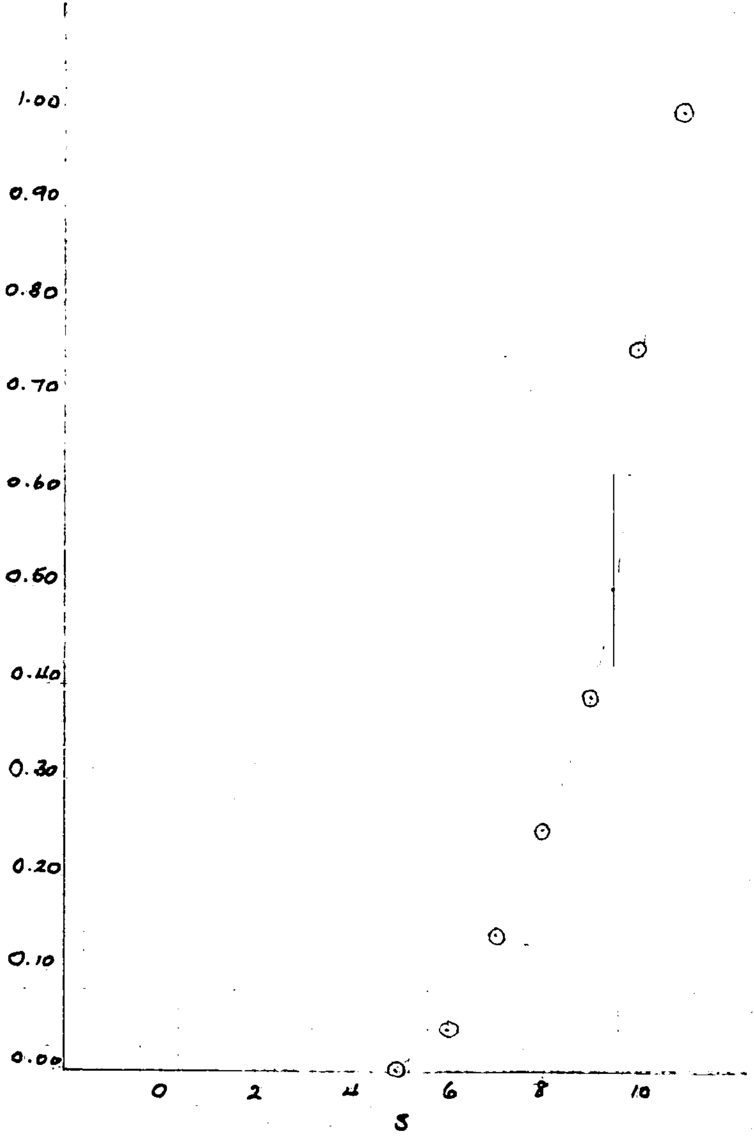
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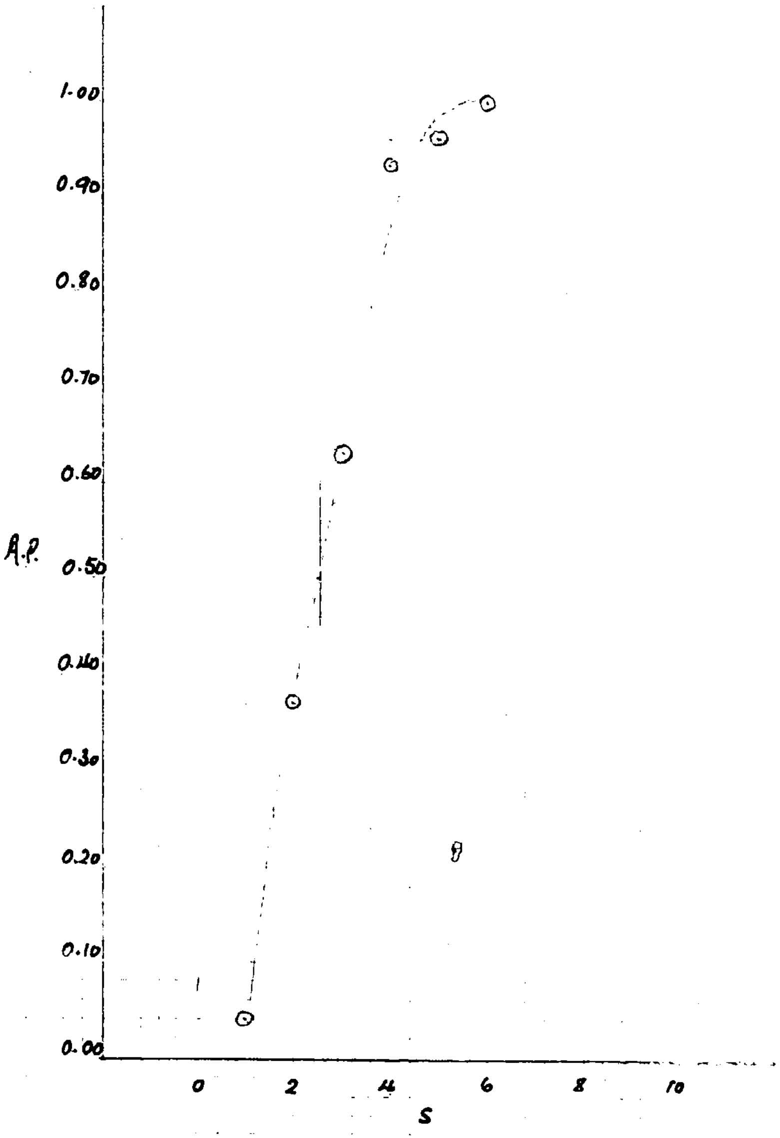
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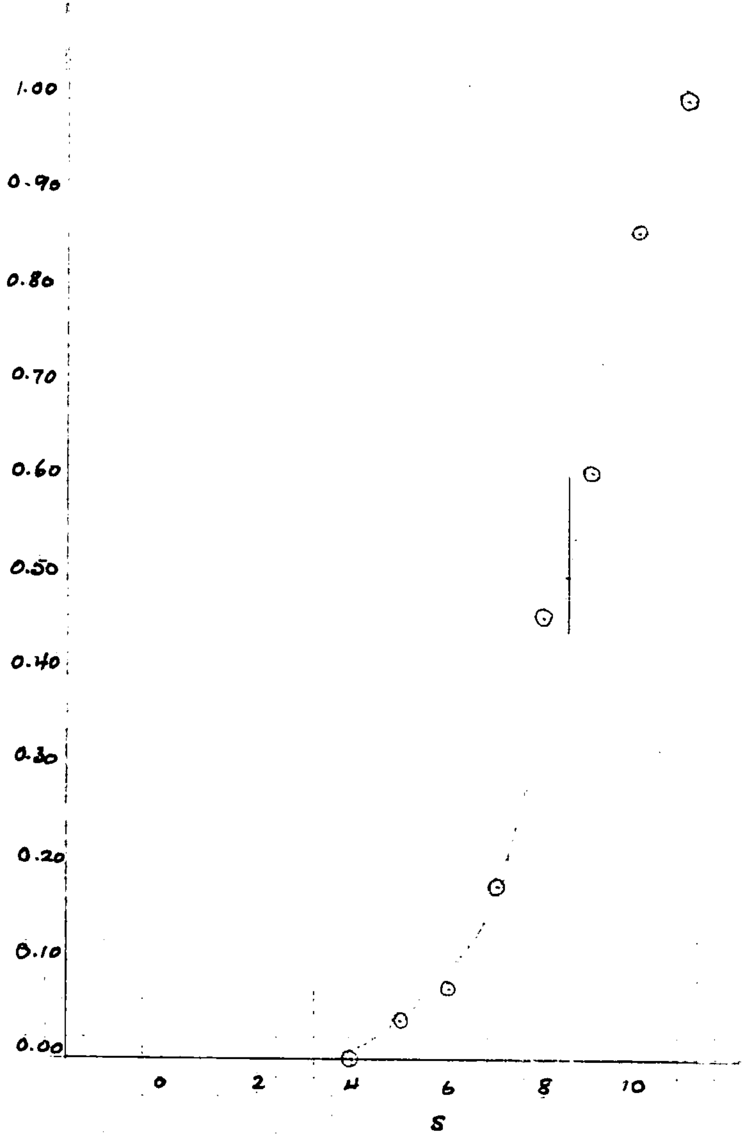
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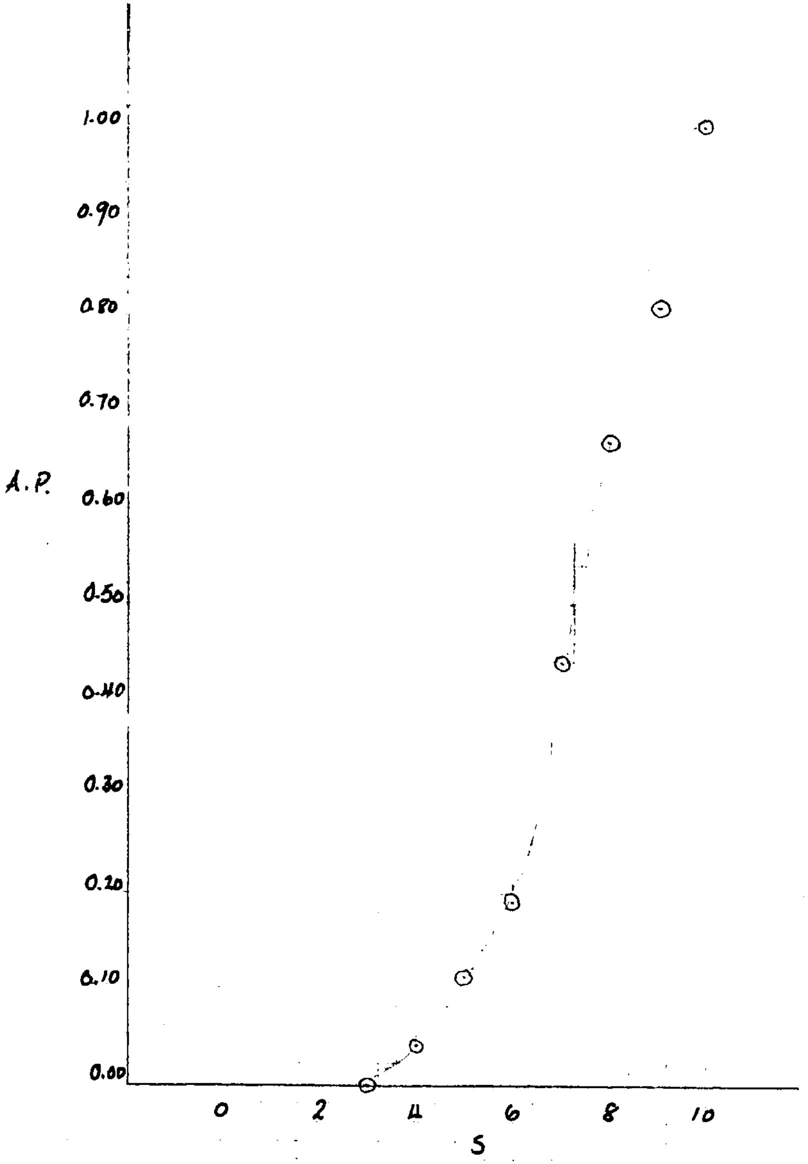
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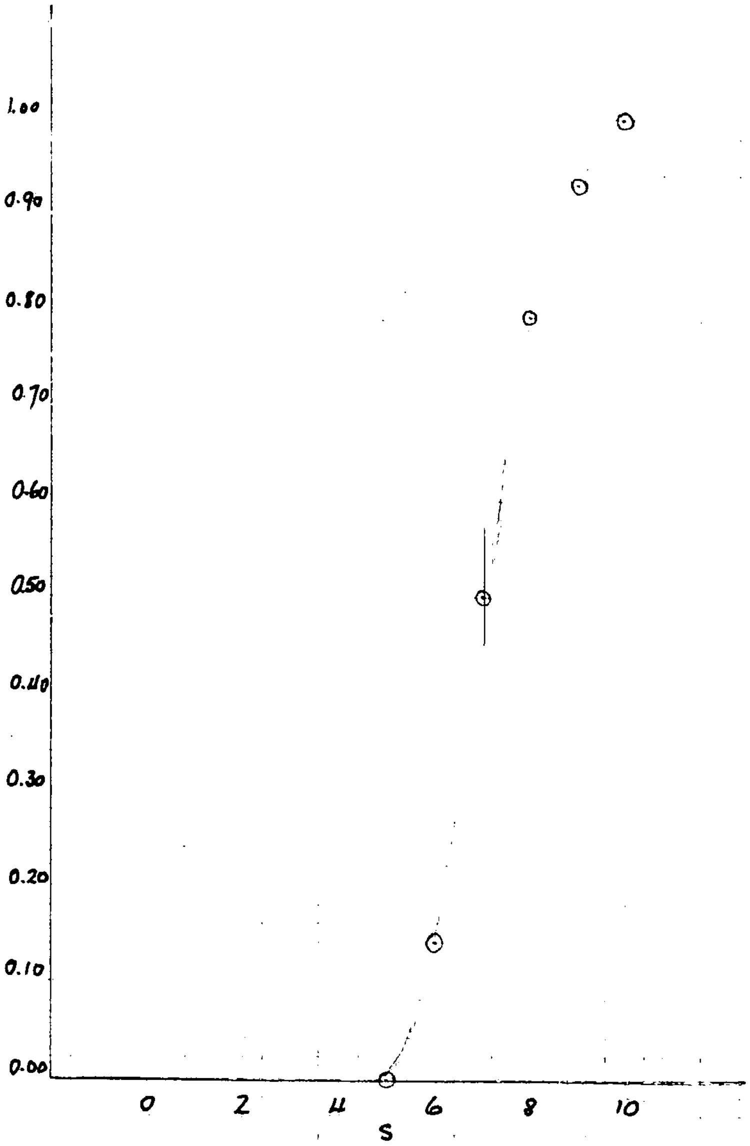
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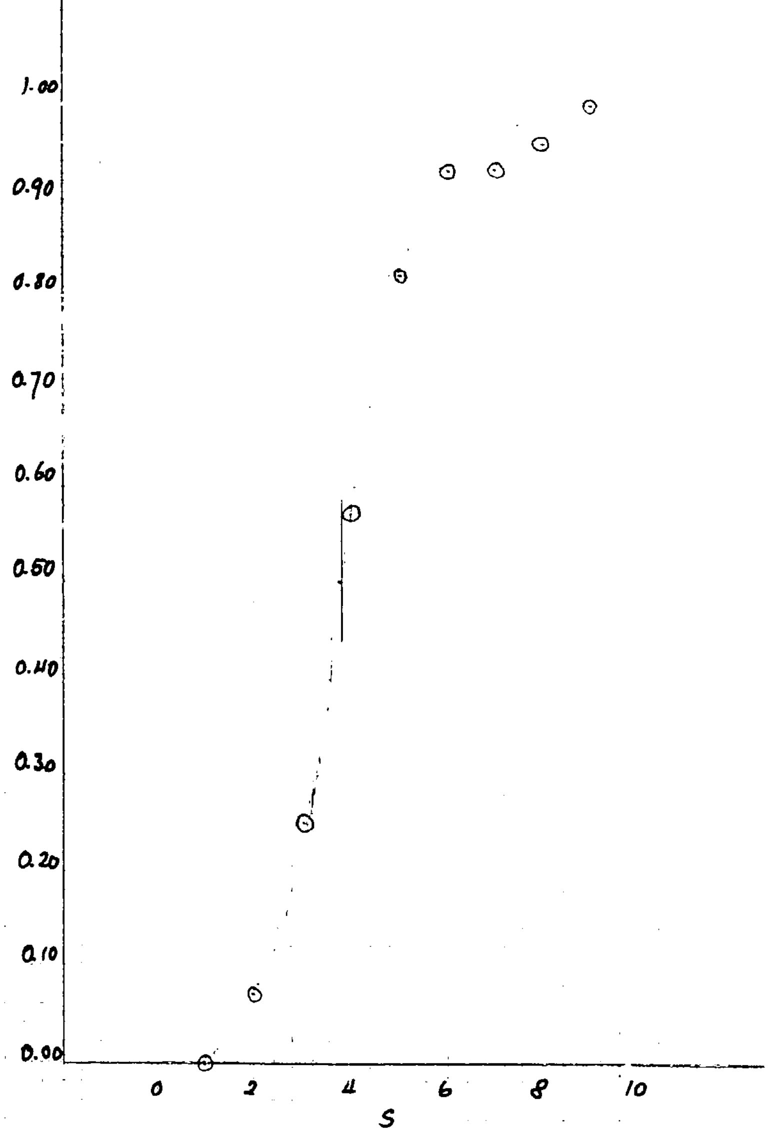
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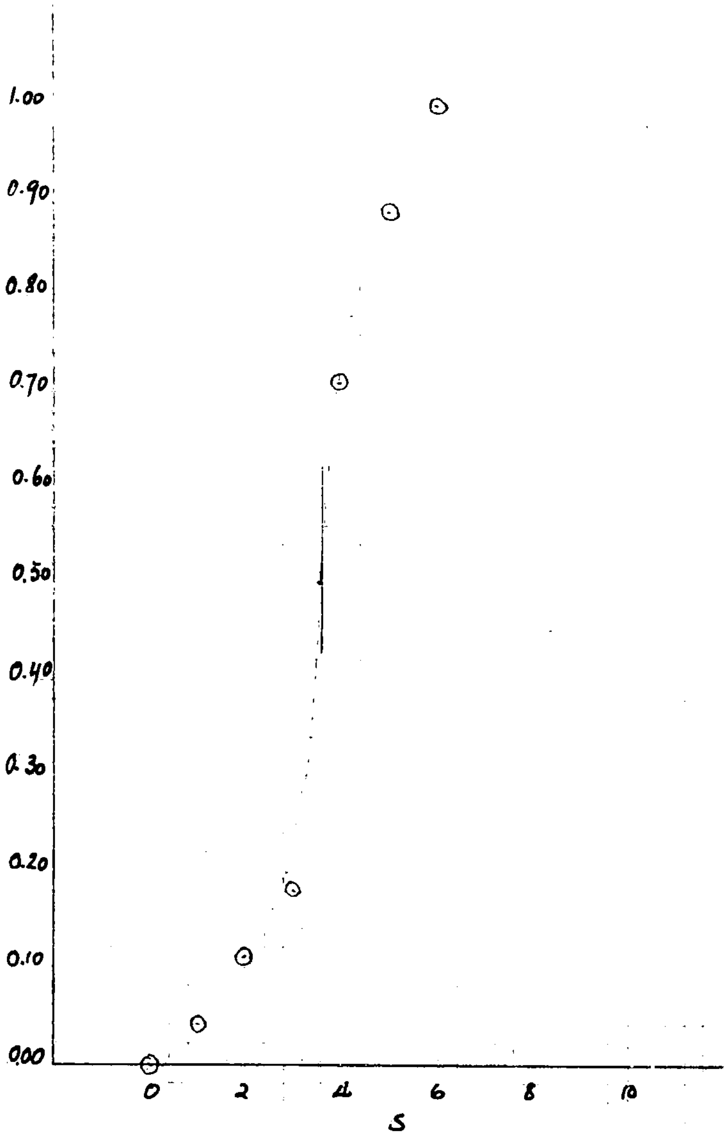
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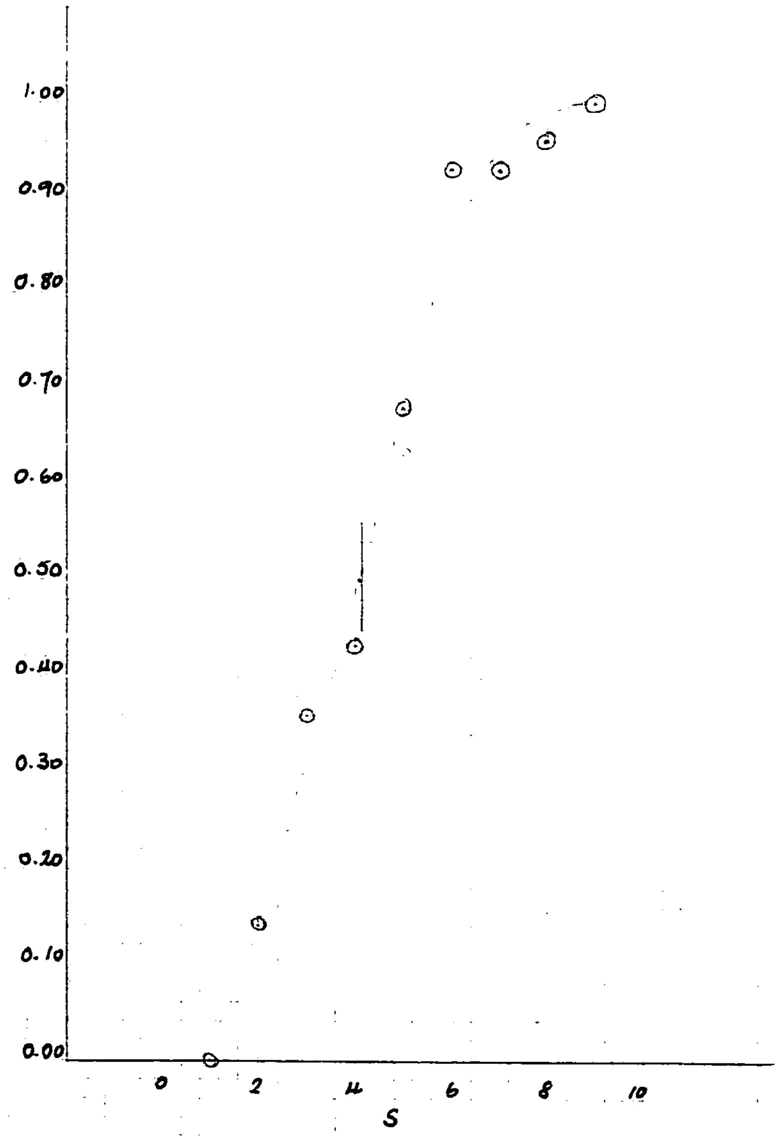
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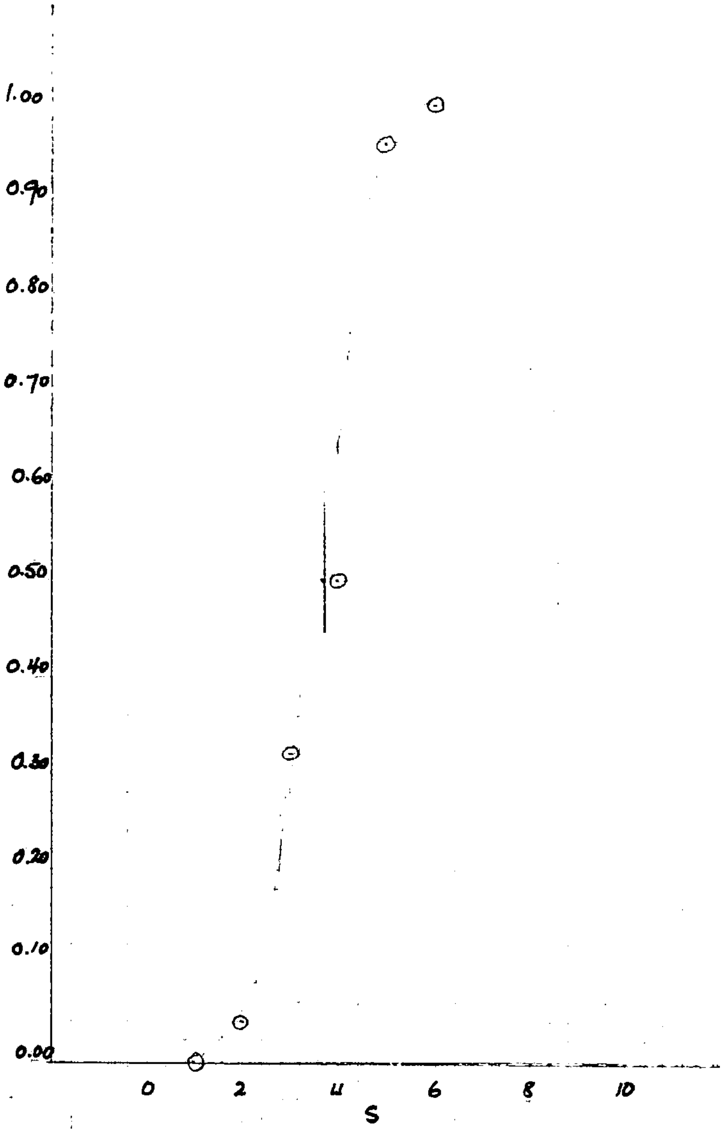
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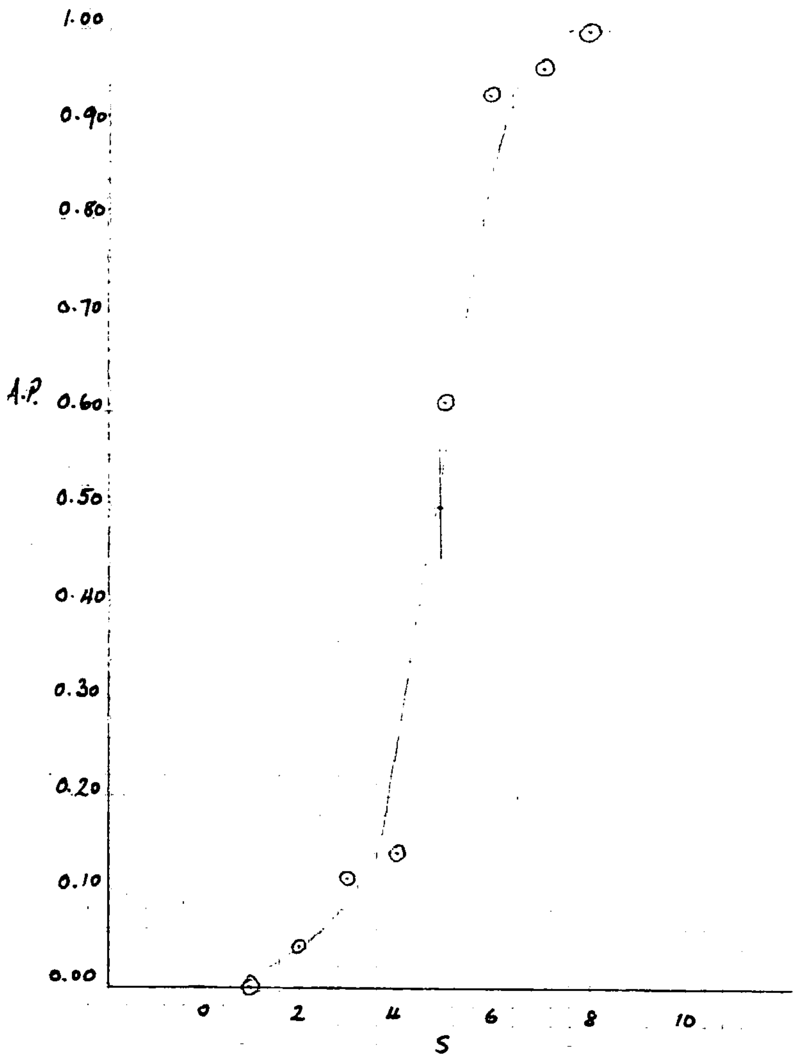

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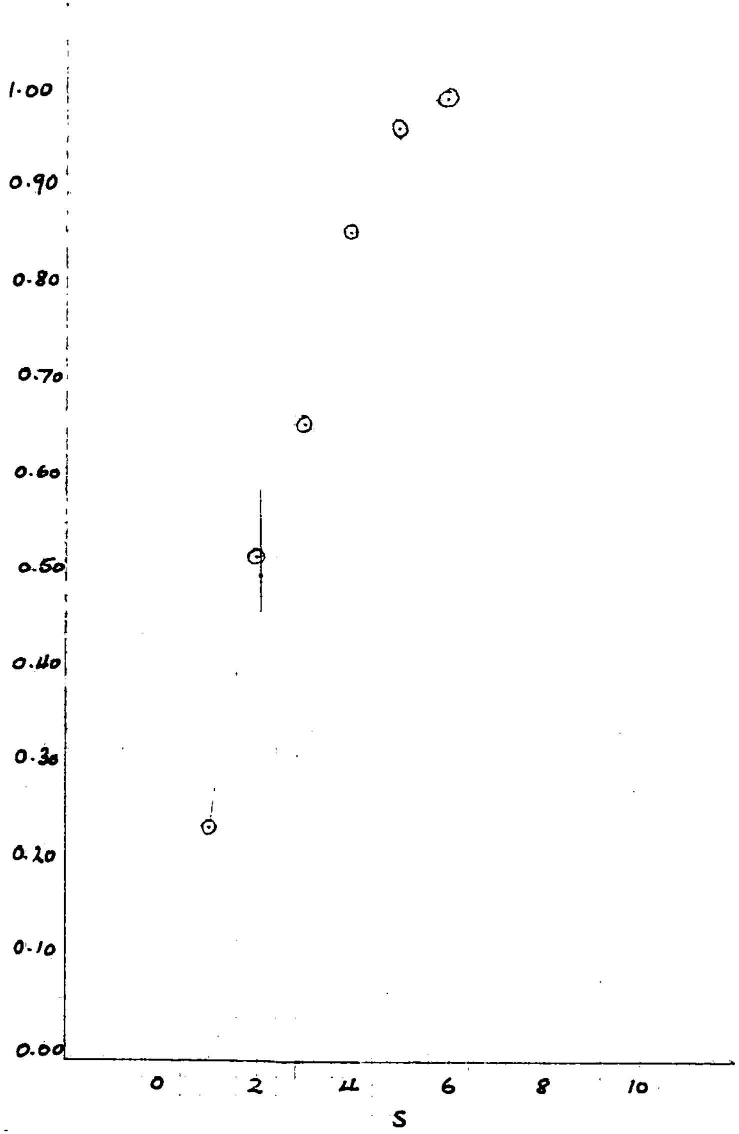

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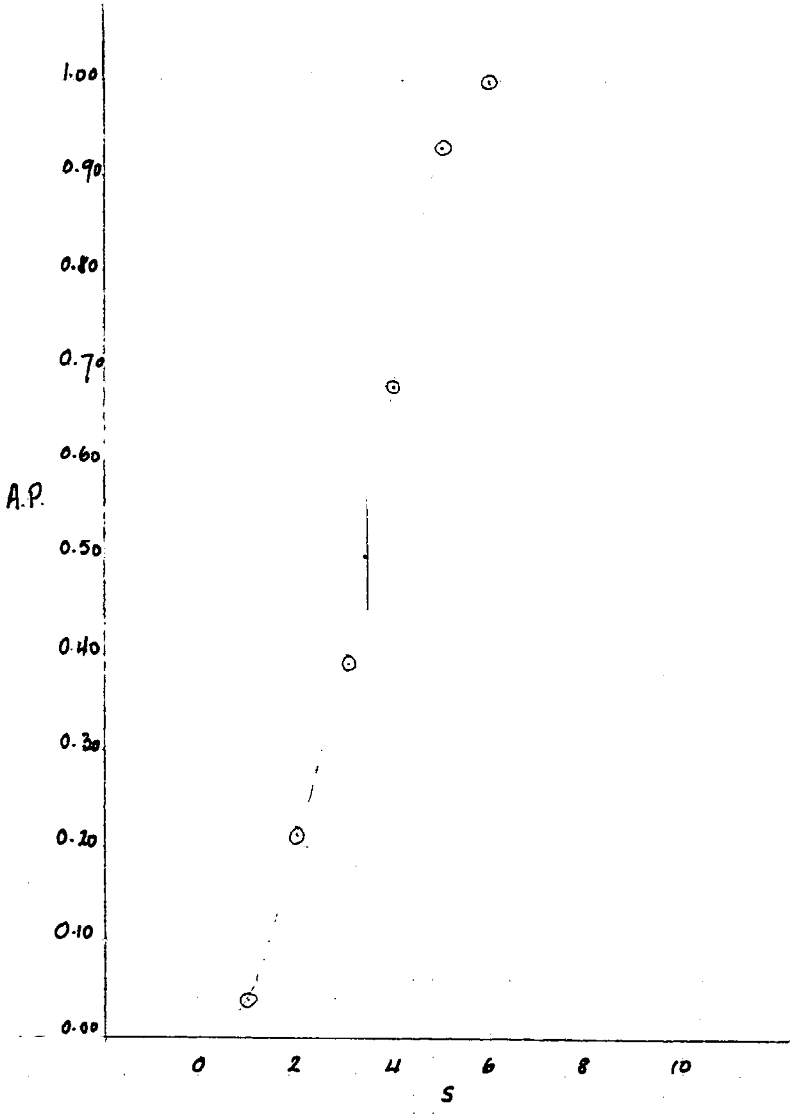
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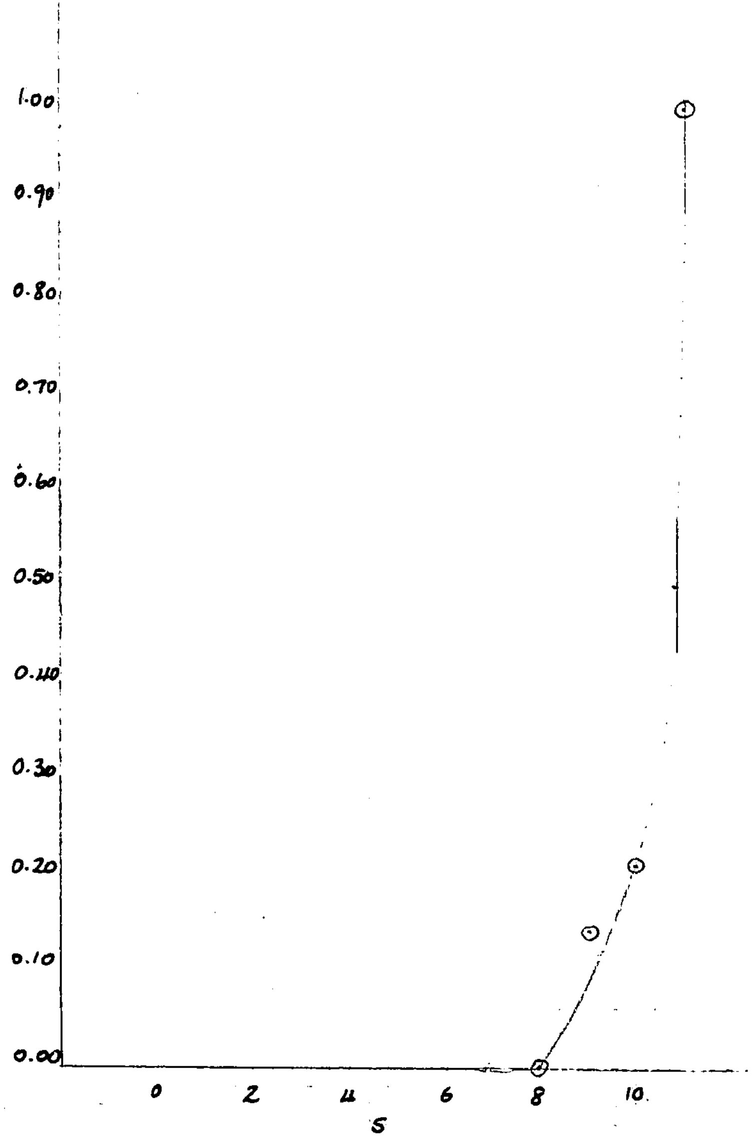
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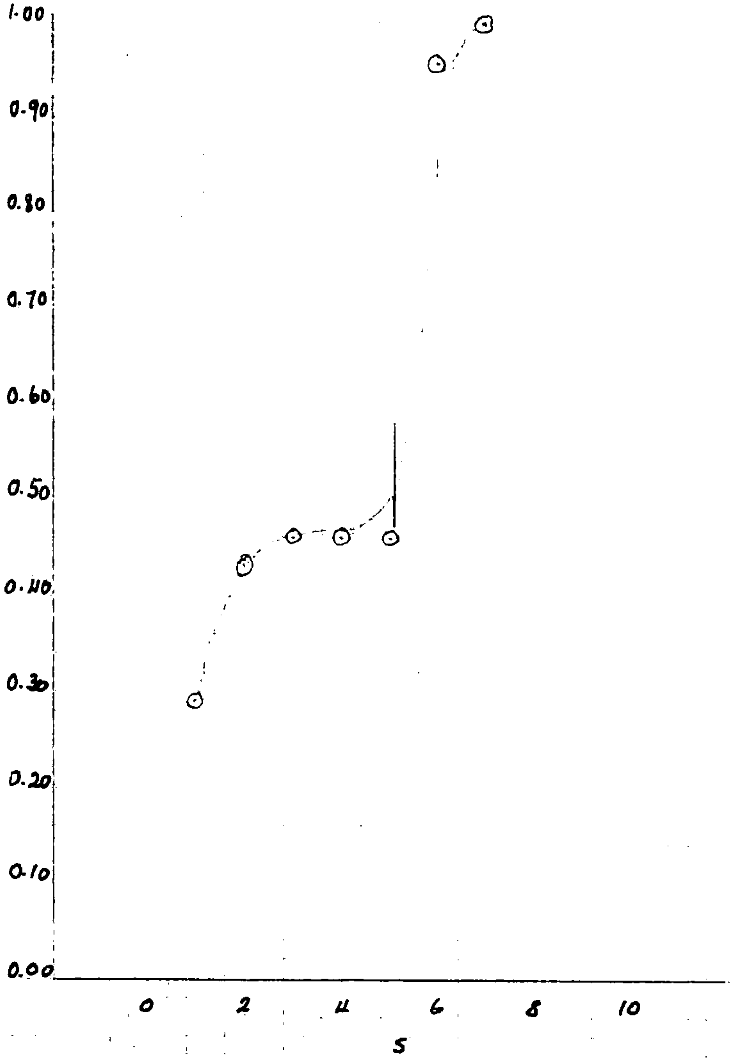
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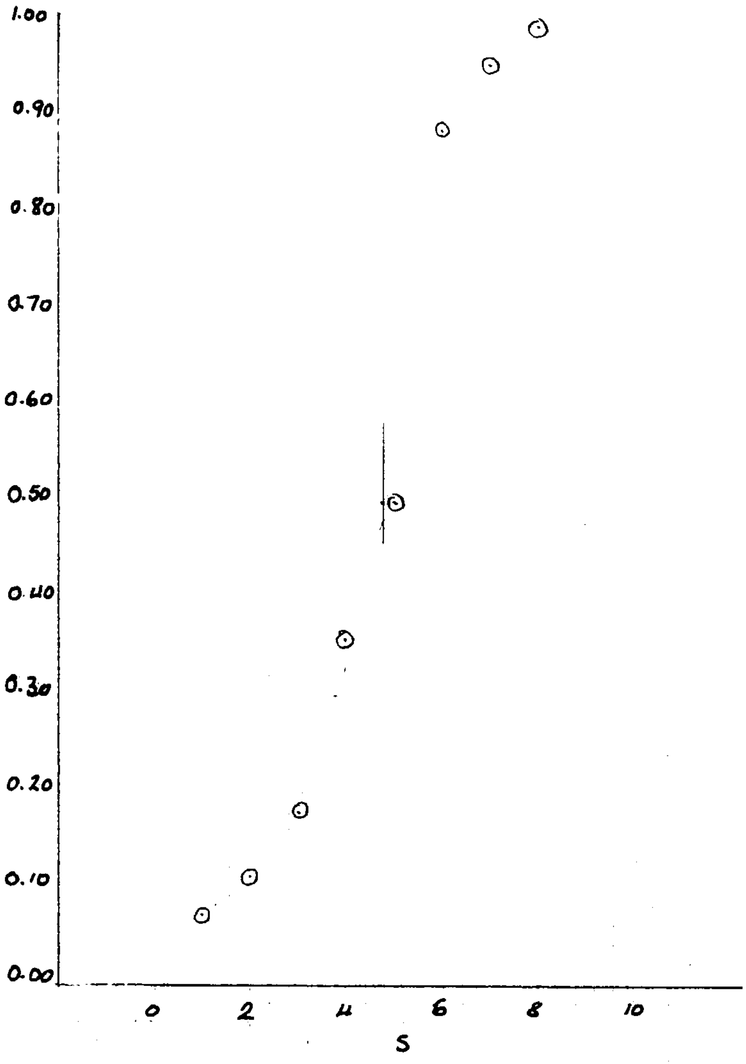
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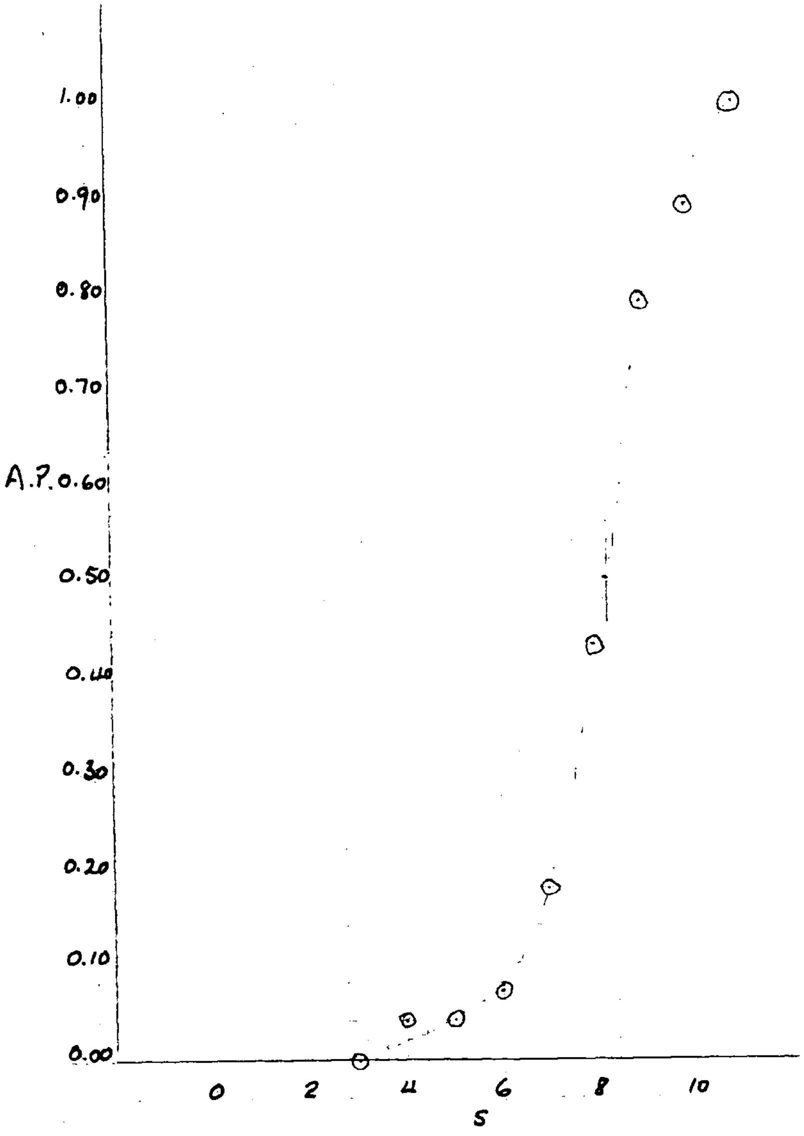
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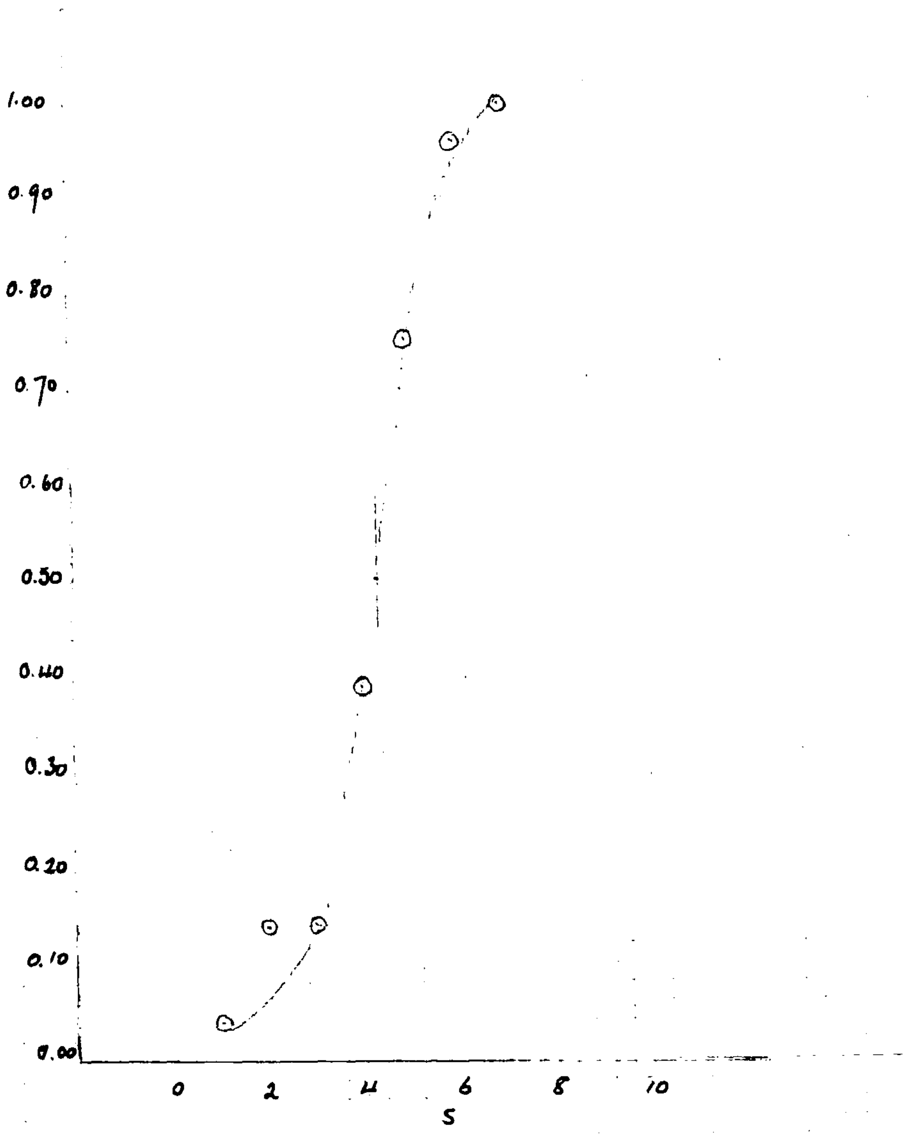
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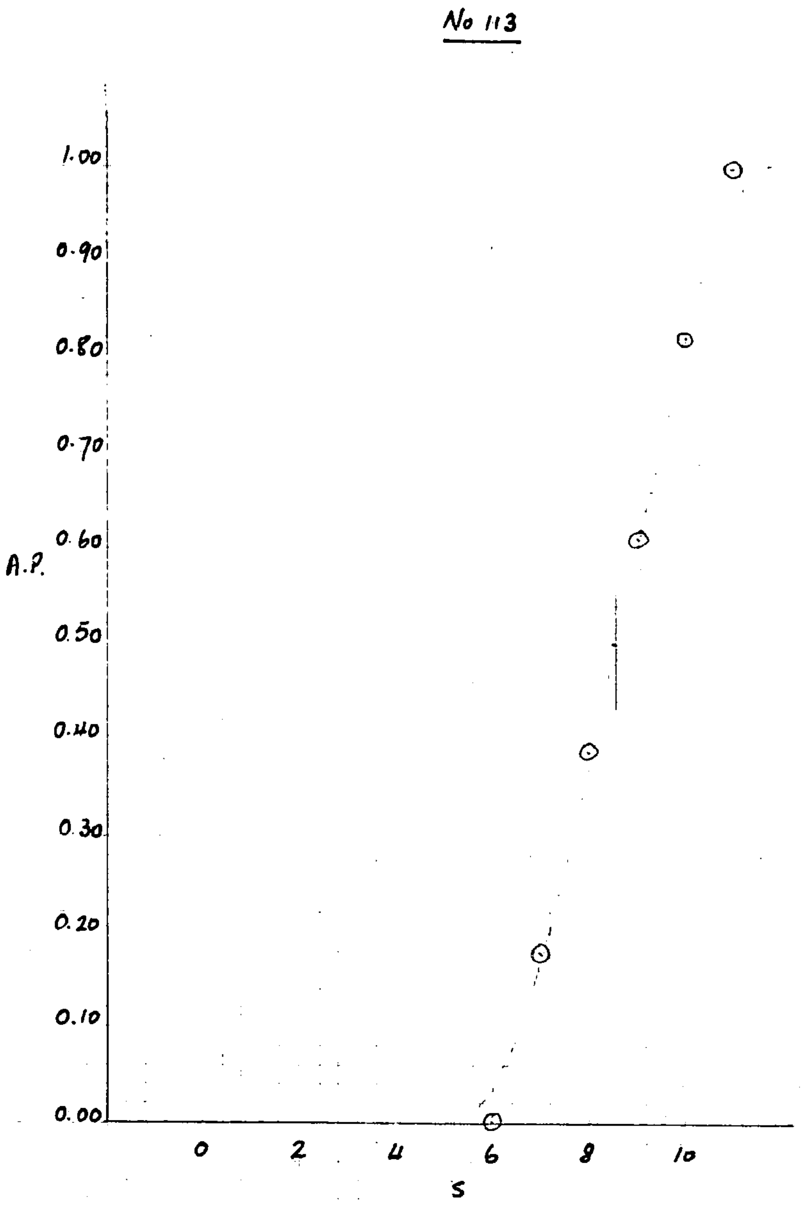
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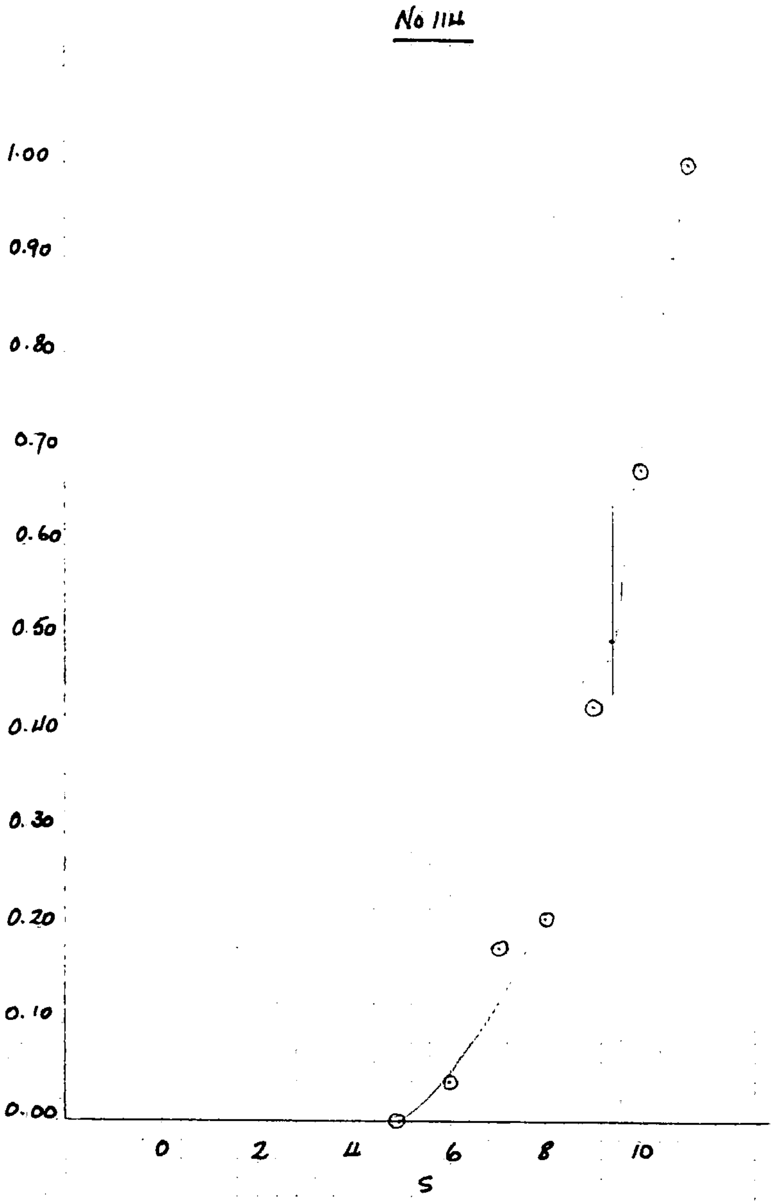
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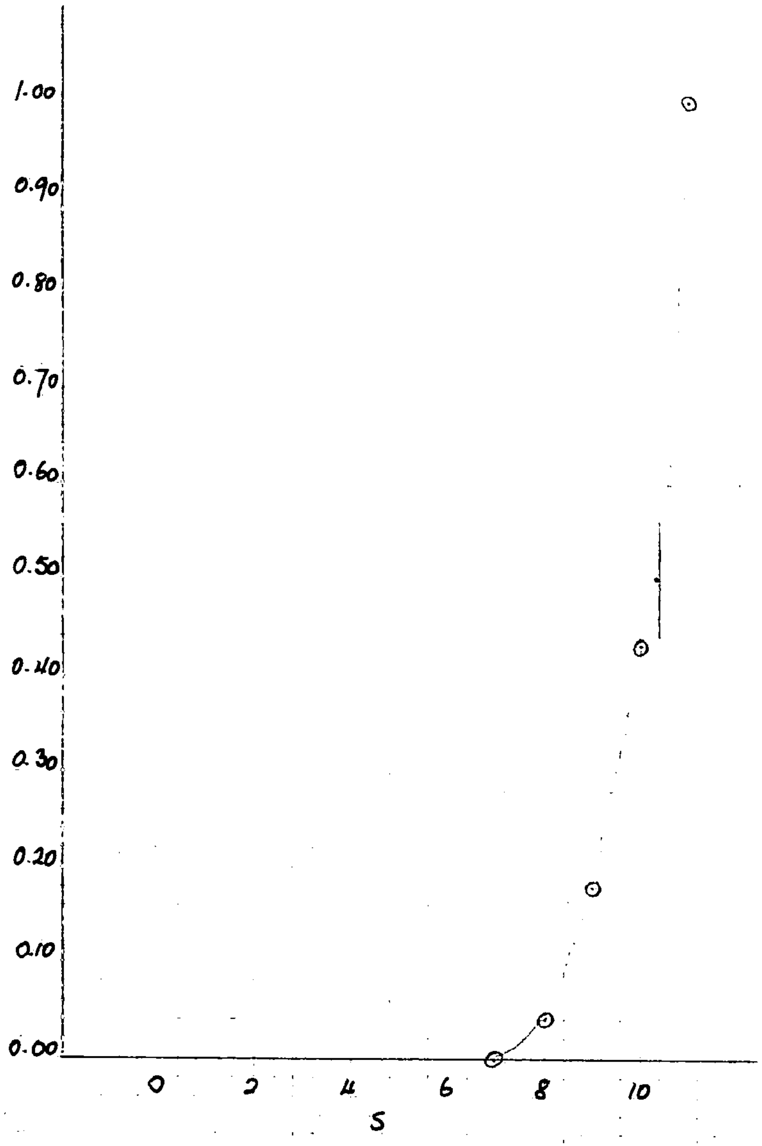

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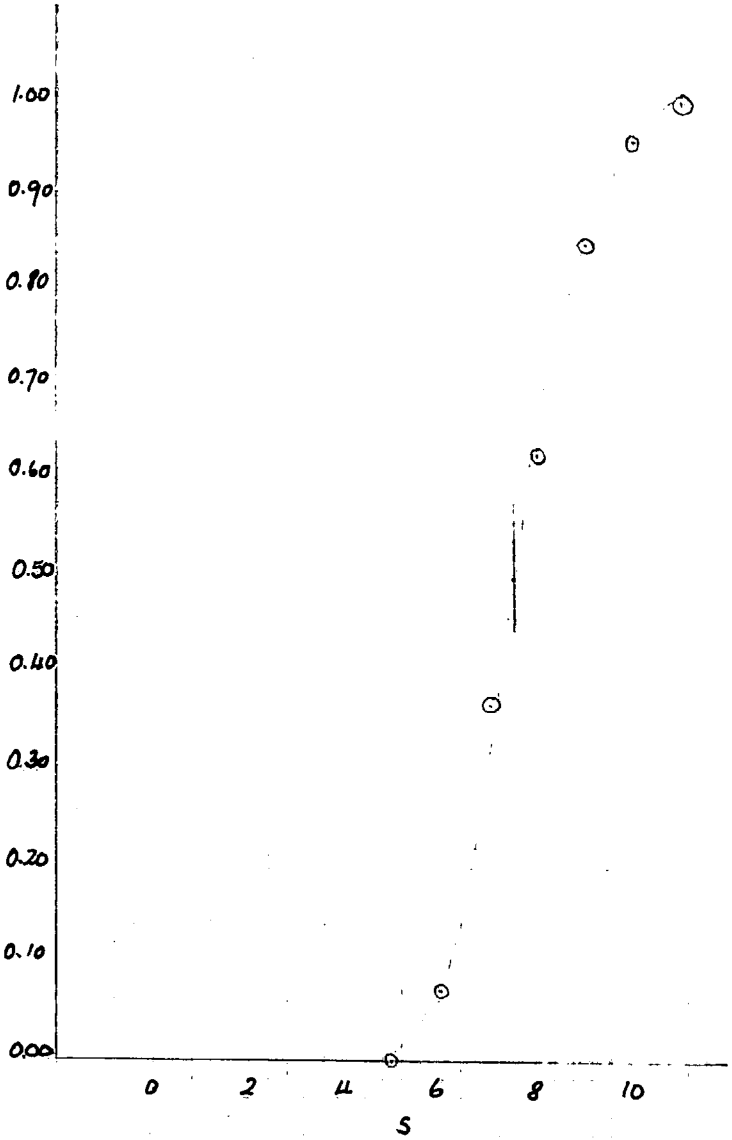

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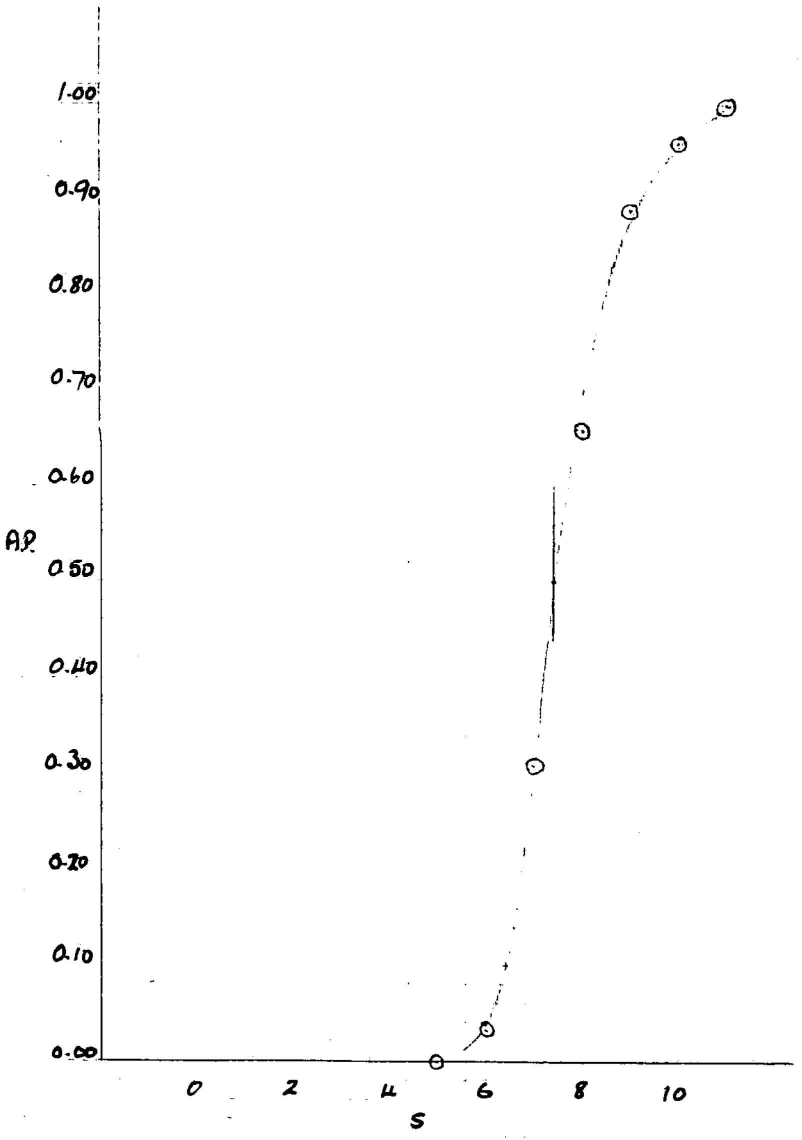
No 117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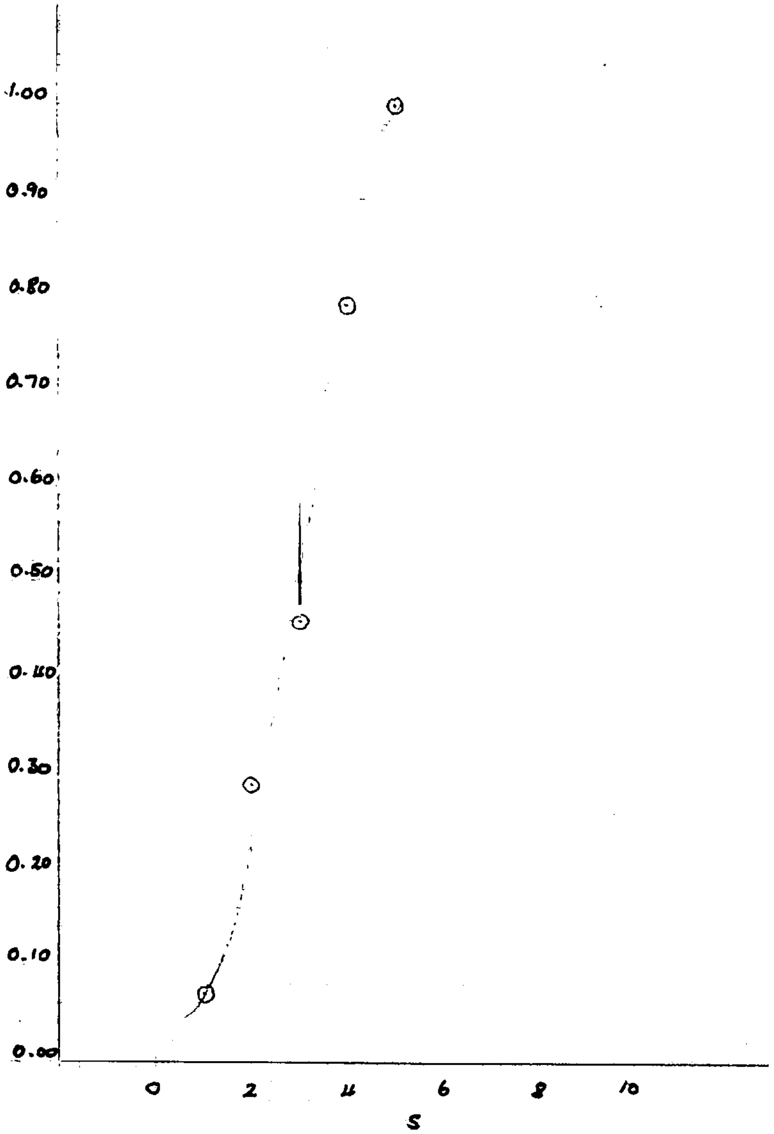
No 118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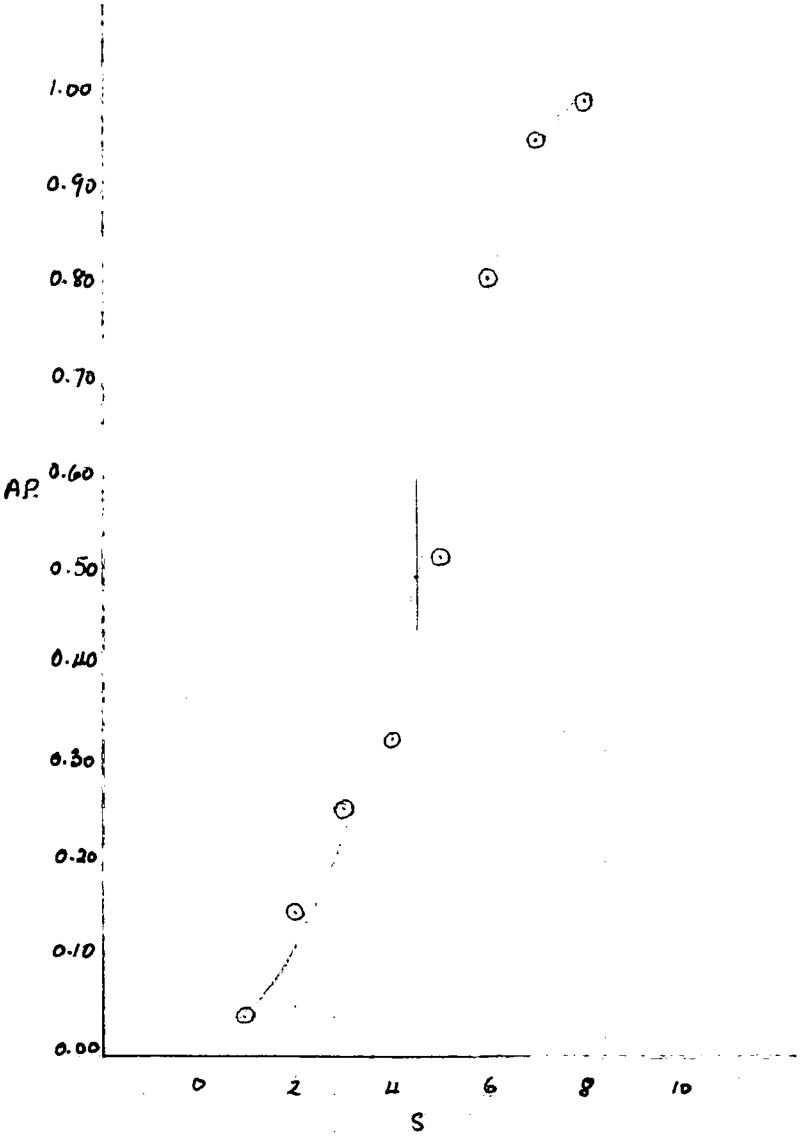
No. 119.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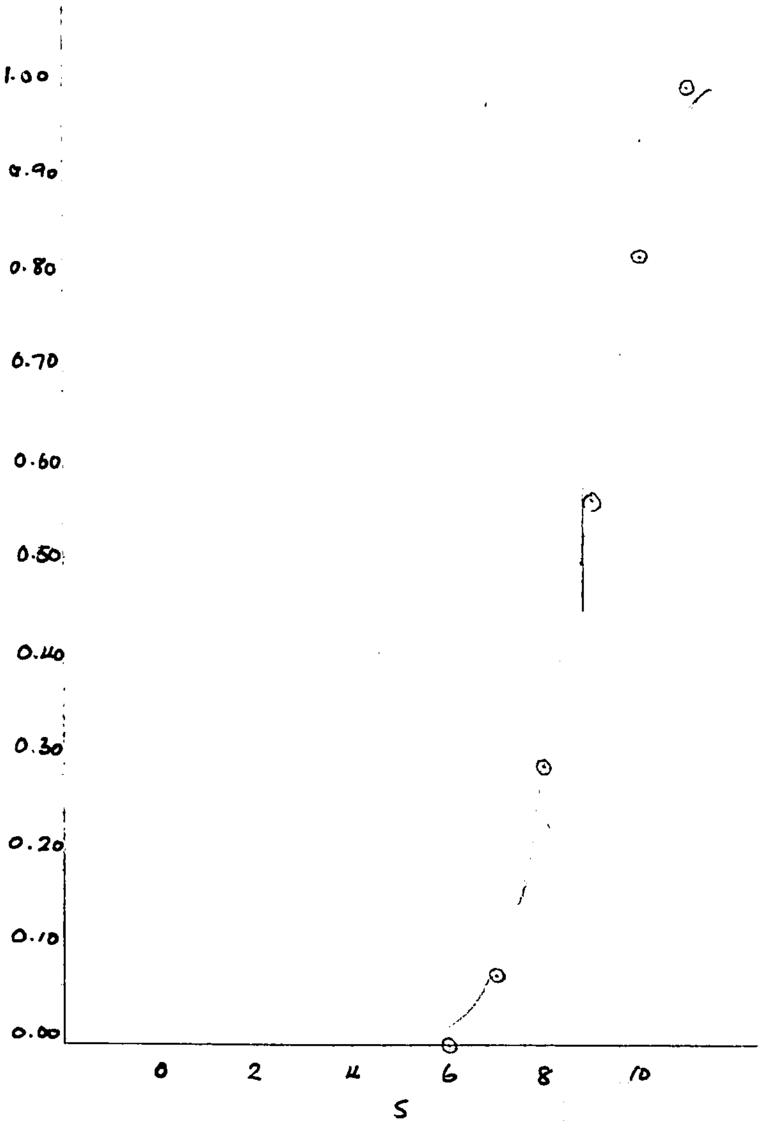
No 120.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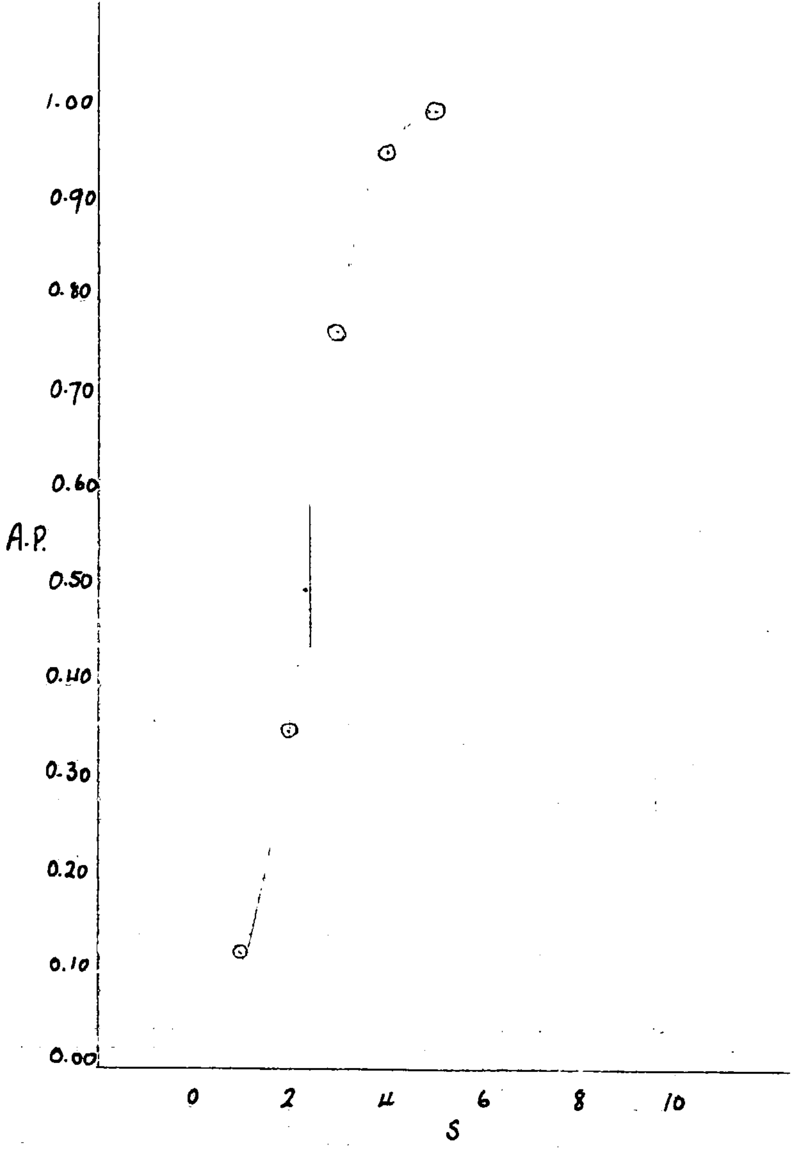
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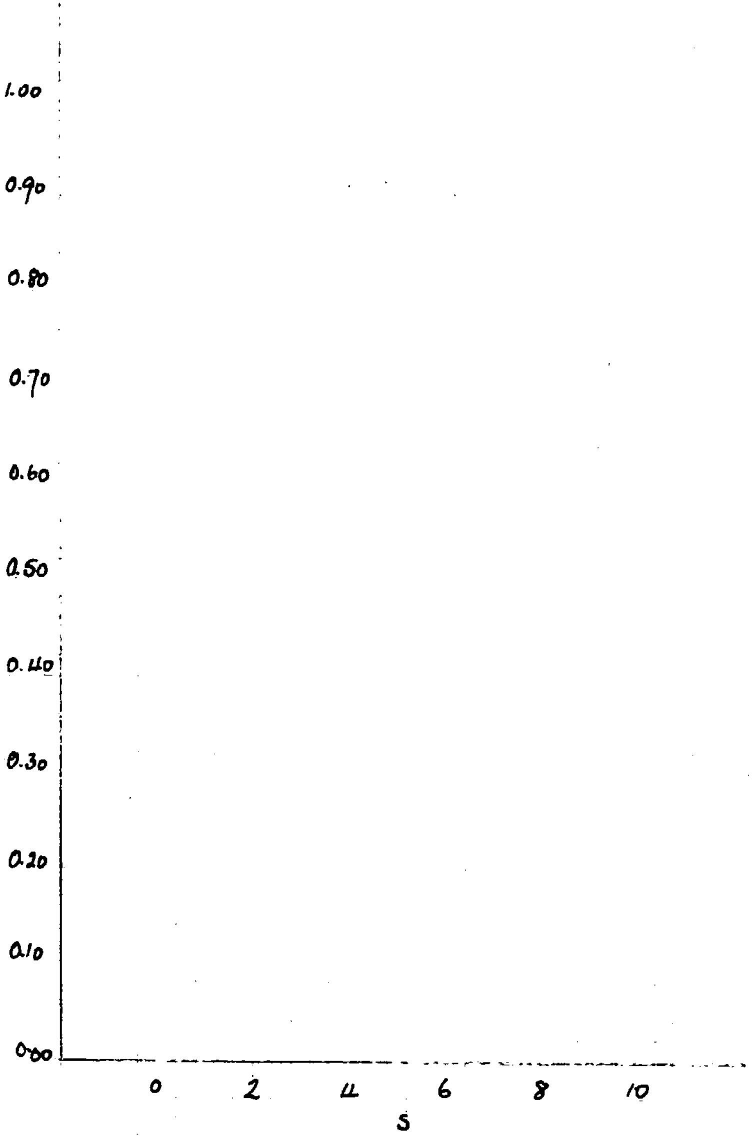
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S

Appendix F

As well as the original statement number, new sub-numbers are given as are s and Q values.

FORM A

Sub-No.	State	s	Q	
1	16	0.1	1.8	In modern times, science is the most important occupation in life.
2	38	1.1	1.6	Without scientists, the human race would still be almost as primitive as men of the stone-age.
3	88	1.2	2.0	Science means progress.
4	121	2.3	1.6	Science sharpens the mind.
5	47	2.5	1.6	It is interesting to work in a laboratory with scientists.
6	50	3.1	1.4	Science leads to an interesting job.
7	36	3.3	1.5	The things I have learned in my science lessons have been useful in my hobbies.
8	37	4.0	1.8	Being a scientist you learn about the Earth and its ways.
9	31	4.1	1.4	If I were a scientist I would not be using the same equipment all the time like a factory worker.
10	12	5.2	1.1	I might like science when I'm older.
11	57	5.6	1.5	Science required a flair for mathematics.
12	60	6.2	1.5	Those who find mathematics difficult can't do science.
13	32	6.3	2.0	Lots of things in science just can't be seen and you just have to believe that things are there and imagine what they look like.
14	100	7.0	1.7	Science is difficult to learn.
15	27	7.4	1.4	I would not like to do all the calculating and measuring involved in a scientist's work.
16	18	8.1	1.6	I don't see why anyone who does not need science for the job he wants should have to take science(s).
17	111	8.1	1.6	Today, the scientist is not held in very high esteem.
18	66	9.5	1.4	Science is uninteresting.
19	86	9.5	1.9	In many ways, science can be a curse on mankind.

Sub-No.	State	s	Q	
20	115	10.3	1.5	Science and its inventions have caused more harm than good.
21	68	10.5	0.6	Science is a waste of time.
				FORM B
1	33	0.7	1.8	Science is the future.
2	25	1.0	1.8	Scientists make the world a better place to live in.
3	55	1.7	1.8	Science has made our high standard of living possible.
4	28	1.8	1.4	Science is an important thing in our lives.
5	97	2.5	1.6	Science helps people to think along logical lines.
6	30	2.5	1.7	I would like to be a scientist because I like to use equipment.
7	42	3.3	1.3	Science will be very useful as it helps to know how things work in the house.
8	17	3.5	1.8	Scientists are repected members of the community.
9	112	4.3	1.7	Scientists are wrongly blamed for the troubles of the world.
10	105	4.9	1.3	My parents like me to know about science.
11	15	5.6	1.2	Scientists are born not made.
12	56	5.7	0.9	Sciences are about facts and substances.
13	48	6.6	2.0	The work in science is hard.
14	74	6.9	1.8	I sometimes wish I was better at science but I don't really think it matters.
15	117	7.5	1.5	A scientist's job is a lonely one.
16	24	7.9	1.4	To become a scientist means too much study.
17	22	8.5	1.8	There is too much science in my timetable.
18	120	8.8	1.8	A scientist is usually uncultured.
19	96	9.5	2.0	Science is cold and impersonal.
20	71	9.9	1.4	I find science boring.
21	68	10.5	0.6	Science is a waste of time.

Appendix G

Simulation of Complex (Multiple-Foci) Attitudes.

It might be expected that the model with one focus is too simple. A more complex model can be demonstrated by a simulation experiment.

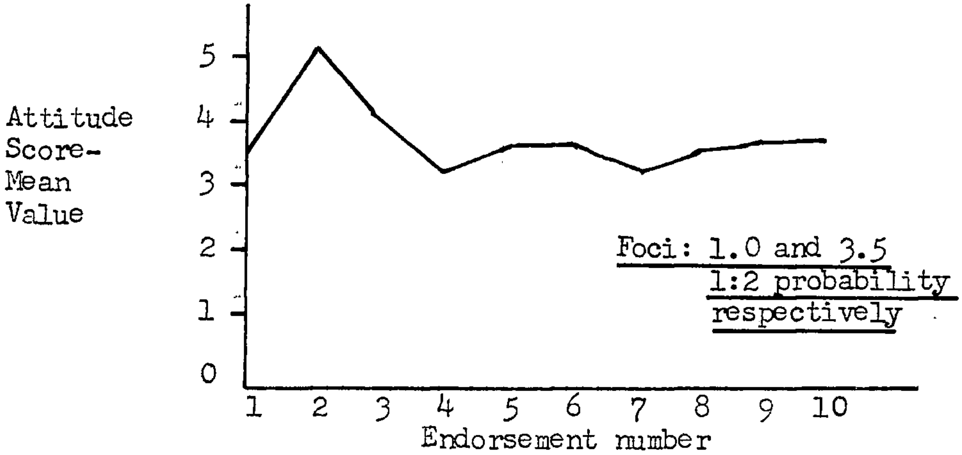
To illustrate the method, consider an attitude comprising two foci, one of which gives twice the probability of endorsement of the other. In an attitude test, such as the one used here, it consists of several aspects of science, for example, items of belief-disbelief and items of like-dislike as described by Katz (19). This would allow the expression of two or more foci. One could be more strongly held than the other and this is represented by the one with the greater probability. Suppose the two foci to be at 1.0 and 3.5 on the 0 - 11 scale. The 3.5 is to be the one with twice the probability of the other.

By taking 40 equally spaced statements of separation 0.28, (— 11/40), and casting a die such that 1 and 6 indicate that focus 1.0 is endorsed while 2, 3, 4 and 5 indicate that focus 3.5 is endorsed, the higher probability is given to the latter attitude. In this way, the movement of the mean can be followed. As the die indicates each focus, statement values on either side are added into the sequence, these being the more probable according to the simple model. Thus, a typical sequence might be;

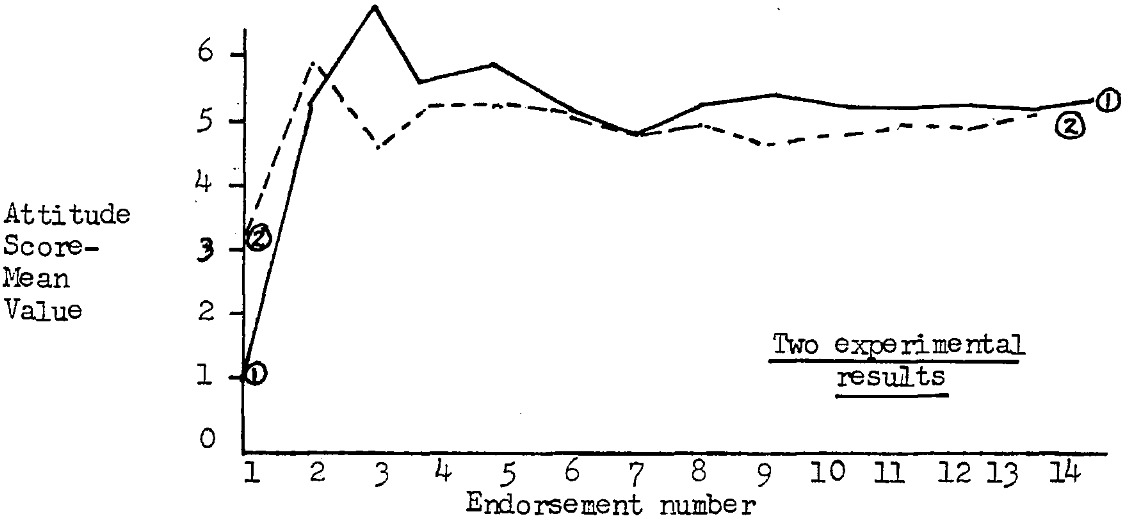
3.5, 3.5 - 0.28, 1.0, 3.5 + 0.28, 1.0 - 0.28, 1.0 + 0.28,
3.5 - 2(0.28), 3.5 + 2(0.28).

As before, each focus has a stable region but one 'saturates' first (1.0 in this case) and drifts. This has its effect on the overall mean. The method allows two foci to be combined, allowing them to eventually drift. It assumes, as before, a 'perfect' method of endorsement in which statements nearest to and on either side of each focus are selected first, in this case according to the predetermined probability.

The graph shows the movement of the mean in an actual trial of this sort.



Many actual results displayed a remarkable similarity to this form, for example;



Most observed results could be explained according to the single focus or the multiple foci model. In that latter case, as few as two foci were usually sufficient. Graphs beginning with negative slopes are demonstrated by having the more negative attitude leading.

From the observed results given, it can be seen that by about the tenth endorsement, the mean has begun to stabilise. This was true of the majority of cases.

Appendix H

FULL NAME ______________________________ AGE _____ years ______ months

Instructions

1. Read through all the statements.
2. Choose the TEN that you most agree with and put a tick (✓) on the line next to each one.
3. Look at the ten you have just chosen and put 1 next to the one you agree with most. Then put 2 next to the one you agree with next and so on until all ten have numbers, one to ten.
4. When this has been done, at the end make a list of the school subjects you prefer, beginning with the one you like most and ending with the one you like least.

PHYSICS

____I don't see why anyone who does not need physics for the job he wants should have to take physics.

____In modern times, science is the most important occupation in life.

____I might like physics when I'm older.

____Physics is difficult to learn.

____The things I have learned in my science lessons have been useful in my hobbies.

____Those who find mathematics difficult can't do physics.

____Being a scientist you learn about the Earth and its ways.

____Lots of things in physics can't be seen and you just have to believe that things are there and imagine what they look like.

____Science means progress.

____In many ways science can be a curse on mankind.

____Science requires a flair for mathematics.

____It is interesting to work in a laboratory with scientists.

____If I were a scientist I would not be using the same equipment all the time like a factory worker.

____Physics is uninteresting.

____Physics sharpens the mind.

____Science and its inventions have done more harm than good.

____Today the scientist is not held in very high esteem.

____I would not like to do all the calculating and measuring involved in a scientist's work.

____Physics leads to an interesting job.

____Physics is a waste of time.

____To become a scientist means too much study.

____Science is the future.

____My parents like me to know about science.

____I sometimes wish I was better at physics but I don't really think it matters.

____Science will be very useful as it helps to know how thing work in the house.

____Sciences are about facts and substances.

____Scientists make the world a better place to live in.

____Scientists are respected members of the community.

____The work in physics is hard.

____Physics is cold and impersonal.

____A scientist is usually uncultured.

____Scientists are born not made.

____Science helps people think along logical lines.

____Scientists are wrongly blamed for the troubles of the world.

____I find physics boring.

____There is too much physics in my timetable.

____A scientist's job is a lonely one.

____I would like to be a scientist because I like to use equipment.

Put your list of school subjects in order on the next side.

Appendix I

Validity from Sixth-Form Results

The scores obtained from the 66 arts and science pupils of the sixth-form were arranged into the following frequency distribution table;

Attitude score	Number of sixth-formers in each group	
	ARTS	SCIENCES
0.0 - 0.4		
0.5 - 0.9		
1.0 - 1.4		3
1.5 - 1.9		2
2.0 - 2.4		8
2.5 - 2.9	5	9
3.0 - 3.4	3	6
3.5 - 3.9	6	1
4.0 - 4.4	5	3
4.5 - 4.9	3	1
5.0 - 5.4	3	0
5.5 - 5.9	3	1
6.0 -6.4	1	
6.5 - 6.9	1	
7.0 - 7.4	2	
7.5 - 7.9		
8.0 - 8.4		
⋮		
Σ	32	34

For which the Overall Median Score $\doteq$ 3.3

Using the median test, the above sample was split into groups having attitude scores above and below the median in arts and in science specialists. The 2 x 2 table was thus constructed and χ^2 calculated to test if the numbers in the cells differed between arts and sciences.

	Above Mdn.	Below Mdn.	Σ
ARTS	7	24	32
SCIENCES	26	8	34
Σ	33	33	66

χ^2 = 15.9 with 1 d.f.

Since it is expected that the median of the sciences group will be less than the median of the arts group (i.e. more favourable), a one-tailed test is possible.

A χ^2 as large as this would occur by chance alone in $p < \frac{1}{2}(0.001)$ i.e. $p < 0.0005$ of occasions.

Therefore, <u>The sciences group is significantly more favourable in attitude to sciences than the arts group.</u>

which is an indication that the test is valid.

Appendix J

Subject- Preference Validity: Overall results for Science

The overall sample (eg. Appendix L) was split into those having attitude scores above or below the overall median and, at the same time, ranking science in the first four places (Ranks 1 and 2) or below (Ranks 3 and 4), as explained on p 64.

The median attitude score for the 1 066 results was 3.685.

2 x 2 table showing the number of pupils above and below the median on the attitude scale (score) and the ranking given to science (category)

Score Category	Above Median	Below Median	Σ
Ranks 1 & 2	356	162	518
Ranks 3 & 4	177	371	548
Σ	533	533	1 066

From this were found;

$\chi^2 = 139$ 1 d.f. Very highly significant $(p \ll (0{\cdot}001))$

Contingency coefficient, $c \doteq 0.339$

which indicates that those above the median on the scale, i.e. favourable in attitude, also tend to prefer science, while those below the median do not. This is as expected and is a further confirmation that the test is valid.

Subject- Preference Validity: Results for the physics (Nuffield versus Conventional) Comparison

This process was repeated for the sample used in the Nuffield/conventional physics comparison and the following results were obtained;

2 x 2 table showing number of pupils above and below the median on the attitude to physics scale and the ranking given to physics.

Score Category	Above Median	Below Median	Σ
Ranks 1 & 2	77	22	99
Ranks 3 & 4	27	83	110
Σ	104	105	209

From this were found;

$\chi^2 = 56.1$ 1 d.f. Very highly significant $\left(p \ll \frac{1}{2}(0.001)\right)$

Contingency coefficient C = 0.461

which indicates that those favourable in attitude to physics also prefer it and those less favourable tend to prefer it less. This is a satisfactory indication that the modified test was also valid and was testing what it was intended to do.

Particular frequency distributions are presented later.

Appendix K.

The test had been constructed in a split-half form so that two scores could be obtained, one on Form A, the other on Form B. The correlation between these scores gives an indication of the reliability of the test.

The scores are set out in correlation tables, each cell being one unit wide for each Form. The Spearman rank correlation coefficient, r_s, was calculated for each year and was corrected by the Spearman-Brown Prophecy formula to give the overall reliability. The significance of r_s was obtained.

Year 0 represents the junior school sample, Year 1, the secondary first year sample and so on to Year 4. There is also a table for the Nuffield versus Conventional test.

Generally, the reliabilities were found to be acceptable ($r \geqslant 0.80$) but that of the junior sample was lower.

The notation is repeated again for convenience;

$$r_s = \frac{\sum x^2 + \sum y^2 - \sum d^2}{2\sqrt{\sum x^2 \sum y^2}} \qquad \text{where} \sum x^2 = \frac{N^3 - N}{12} - \sum T,$$

similarly for $\sum y^2$.

$$T = \frac{t^3 - t}{12}$$ where t = number tied in any one group.

$\sum d^2$ = difference squared between corresponding ranks.

N = number of observations.

$\underline{t}$ = Student's t statistic. d.f. = degrees of freedom.

p = probability. r = reliability.

Table of Form A score against Form B score for reliability correlations.

Form B score (Y)

Form A score (X)

Year 0	0.0-0.9	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	Σ	Joint Rank
0.0 - 0.9												
1.0 - 1.9				1							1	1
2.0 - 2.9		1	25	22	9						57	30
3.0 - 3.9		1	12	22	11	2					48	82½
4.0 - 4.9			1	4	6	2	1				14	113½
5.0 - 5.9					1						1	121
6.0 - 6.9								1			1	122
7.0 - 7.9						1					1	123
8.0-8.9												
9.0-9.9												
Σ		2	38	49	27	5	1	1			123	
Joint Rank		1½	21½	65	103	119	122	123				

From which the following were found;

$$\frac{N^3-N}{12} = 155062 \qquad \Sigma y^2 = 143367 \qquad \Sigma x^2 = 130195$$

$$\Sigma d^2 = 165849$$

$$r_s = 0.394$$

Significance: t = 4.8 121 d.f. which is highly significant, $(p < 0.001)$, so Form A correlates significantly with form B. (The correlation is positive.)

The Spearman-Brown Prophecy formula gives the reliability

r = 0.57 for the whole test.

Table of Form A score against Form B score for reliability correlations.

Form B score (Y)

Form A score (X)

Year 1.	0.0-0.9	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	Σ	Joint Rank
0.0 - 0.9												
1.0 - 1.9												
2.0 - 2.9		5	12	26	2	1					46	23½
3.0 - 3.9		1	26	14	23	4		1			69	81
4.0 - 4.9			4	21	10	11	2				48	139½
5.0 - 5.9			1		11	4	8	2			26	176½
6.0 - 6.9						1	7	3			11	195
7.0 - 7.9							6		5		11	206
8.0 - 8.9							1		1		2	212½
9.0 - 9.9												
Σ		6	43	61	46	21	24	6	6		213	
Joint Rank		3½	28	80	133½	167	189½	204½	210½			

From which the following were found;

$$\frac{N^3 - N}{12} = 80528 2 \qquad \Sigma y^2 = 758910 \qquad \Sigma x^2 = 769670$$

$$\Sigma d^2 = 529702$$

$$r_s = 0.67$$

Significance: $\underline{t} = 13.4$ 211 d.f. which is highly significant, ($p < 0.001$), so Form A correlates significantly with form B. (The correlation is positive).

The Spearman-Brown Prophecy formula gives a reliability

<u>r = 0.80</u> for the whole test.

Table of Form A score against Form B score for reliability correlations.

Form B score (Y)

Form A score (x)

Year 2.	0.0 – 0.9	1.0 – 1.9	2.0 – 2.9	3.0 – 3.9	4.0 – 4.9	5.0 – 5.9	6.0 – 6.9	7.0 – 7.9	8.0 – 8.9	9.0 – 9.9	Σ	Joint Rank
0.0 – 0.9												
1.0 – 1.9			1	1							2	1½
2.0 – 2.9		12	22	22	6						62	34½
3.0 – 3.9		2	21	24	18	4					69	99
4.0 – 4.9			4	14	8	6		1			33	150
5.0 – 5.9			1	3	4	8	8				24	178½
6.0 – 6.9				2	3	7	7	2			21	201
7.0 – 7.9				2	3	2	4	2	3		16	219½
8.0 – 8.9						1	1	1	1		4	229½
9.0 – 9.9												
Σ		14	49	68	42	28	20	6	4		231	
Joint Rank		7½	39	97½	152½	187½	211½	224½	229½			

From which the following were found;

$$\frac{N^3-N}{12} = 1027180 \qquad \Sigma y^2 = 982271 \qquad \Sigma x^2 = 974698$$

$$\Sigma d^2 = 573112$$

$$r_s = 0.71$$

Significance: t = 15.2 229 d.f. which is highly significant, ($p < 0.001$), so Form A correlates significantly with Form B. (The correlation is positive.)

The Spearman-Brown Prophecy formula gives a reliability

r = 0.83 for the whole test.

Table of Form A score against Form B score for Reliability Correlations.

Form B score (Y)

Form A Score (X)

Year 3	0.0 - 0.9	1.0 - 1.9	2.0 - 2.9	3.0 - 3.9	4.0 - 4.9	5.0 - 5.9	6.0 - 6.9	7.0 - 7.9	8.0 - 8.9	9.0 - 9.9	Σ	Joint Rank
0.0 - 0.9												
1.0 - 1.9		5	2								7	4
2.0 - 2.9		13	21	20	3	3					60	37½
3.0 - 3.9		1	21	23	12	4		1			62	98½
4.0 - 4.9		1	3	13	11	10	3	1			42	150½
5.0 - 5.9				3	8	9	4	1	1		26	184½
6.0 - 6.9					2	2	7			1	12	203½
7.0 - 7.9				3		2	7	3	2		17	218
8.0 - 8.9			1				2	2			5	229
9.0 - 99								2			2	232½
Σ		20	48	62	36	30	23	10	3	1	233	
Joint Rank		10½	44½	99½	148½	181½	208	224½	231	233		

From which the following were found;

$$\frac{N^3 - N}{12} = 1114092 \qquad \Sigma y^2 = 1066558 \qquad \Sigma x^2 = 1077259$$

$$\Sigma d^2 = 571657$$

$$r_s = 0.73$$

Significance: $\underline{t} = 17.5$ 231 d.f. which is highly significant, ($p < 0.001$), so Form A correlates significantly with Form B. (The correlation is positive.)

The Spearman-Brown Prophecy formula gives a reliability

r = 0.84 for the whole test.

Table of Form A score against Form B score for reliability correlations.

Form B score (Y)

Form A score (X)

Year 4	0.0-0.9	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	Σ	Joint Rank
0.0 - 0.9												
1.0 - 1.9		5	3								8	4½
2.0 - 2.9		4	16	12	7						33	25
3.0 - 3.9		3	19	20	9	1	1				53	68
4.0 - 4.9			11	19	16	9	3				58	123½
5.0 - 5.9			3	10	6	9	4	1			33	169
6.0 - 6.9			1	2	9	5	5	3			25	198
7.0 - 7.9					2	7	11	9	2		31	226
8.0 - 8.9						1	2	1			4	243½
9.0 - 9.9							1				1	246
Σ		12	47	63	49	32	27	14	2		246	
Joint Rank		6½	36	81	147	184½	217	237½	245½			

From which the following were found;

$$\frac{N^3-N}{12} = 1\ 240\ 577.5 \qquad \Sigma y^2 = 1\ 202\ 090 \qquad \Sigma x^2 = 1\ 196\ 583.5$$

$$\Sigma d^2 = 731\ 467$$

$$r_s = 0.70$$

Significance: $\underline{t} = 15.3$ 244d.f. which is highly significant, ($p < 0.001$), so Form A correlates significantly with Form B. (The correlation is positive.)

The Spearman-Brown Prophecy formula gives a reliability

$\underline{r = 0.82}$ for the whole test.

Table of Form A score against Form B score for reliablity correlations.

Form B score (Y)

Form A score (X)

Nuffield versus conventional	0.0 – 0.9	1.0 – 1.9	2.0 – 2.9	3.0 – 3.9	4.0 – 4.9	5.0 – 5.9	6.0 – 6.9	7.0 – 7.9	8.0 – 8.9	9.0 – 9.9	Σ	Joint Rank
0.0 – 0.9												
1.0 – 1.9			1								1	1
2.0 – 2.9		8	17	7	1						33	18
3.0 – 3.9		9	21	18	4	3	2				57	63
4.0 – 4.9		5	15	13	6	2					41	112
5.0 – 5.9		4	7	9	7	8	7	1	1		44	$154\frac{1}{2}$
6.0 – 6.9			10	6	10	9	11				46	$199\frac{1}{2}$
7.0 – 7.9			1	3	3	4	5	4	2	2	24	$234\frac{1}{2}$
8.0 – 8.9						1	1				2	$247\frac{1}{2}$
9.0 – 9.9									1		1	249
Σ		26	72	56	31	27	26	5	4	2	249	
Joint Rank		$13\frac{1}{2}$	$62\frac{1}{2}$	$126\frac{1}{2}$	170	199	225	241	$245\frac{1}{2}$	$248\frac{1}{2}$		

From which the following were found;

$$\frac{N^3-N}{12} = 1\,307\,250 \qquad \Sigma y^2 = 1\,254\,689 \qquad \Sigma x^2 = 1266565$$

$$\Sigma d^2 = 872\,130$$

$$r_s = 0.66$$

Significance: $\underline{t} = 13.4$ 247 d.f. which is highly significant, ($p < 0.001$), so Form A correlates significantly with Form B. (The correlation is positive.)

The Spearman-Brown Prophecy formula gives a reliability

r = 0.80 for the whole test.

Appendix L

For Hypothesis 1

To test the general attitude to science of the sample, the overall frequency distribution was found.

Frequency distribution of attitude to science scores for the whole of the sample.

Attitude Score	Frequency
1.0 - 1.4	11
1.5 - 1.9	5
2.0 - 2.4	49
2.5 - 2.9	164
3.0 - 3.4	204
3.5 - 3.9	131
4.0 - 4.4	112
4.5 - 4.9	72
5.0 - 5.4	49
5.5 - 5.9	78
6.0 - 6.4	60
6.5 - 6.9	56
7.0 - 7.4	42
7.5 - 7.9	15
8.0 - 8.4	5
8.5 - 8.9	1
9.0 - 9.4	2
9.5 - 9.9	0

Sample size 1 066

Therefore,

Number expected above 5.5 = 533
and Number expected below 5.5 = 533
but Number observed above 5.5 = 873
and Number observed below 5.5 = 193

So:-

$$\chi^2 = \frac{(873 - 533)^2}{533} + \frac{(533 - 193)^2}{533}$$

$\doteq$ 435 with 1 d.f. (one-tailed)

A value of χ^2 as high as this is unlikely to occur by chance alone. $(p \ll 0.001)$

<u>This demonstrates that the general attitude to science of the sample was favourable.</u>

Appendix M

for Hypothesis 2.

In testing for differences in attitude between boys and girls, grammar and modern schools were considered separately, as well as together. Each year was tested in this manner, from Year One, the first year of the secondary schools, to Year Four, the fourth year of the secondary schools. Year 0, the primary sample was also tested similarly, but could not, of course, be divided into grammar and modern samples. The following frequency distributions were drawn up.

Frequency distributions for each year group for grammar, modern, boys and girls separately.

Attitude score	YEAR ONE				YEAR TWO			
	Grammar		Modern		Grammar		Modern	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
1.0-1.4					1	1		
1.5-1.9					1	3		
2.0-2.4	3	1	2		7	6	1	
2.5-2.9	9	15	14	3	13	11	12	3
3.0-3.4	17	20	9	4	19	11	11	7
3.5-3.9	10	10	9	5	3	6	8	7
4.0-4.4	3	8	9	3	5	10	6	3
4.5-4.9	2	3	5	6	1	4	3	2
5.0-5.4	0	3	2	2	1	2	1	8
5.5-5.9	0	6	7	3	2	4	0	7
6.0-6.4	0	1	4	3	1	1	6	7
6.5-6.9	0	0	1	8	1	1	5	4
7.0-7.4	1	0	2	5	1	0	2	4
7.5-7.9			1	1			2	2
8.0-8.4			1	1			1	
8.5-8.9								
9.0-9.4								
9.5-9.9								
Σ	45	67	66	44	56	60	58	54

Attitude score	YEAR THREE				YEAR FOUR			
	Grammar		Modern		Grammar		Modern	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
1.0-1.4	4	2			3	2		
1.5-1.9	1	1			1	0		
2.0-2.4	7	7	3		3	2	1	
2.5-2.9	13	12	7	4	7	7	10	2
3.0-3.4	14	12	13	2	16	11	12	2
3.5-3.9	4	7	6	9	5	3	11	8
4.0-4.4	10	6	8	5	3	9	12	6
4.5-4.9	3	3	5	8	3	5	9	9
5.0-5.4	1	1	4	6	1	2	8	2
5.5-5.9	1	1	1	5	3	6	6	8
6.0-6.4	1	3	3	4	1	3	1	2
6.5-6.9	0	0	5	9	0	10	3	4
7.0-7.4	2	0	0	4	1	5	2	5
7.5-7.9		0	1	4	2	3	0	0
8.0-8.4		1	1					1
8.5-8.9			1					
9.0-9.4								
9.5-9.9								
Σ	61	56	58	60	49	68	75	49

Attitude score	YEAR 0	
	Boys	Girls
1.0-1.4		
1.5-1.9		
2.0-2.4	4	1
2.5-2.9	25	18
3.0-3.4	22	20
3.5-3.9	6	10
4.0-4.4	2	7
4.5-4.9	1	2
5.0-5.4	1	0
5.5-5.9	1	1
6.0-6.4		2
6.5-6.9		
7.0-7.4		
7.5-7.9		
8.0-8.4		
Σ	62	61

For each set of boys and girls, the median was found. This was repeated with the overall (grammar + modern) sample for each year. From this median, the number of boys and girls above and below it were found and 2x2 tables drawn up to show the number of boys above and below the median compared with the number of girls above and below the median.

The median test was used to test the significance of any difference, as described on page 62. χ^2 was calculated with one degree of freedom and the probability that such a χ^2 could occur by chance alone, p, was determined. The test was one-tailed, that is, the direction of a difference was predicted in the initial hypothesis. In this case, the boys were expected to be more favourable than the girls in attitude to science. The value of p was therefore halved. $p < 0.05$ was accepted as confirming the alternative hypothesis that the boys were more favourable to science than the girls.

On this basis, all overall samples showed a significant difference, all modern school samples did likewise, as did the fourth year of the grammar school sample and the junior school sample, Year 0.

The 2x2 tables follow.

Tables to compare boys' attitude scores above and below the medians with girls' attitude scores above and below the median.

YEAR 1

GRAMMAR

Score / Sex	Above Median	Below Median	$\sum$
BOYS	25	20	45
GIRLS	31	36	67
$\sum$	56	56	112

Median for this sample = 3.4
$\chi^2 = 0.6$ 1 d.f.
$p < 0.25$ (1-tailed)

MODERN

Score / Sex	Above Median	Below Median	$\sum$
BOYS	41	25	66
GIRLS	14	30	44
$\sum$	55	55	110

Median for this sample = 4.4
$\chi^2 = 8.5$ 1 d.f.
$p < 0.005$ (1-tailed)

OVERALL

Score / Sex	Above Median	Below Median	$\sum$
BOYS	63	48	111
GIRLS	48	63	111
$\sum$	111	111	222

Median for this sample = 3.7
$\chi^2 = 3.5$ 1 d.f.
$p < 0.05$ (1-tailed)

YEAR 2

GRAMMAR

Score / Sex	Above Median	Below Median	$\sum$
BOYS	32	24	56
GIRLS	26	34	60
$\sum$	58	58	116

Median for this sample = 3.3
$\chi^2 = 1.7$ 1 d.f.
$p < 0.10$ (1-tailed)

MODERN

Score / Sex	Above Median	Below Median	$\sum$
BOYS	37	21	58
GIRLS	19	35	54
$\sum$	56	56	112

Median for this sample = 4.4
$\chi^2 = 8.0$ 1 d.f.
$p < 0.005$ (1-tailed)

OVERALL

Score / Sex	Above Median	Below Median	$\sum$
BOYS	68	46	114
GIRLS	46	68	114
$\sum$	114	114	228

Median for this sample = 3.6
$\chi^2 = 7.7$ 1 d.f.
$p < 0.005$ (1-tailed)

YEAR 3

GRAMMAR

Score Sex	Above Median	Below Median	Σ
BOYS	32	29	61
GIRLS	27	29	56
Σ	59	58	117

Median for this sample = 3·2
$\chi^2 = 0.075$ 1 d.f.
$p < 0.25$ (1-tailed)

MODERN

Score Sex	Above Median	Below Median	Σ
BOYS	38	20	58
GIRLS	21	39	60
Σ	59	59	118

Median for this sample = 4.4
$\chi^2 = 8.55$ 1 d.f.
$p < 0.005$ (1-tailed)

OVERALL

Score Sex	Above Median	Below Median	Σ
BOYS	67	52	119
GIRLS	51	65	116
Σ	118	117	235

Median for this sample = 3.8
$\chi^2 = 3.1$ 1 d.f.
$p < 0.05$ (1-tailed)

YEAR 4

GRAMMAR

Score Sex	Above Median	Below Median	Σ
BOYS	34	15	49
GIRLS	25	43	68
Σ	59	58	117

Median for this sample = 3.9
$\chi^2 = 20.3$ 1d. f.
$p < 0.0005$ (1-tailed)

MODERN

Score Sex	Above Median	Below Median	Σ
BOYS	45	30	75
GIRLS	17	32	49
Σ	62	62	124

Median for this sample = 4.4
$\chi^2 = 6.6$ 1 d. f.
$p < 0.005$ (1-tailed)

OVERALL

Score Sex	Above Median	Below Median	Σ
BOYS	77	47	124
GIRLS	44	73	117
Σ	121	120	241

Median for this sample = 4.2
$\chi^2 = 13.5$ 1 d. f.
$p < 0.0005$ (1-tailed)

YEAR 0

Score Sex	Above Median	Below Median	Σ
BOYS	36	26	62
GIRLS	25	36	61
Σ	61	62	123

Median of this sample = 3·2

$\chi^2 = 2.9$ 1 d.f.

$p < 0.05$ (1-tailed)

Appendix N.

The Effect of a Disproportionate number of Girls on the Overall Mean Attitude Score of a Sample.

Let the number of boys be k and the total for the boys' attitude scores be B.

Let the number of girls be x and the total for the girls' attitude scores be G.

$\therefore$ Overall mean attitude score $= \dfrac{B + G}{(x+k)} = M.$

Now $\dfrac{G}{x} = \bar{G}$ (mean attitude score for the girls and this is constant as x varies.)

$$\therefore M = \frac{B + x\bar{G}}{(x+k)} = \frac{B}{(x+k)} + \bar{G}\,\frac{x}{(x+k)}$$

To test how the overall mean score varies with the number of girls;

$$\frac{dM}{dx} = -\frac{B}{(x+k)^2} + \bar{G}\,\frac{(x+k)-x}{(x+k)^2}$$

$$= \frac{\bar{G}k}{(x+k)^2} - \frac{B}{(x+k)^2}$$

$$= \frac{\bar{G}k - B}{(x+k)^2}$$

Now it has been established in this work that, usually, $\bar{G} < B/k$. So $\bar{G}k < B$ $(x>0,\ k>0,\ B>0,\ G>0.)$

$\therefore \dfrac{dM}{dx} < 0$, that is, as the number of girls increases in the sample, the overall mean moves towards the mean of the girls. The same argument applies to the boys where the movement of the mean will be in the other direction.

Therefore, the proportion of boys and girls in each group must be the same to obviate a movement of mean in one group not shown in another under comparison. The same can be said of the median.

Appendix O

for Hypothesis 3.

Using the data in the frequency distributions of Appendix M, the samples were matched so that equal proportions of boys and girls were present in the grammar and modern school samples in each year group. Where it was necessary to remove a small number of boys or girls, this was done in a random manner with the original data. The data was then grouped as shown below and 2 x 2 tables constructed to compare those above and below the median in the two samples for each year group.

Frequency distributions for Years 1 to 4 for grammar and modern school pupils after adjustments to balance the sex proportions.

Attitude Score	Year 1		Year 2		Year 3		Year 4	
	Grammar	Modern	Grammar	Modern	Grammar	Modern	Grammar	Modern
1.0 - 1.4			2		5		4	
1.5 - 1.9			3		1		1	
2.0 - 2.4	3	1	13	1	14	3	5	
2.5 - 2.9	19	12	23	13	25	10	11	10
3.0 - 3.4	30	12	29	17	25	15	25	12
3.5 - 3.9	15	13	8	15	10	14	6	16
4.0 - 4.4	10	8	15	8	16	13	11	15
4.5 - 4.9	3	9	5	5	5	13	7	14
5.0 - 5.4	3	3	3	9	2	10	3	6
5.5 - 5.9	6	7	6	7	2	6	8	9
6.0 - 6.4	0	5	2	13	4	7	3	3
6.5 - 6.9	0	9	2	9	0	14	5	6
7.0 - 7.4	1	7	1	6	2	4	5	6
7.5 - 7.9		1		4	0	5	4	0
8.0 - 8.4		1		1	1	1		1
8.5 - 8.9						1		
Σ	90	88	112	108	112	116	98	98

2 x 2 tables to compare sex-proportion - matched samples above and below the median between the grammar and modern school samples.

YEAR 1

Score Group	Above Median	Below Median	Σ
Grammar	58	32	90
Modern	31	57	88
Σ	89	89	178

YEAR 2

Score Group	Above Median	Below Median	Σ
Grammar	73	39	112
Modern	37	71	108
Σ	110	110	220

YEAR 1

Median = 3.7
$\chi^2 = 14.0$ 1 d.f.
$p < 0.0005$ (1-tailed)

YEAR 2

Median = 3.7
$\chi^2 = 20.5$ 1 d.f.
$p < 0.0005$ (1-tailed)

YEAR 3 YEAR 4

Score Group	Above Median	Below Median	Σ	Score Group	Above Median	Below Median	Σ
Grammar	77	35	112	Grammar	56	42	98
Modern	37	79	116	Modern	42	56	98
Σ	114	114	228	Σ	98	98	196

Median = 3.8
$\chi^2 = 29.0$ 1 d.f.
$p < 0.0005$ (1-tailed)

Median = 4.1(5)
$\chi^2 = 3.4$ 1 d.f.
$p < 0.05$ (1-tailed)

χ^2 was evaluated for each table and its associated probability p found for such a χ^2 to occur by chance alone. Since it is predicted that the grammar school sample is more favourable in attitude than the other sample, the test is one-tailed. On this basis it is seen that the grammar school sample is more favourable to science at all the ages considered and especially this is true of the Years 1 to 3.

Appendix P.

for Hypothesis 4.

In comparing the elder pupils with the younger for any difference in attitude to science, the samples were again matched for sex-proportions, as in Appendix M. Years 1 and 2 were the younger group and Years 3 and 4 were the elder.

Frequency distributions of attitude scores, matched for proportions of boys and girls, for Years 1 and 2 and Years 3 and 4.

Score	Years 1 & 2	Years 3 & 4
1.0 - 1.4	2	9
1.5 - 1.9	3	2
2.0 - 2.4	18	22
2.5 - 2.9	67	56
3.0 - 3.4	88	77
3.5 - 3.9	51	46
4.0 - 4.4	41	55
4.5 - 4.9	22	39
5.0 - 5.4	18	21
5.5 - 5.9	26	25
6.0 - 6.4	20	17
6.5 - 6.9	20	25
7.0 - 7.4	15	17
7.5 - 7.9	5	9
8.0 - 8.4	2	3
8.5 - 8.9	0	1
Σ	398	424

The median attitude score for all the 822 subjects was 3.846

Score Category	Above Median	Below Median	Σ
Years 1 & 2	213	185	398
Years 3 & 4	198	226	424
Σ	411	411	822

2 x 2 table of above and below median attitude scores at the age groups from the frequency distributions above.

$\chi^2 = 3.5074$ 1 d.f. $p < 0.05$ for a 1-tailed test.

Therefore, Years 1 and 2 are more favourable in attitude to science than Years 3 and 4.

Appendix Q

for Hypothesis 5.

The results of the Nuffield/conventional comparison were treated as in Appendix P. The samples were matched, the median found and a 2 x 2 table drawn up to compare those above and below the median in the two groups.

Frequency distributions of attitude scores for the Nuffield/conventional comparison.(Physics questionnaire) Matched for proportions of boys and girls.

Score	Conventional	Nuffield
1.0 - 1.4		
1.5 - 1.9		
2.0 - 2.4	7	2
2.5 - 2.9	21	20
3.0 - 3.4	24	15
3.5 - 3.9	19	15
4.0 - 4.4	7	9
4.5 - 4.9	5	6
5.0 - 5.4	3	7
5.5 - 5.9	12	15
6.0 - 6.4	8	15
6.5 - 6.9	6	5
7.0 - 7.4	5	5
7.5 - 7.9	0	1
8.0 - 8.4	0	0
8.5 - 8.9	0	0
9.0 - 9.4	0	2
9.5 - 9.9	0	0
Σ	117	117

Each group had 81 boys and 36 girls and the overall median attitude score for the 234 subjects was 3.91.

Score / Category	Above Median	Below Median	Σ
Conventional Physics	68	49	117
Nuffield Physics	49	68	117
Σ	117	117	234

2 x 2 table of above and below median attitude scores for the two physics courses from the frequency distributions above.

$\chi^2 = 5.547$ 1 d.f. $p < 0.02$ (two-tailed)
or $p < 0.01$ (one-tailed)

These results indicate, *at the least*, that no difference exists between the two groups in attitude to physics.

Appendix R.

The correlation between attitude score to science and examination attainment.

The attitude scores and examination percentages of the pupils of forms 3b, 3c, and 3d of the grammar school sample were taken for comparison. These forms are streamed according to ability from 3b, the more able, to 3d, the less able, and were taught by one teacher for physics and another for chemistry. Since 3a was taught by a different teacher, their results were not included. The data are set out in correlation tables, one for each form and an overall table. Each cell represents the number of pupils with a given attitude score and the examination percentage they obtained. The examination percentage was found from an average of the physics and chemistry marks of the end-of-term examinations. Note that, in the tables, the attitude-score order has been reversed. Low attitude score corresponds with high favourability to science while high examination score is high attainment.

The results were treated in a similar way to those of Appendix K and the Spearman rank correlation coefficient found, along with its statistical significance.

Correlation table of Attitude score against Examination Score for 3b.

EXAMINATION % ATTITUDE Score	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	Σ	Rank
8.0 – 8.9											
7.0 – 7.9											
6.0 – 6.9											
5.0 – 5.9		1	0	1	1					3	2
4.0 – 4.9			1	1	0	5	1			8	7½
3.0 – 3.9				1	3	4	5			13	18
2.0 – 2.9					3	1	2			6	27½
1.0 – 1.9						1	2			3	32
Σ		1	1	3	7	11	10			33	
Rank		1	2	4	9	18	29				

From which the following results were found;

$$\frac{N^3 - N}{12} = 2992 \qquad \Sigma y^2 = 2770 \qquad \Sigma x^2 = 2747$$

$$\Sigma d^2 = 3466$$

$$r_s = 0.37$$

Significance: t = 2.24 31 d.f. (p 0.025 one-tailed,) and this was accepted as indicating that there exists a positive correlation between attitude to science and attainment as defined here, for this sample.

Correlation table of Attitude score against Examination Score for 3c.

EXAMINATION % ATTITUDE Score	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	Σ	Rank
8.0 - 8.9											
7.0 - 7.9					1					1	1
6.0 - 6.9				1						1	2
5.0 - 5.9				2						2	3½
4.0 - 4.9				1	2	1				4	6½
3.0 - 3.9		1			7	1				9	13
2.0 - 2.9				2	2	4	1			9	22
1.0 - 1.9					1					1	27
0.0 - 0.9											
Σ		1	0	6	13	6	1			27	
Rank		1	-	4½	14	23½	27				

From which the following results were found;

$$\frac{N^3-N}{12} = 1612 \qquad \Sigma y^2 = 1395 \qquad \Sigma x^2 = 1487$$

$$\Sigma d^2 = 1779$$

$$r_s = 0.38$$

Significance: t = 2.06 25 d.f. ($p < 0.025$ one-tailed), and this was accepted as indicating that there exist a positive correlation between attitude score and attainment as defined here, for this sample.

Correlation table of Attitude score against

Examination Score for 3d.

EXAMINATION % ATTITUDE Score	10 – 19	20 – 29	30 – 39	40 – 49	50 – 59	60 – 69	70 – 79	80 – 89	90 – 99	Σ	Rank
8.0 – 8.9											
7.0 – 7.9											
6.0 – 6.9				1						1	1
5.0 – 5.9	1		1							2	2½
4.0 – 4.9			3		1					4	5½
3.0 – 3.9		3	5	1	1					10	12½
2.0 – 2.9			2	3	3					8	21½
1.0 – 1.9											
Σ	1	3	11	5	5					25	
Rank	1	3	10	18	23						

From which the following results were found;

$$\frac{N^3 - N}{12} = 1300 \qquad \sum y^2 = 1168 \qquad \sum x^2 = 1487$$

$$\sum d^2 = 1405$$

$$r_s = 0.40$$

Significance: t = 2.42 23 d.f. (p 0.025 one-tailed), and this was accepted as indicating that there exists a positive correlation between attitude to science and attainment as defined here, for this sample.

Correlation table of Attitude score against Examination Score for 3b, 3c, and 3d combined to demonstrate masking of the correlation by ability.

Examination % / Attitude Score	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	Σ	Rank
8.0 - 8.9											
7.0 - 7.9					1					1	1
6.0 - 6.9				2						2	2½
5.0 - 5.9	1	1	1	3	1					7	7½
4.0 - 4.9			4	2	3	6	1			16	18½
3.0 - 3.9		4	5	2	11	5	5			32	42½
2.0 - 2.9			2	5	8	5	3			23	70
1.0 - 1.9					1	1	2			4	83½
Σ	1	5	12	14	25	17	11			85	
Rank	1	4	12½	25½	45	66	80				

The three forms were taught by the same teacher and given the same examinations and marked by that teacher. The correlation is seen to be reduced.

The following results were obtained;

$$\frac{N^3 - N}{12} = 51000 \qquad \sum y^2 = 48800 \qquad \sum x^2 = 46900$$

$$\sum d^2 = 66900 \text{ (all rounded)}$$

$$\underline{r_s = 0.3}$$ (rounded up)

Significance: $\underline{t} = 2.9$ 83 d.f. (p 0.005 one-tailed)

So this reduced correlation remained very significant.

Appendix S

Summary of an experiment to test reaction time in the menstrual cycle.

The hypothesis being tested was that the reaction time was longer over the time of menstruation as compared with the null hypothesis that there was no difference in reaction time throughout the cycle.

A twenty-year old girl was tested over 115 days on alternate days. Here, reaction time to a flashing light was found. The apparatus was an electronic, digital counter behind a screen. A light, visible to the girl was in front of the screen. When the experimenter pressed a switch, the light came on and the counter started. The subject held a switch which she pressed as soon as the light came on. This stopped the counter. The difference in time between the appearance of the light and the pressing of the subject's switch was noted. This was the reaction time. At each session, the process was repeated forty times, more producing boredom and fatigue. An arithmetic mean reaction time for each occasion was found. A median test was applied to the results.

A 2x2 table of reaction time and menstrual cycle. The first and last quarters are the quarters immediately after and before menstruation respectively. The second and third quarters are those covering the mid-cycle.

	Reaction Time		
	Above Median	Below Median	Σ
1st & last quarters	20	9	29
2nd & 3rd quarters	9	20	29
Σ	29	29	58

for which $\chi^2 = 6.9$ with 1 d.f. $p < 0.005$ (one-tailed)

So it was concluded that, for this girl, the reaction time in mid-cycle was faster than over and just before menstruation. The range of time was 0.20s to 0.26s. Tests on a male failed to produce such a pattern, smaller variations occurring at random.

This provides an interesting **basis for wider tests.**

Appendix T

Duckworth and Entwistle's original repertory test had 18 items. These items were statements which could be applied to any subject, known as constructs. Each construct and its opposite were found by interview with sixth formers and made into the grid below. For each subject, a pupil then decided which comment, A or B, applied best to that subject. Undecided answers were discouraged. Scoring favourable comments with +1 and unfavourable with -1 (rare undecided as 0) allows a matrix to be built up for each subject. Factor analysis was applied and identified factors of interest, difficulty and freedom (imagination). The reliability (by test-retest) was about 0.5.

This test was applied to 28 pupils in the B stream of a 4 F.E. grammar school for the subjects shown at the top of the grid. Afterwards, these pupils were asked to decide which statements were favourable and which were unfavourable. For the majority of the comments, the agreement was very good but construct 8 was found to be ambiguous in this respect so it was omitted from the analysis. The grid was scored as above and the total for each subject found. This simplified method gives a rough idea of the pupil's attitude to each subject since large positive scores indicate a favourable attitude and large negative scores indicate an unfavourable attitude. Low scores of either sign indicate neutrality, the range being from -17 to +17.

The results were grouped as follows; for boys and girls separately, the totals for maths, physics and chemistry were added and the totals for the two foreign languages and English were added. Again a high positive score would indicate favourability to science or the arts while large negative scores would indicate the opposite. Note that the sample contained 12 boys and 16 girls so the range for the boys is from -612 to + 612 while for the girls it is from -816 to +816.

Table of scores for sciences and arts for boys and girls.

	sciences	arts		sciences	arts	
Boys	239	13	OR	6.6	0.36	Boys
Girls	-112	98		-2.3	2.1	Girls
				on the -17 to +17 scale		

These figures show that, in a forced choice situation, the sample gave signs of a sex-difference with the boys favouring science and the girls not doing so.

The disadvantages of the grid are that it assumes that all the constructs have functional communicability and communicability at all levels of age and ability. It also assumes that the relevant personal constructs are accessible and are elicited by the constructs in the test. Problems of exaggeration and masking have already been mentioned.

The Thurstone test overcomes some of these difficulties by allowing a choice of statements of approximately the same value on the ordinate scale.

REPERTORY GRID

comment A	Subjects						comment B
	MATHS.	PHYSICS	CHEM.	ENGLISH	GERMAN	FRENCH	
1. Rather dull & monotonous.							Can be exciting.
2. Helps to satisfy my curiosity about life.							Does not really satisfy my curiosity
3. My own ideas can be used.							Not much need for my own ideas.

4. Most pupils can do it quite well.							Few seem to be able to do it well.
5. Doesn't require too much hard work.							Needs really hard work.
6. Rather narrow and specialised.							Of fairly general interest.
7. A lot of learning by heart.							Learning by heart not really important.
8. Needs quite a lot of imagination.							Imagination seldom required.
9. Tends to be difficult.							Fairly easy.
10. Knowledge useful in everyday life.							Knowledge not much use in everyday life.
11. Requires wide reading outside lessons.							Schoolbooks and lessons enough.
12. Usually interests me.							Often bores me.
13. Important for solving world problems.							Not particularly important for solving world problems.
14. Gives opportunity to think out for myself.							Too much of other people's knowledge.
15. Tends to be complicated							Generally straightforward.
16. I enjoy it more than I used to.							My liking for it has decreased.
17. Knowledge of it helps people to understand one another.							Knowledge of it doesn't seem to help in understanding.
18. Facts and ideas hard to grasp.							Facts and ideas not really difficult.

Table showing the proportion endorsing comment A as favourable or unfavourable

Comment No.	Favour.	Unfavour.	Comment No.	Favour.	Unfavour.
1	0.00	1.00	10	0.93	0.07
2	0.93	0.07	11	0.04	0.96
3	0.89	0.11	12	1.00	0.00
4	0.93	0.07	13	0.86	0.14
5	0.74	0.26	14	0.89	0.11
6	0.07	0.93	15	0.07	0.93
7	0.19	0.81	16	1.00	0.00
8	0.64	0.36	17	0.89	0.11
9	0.04	0.96	18	0.07	0.93