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Examination of the Role of Movement in Brain-injured Patients' Processing of Facial Information

By

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Abstract

Bruce and Young's (1986) claims for the distinct processing routes involved in facial expression recognition, familiar face identity and unfamiliar face matching were examined in a group of brain-injured patients, using a common forced-choice procedure. Four patients were observed who showed specific dissociable impairments on one of the face processing tasks, whilst maintaining intact performance on the other two tasks. However, similar differences were observed in the performance of a group of normal subjects. Therefore, it was argued that if specific dissociable impairments are to provide support for the independence of each processing route, much larger impairments are needed in the patient group.

During our perception of facial information under everyday circumstances, we generally perceive dynamic faces. However, it was noted that the majority of face processing tasks, consisted of static stimuli (commonly photographs), making their task demands somewhat unnatural. It was considered important to examine the role of movement in the processing of facial information. Three agnosic patients' ability to process movement and facial expressions was assessed.

One agnosic patient was able to successfully process movement and more importantly movement facilitated his impaired processing of static facial expressions. An extensive examination of this patient revealed that, dynamic information did not facilitate his processing of identity, for which he was severely impaired, but he was able to use movement in his processing of lip-read speech, as well as facial expressions.

It was shown that movement is able to selectively feed into various face processing channels, with facilitative consequences upon recognition. Movement can provide both a supplementary source of information to static form and a pure movement pattern from which recognition can occur, in the absence of the underlying structural/configural information.

There are several implications of these findings; firstly, greater emphasis needs to be placed upon the designs of future face processing tasks, specifically questioning the role of movement in the processing of facial information and secondly, this facilitative role of movement observed in this agnosic patient's processing of facial information, has important applications for the remediation of face processing deficits.

To
My Parents
with Love and Thanks
for all Your Support.

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Declaration

This research was carried out by the author between 1989 and 1991 at the Universities of Lancaster and Durham. I wish to acknowledge Ms. J.S.M. Saul (Lancaster University) for her help in obtaining the data described in chapter two. The analysis and discussion of this data was completed by myself. I declare that the rest of the work contained in this thesis is my own and that no part has been previously submitted in candidature for any other degree.

Statement of Copyright

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Chapter One

Introduction

1.1 Brain-damage; causes and effects.

Normal brain functioning can be affected in a number of different ways, including vascular disorders (which interfere with the flow of the blood supply to the brain causing the death of cells in the oxygen deprived areas), infections (which can spread from other parts of the body or enter the brain directly when the skull is damaged, restricting the blood supply to the brain, but also producing swelling, which compresses areas of the brain causing the further destruction of brain cells), and head-injury, (which directly damages the brain cells at the time of impact and can indirectly cause further damage due to swelling that restricts blood flow around the brain). Damage to the brain results in various observable deficits including motor and sensory deficits, cognitive deficits; including perceptual, intelligence and memory deficits and behavioural deficits; including temper outbursts, disinhibition and lack of insight.

The effects of cerebral insult upon cognitive functioning form the underlying structure of this thesis. The effects of brain-injury upon the processing of facial information, including facial identity, facial expression, lip-read speech and unfamiliar face matching will be examined, whilst specifically examining the role of movement in the processing of identity, expression and lip-read speech. The current literature has failed to consider the role of dynamic information in the processing of these sources of facial information, despite the obvious utilisation of movement in our every day processing of facial information.

1.2 Prosopagnosia; an overview.

1.2.1 Definition.

Brain-injury can cause a number of face processing impairments including visual perceptual problems, where patients describe faces as contorted or warped, a condition known as metamorphopsia, (Hécaen and Angelergues, 1962, Shuttleworth, Syring and Allen, 1982), and the recognition impairment "prosopagnosia" a term coined by Bodamer (1947), meaning from the Greek, *proso*-face, *a*-not, and *gnosis*-knowledge, where patients are unable to overtly recognise once highly familiar faces and sometimes are unable to recognise their own face when looking in the mirror (Shuttleworth, Syring and Allen, 1982). Prosopagnosics develop successful strategies to aid this debilitating recognition disorder, using other sources of information like for example, voice, gait, posture and personal accessories to aid recognition. Hécaen and Angelergues (1962) reported how one of their prosopagnosic patients would recognise his wife at social occasions by the dress that she wore. A strategy whose success surely is most unpredictable, in being dependent upon no one else wearing the same dress!

In severe cases a patient will be impaired at processing all sources of facial information, but more interesting are the cases of patients who exhibit selective face processing impairments. The existence of brain-injured patients with selective face processing impairments suggests there are functionally independent processing channels for the different sources of facial information. These processing channels not only lie in close proximity and may be able to pass information between themselves (and more importantly receive information from other processing channels like the movement processing channel), but they can also be selectively damaged, causing selective face processing impairments. Evidence from the current literature which supports the existence of several distinct face processing channels, as proposed by Bruce and Young (1986) will be examined in detail later in this introduction.

1.2.2 Apperceptive or associative ?

Prosopagnosia is an uncommon condition. Generally, it is not considered to be a perceptual disorder as prosopagnosics are very capable of recognising a face as a face and are able to distinguish human from animal faces, although sometimes the gross metamorphopsic perceptual disturbances are seen along side face agnosia (Shuttleworth, Syring and Allen, 1982), while on other occasions these metamorphopsic disturbances can exist despite normal face recognition (Bodamer's 1947 patient 'B'). Prosopagnosics are also able to name the features of the face, make judgements regarding the age of a face, and say whether a face is for example round or narrow, yet they are unable to obtain even a sense of familiarity when that face is seen again (Hécaen and Angelergues; 1962, personal observation). This type of face recognition disorder has tentatively been given the label of "associative" agnosia, where a disconnection between the perception and the stored contextual associations is proposed and it can be differentiated from "apperceptive" face agnosia where the disorder is essentially perceptual, (for a more detailed account of the apperceptive and associative forms of prosopagnosia, see De Renzi, Faglioni, Grossi and Nichelli, 1991). Lissauer (1890) was the first to propose these two distinct types of agnosia in his accounts of visual object recognition impairments, but they cannot account for all the types of agnosic conditions cited in the literature.

The notion of prosopagnosia being a multi stage disorder, able to take different forms depending upon the stage in visual information processing at which the damage has occurred, is an interesting interpretation but is not without criticism. For example, some patients with gross perceptual problems are able to recognise faces and similarly some prosopagnosic patients are able to recognise other sources of facial information including facial expressions, as noted by Bruyer, Laterre, Seron, Feyereisen, Strypstein, Pierrard and Rectem, (1983). A detailed account of dissociable face processing impairments can be found later in this introduction. As Benton (1990) remarked, Lissauer intended us to consider these different agnosic descriptors not as "all or non" definitions, but as useful labels which can account for some, but not all aspects of a patient's disorder.

1.2.3 Overt/covert distinction.

As stated previously, prosopagnosia represents an inability to overtly recognise familiar faces. Some prosopagnosic patients however, despite being unable to recognise faces overtly do show a degree of 'covert' recognition. Bauer (1984), measuring the electrodermal skin conductance responses of a prosopagnosic patient, found greater skin conductance responses to correct than to incorrect names of familiar persons (demonstrating covert recognition abilities), despite the patients complete failure to overtly identify any of the faces. Tranel and Damasio (1985) have also shown greater electrodermal skin conductance responses to familiar than unfamiliar faces. De Haan, Young and Newcombe (1987b), have described details of a prosopagnosic patient who has shown faster reaction times for matching familiar than unfamiliar faces. These covert recognition effects exist not only for faces. Tranel, Damasio and Damasio (1987) again measuring electrodermal skin conductance responses, found that visually agnosic patients could discriminate between familiar and unfamiliar buildings and cars, despite being unable to overtly recognise them.

1.2.4 Is prosopagnosia specific to faces ?

Prosopagnosia is commonly accompanied by other recognition deficits including object and colour agnosia, although it can exist on its own (De Renzi, 1986). The number of prosopagnosic patients with some degree of object recognition impairment is probably a lot larger than was originally thought, as the nature of the testing can significantly influence the type of impairment observed. For example, if one was to ask in object recognition tasks as one does in face identity tasks, 'whose object is it ?,' most prosopagnosics would experience problems in making the correct judgement. However, if you ask 'what object is it ?' then prosopagnosics perform within the normal range. Prosopagnosia is rarely however, accompanied by deficits in the processing of movement (Damasio, Damasio and Tranel, 1989).

1.2.5 Within-category disorder ?

Prosopagnosia has been considered to be a specific problem affecting the making of within-category classification judgements. Prosopagnosics are able to decide if what they see is a face or indeed if it is an object, but are unable to say whose face or whose object. Thus, they can recognise the class, but cannot recognise the specific member within the class. The size and constitution of the class is very important (Damasio, 1990) and prosopagnosics appear to have the most problems with those classes that consist of many different, but physically alike stimuli, eg. faces. Damasio, Damasio and Tranel (1989) pointed out that the distinctiveness of each member within a class is very important and can significantly aid recognition. For example, the animal class has many different but physically alike stimuli, but the physically distinct members are more easily recognised. De Renzi (1989), however, pointed out that if prosopagnosia really does reflect an inability to make within-category classifications, then this deficit should be more evident in the patients day to day existence. He gave the example, of picking up ones coat from the coat stand, which requires the recognition of one specific coat from a collection of many others.

1.2.6 Memory disorder ?

Warrington and James (1967) suggested that prosopagnosia may actually reflect a memory disorder, where partial amnesia exists for the long term memory store of face identity information. They claim that this results from damage to the right temporal lobe. Thus, there is a dissociation in the prosopagnosic condition between the ability to obtain information concerning the generic class to which a form belongs and an inability to access any conceptual historical information concerning the specific relationship of that form to the perceiver. Hécaen and Angelergues (1962) agreed, pointing out that there is a dysfunction affecting the ability to gain from the visual percept, the stored contextual information.

1.2.7 Anatomical nature of prosopagnosia.

The exact anatomical nature of prosopagnosia varies but the cases that have come to autopsy, have all demonstrated bilateral lesions. There is however, surgical, CT scan and autopsy evidence, presented by Hécaen and Angelergues (1962), Bliestle, Regard, Landis and Kleihues (1987), Meadows (1974), Assal (1969), De Renzi (1986), and Landis, Cummings, Christen, Bogan and Imhof (1985) to name but a few, of patients with varying degrees of agnosia for faces associated with unilateral lesions in the right hemisphere. Benton (1990), in his review of face recognition commented that he believed the mechanisms underlying the processing of face identity are most probably bilateral but the "crucial lesion" producing the impairment is unilateral. Damasio, Damasio and Van Hoesen (1982) believed that unilateral lesions to the right hemisphere, which result in face agnosia, do so because they cause "visuospatial disturbances" which are not limited to faces. Evidence from commissurotomised patients suggested that the processing of faces can be handled by both the left and right hemisphere, as patients are able to recognise faces presented in either the left or right visual fields (Levy, Trevarthen and Sperry, 1972). It appears that unilateral lesions to the right hemisphere are more commonly associated with prosopagnosia than a unilateral lesion in the left hemisphere, although frequently prosopagnosia occurs with bilateral damage.

The damage found in prosopagnosia usually involves the fusiform and lingual gyri of the inferior occipital and temporal association cortices and is thought to primarily affect Brodmann's areas 18, 19 and 37. (See for example, Damasio, Tranel and Damasio, 1990). Thus, the processing of faces can involve the early visual association cortices, the higher-order and multimodal association cortices located anteriorly in the temporal lobe and the mesial temporal lobe structures, including the limbic structures of both hemispheres.

1.3 Consequences of face processing impairments.

Disorders affecting the processing of facial information, particularly prosopagnosia, cause for the patient extreme social problems. The patients find socialising very hard and they may as a result become very withdrawn, as they are unable to recognise their once highly familiar friends. Socialising can be further complicated by an inability to analyse facial expressions, as the patient is unable to recognise when someone is getting angry, or when their comments are upsetting someone else. Patients tend to develop other strategies to aid their recognition, basing their identity recognition judgements upon for example voices. This suggests that face agnosia represents damage to the visual information processing channel, where information pertaining to faces can still be obtained from other processing channels, like the auditory channel. However, this does not explain why some agnosics can use other sources of information like gait, posture etc. to base their recognition judgements upon. Damasio, Damasio and Tranel (1989) pointed out that there must be different visual routes that can gain access to identity information, some routes process posture and gait etc. and are distinct from the visual routes which process face structure.

1.4 Movement, colour and form perception.

Seeing is a particularly complicated process. One would intuitively feel that the objects which we perceive, their colour and their movements, are processed in unity, by a single processing channel. However, we now know that this intuition is wrong. What could probably be considered to be one of the most important advances in our neurological understanding of brain functioning, was the proposals by, amongst others Livingstone (1988) and Livingstone and Hubel (1988), (although the notion had been around for many years previous to this), who advanced that movement, colour, form and depth are actually processed by independent processing systems in the brain. They claimed that this segregation of perceptual processes can help explain why brain-injured patients can experience such specific perceptual losses. For example, no longer being able to recognise the colour of an object, which they are able to see move before them.

They also claimed that this evidence can help explain many 'visual effects' for example, the figure/ground illusion, the corridor illusion and illusory borders etc., many of which are lost at equiluminance.

This segregation of movement, colour, form and depth was not only a very important advancement in our understanding of brain functioning in its own right, but it has also encouraged a "new way of thinking" in current neuropsychological research. If "perception" is handled by several distinct processing channels, then it is possible that other cognitive functions like for example, face processing (which broadly encompasses many different sources of information), could also utilise several independent processing channels, one for each of its different sources of information. Bruce and Young (1986) developed such a notion in their functional model of face recognition which shall be discussed later.

1.4.1 Evidence for their functional independence.

Movement, colour and form perception are considered to utilise distinct processing channels and there is both anatomical, physiological and psychological evidence in support of their functional independence. Livingstone (1988) and Livingstone and Hubel (1988), provided an anatomical/physiological account of these dissociable functions. They reported that the first division of function occurs at the lateral geniculate bodies, where information from the retina is assimilated by either the colour contrast sensitive parvocellular system or the luminance contrast sensitive magnocellular system. The parvo- and magnocellular divisions then project to different layers of V1 and then onto the different regions of V2, where the signals from the magnocellular division provide information about motion and depth and the signals from the parvocellular division provide information about shape. Information from the parvo- and magnocellular systems is also combined in V1 where it provides information about colour and luminance, which is also transmitted to V2 and V4. (See Cowey, 1985, for an additional report; Zeki, 1978 for an account of the functional dissociation of colour, directional selectivity and orientation; and Von Grünau, 1978 for an account of the dissociation and interaction of form and motion information).

Psychological evidence for the existence of distinct processing channels for form, movement and colour is provided in reports of the effects of brain injuries. Zihl, Von Cramon and Mai (1983) described the case of LM, a patient with bilateral posterior brain damage who exhibited a selective movement recognition impairment, whilst maintaining intact perception of colour and form. LM had particular difficulties perceiving movement in depth. When cars or people moved towards her she was unable to perceive their movement as a continuum, she perceived their initial position and then suddenly they were in another position. This caused problems for her own mobility, she experienced difficulties negotiating traffic and socialising, as cars and people did not move gradually, but "jumped" from one position to another. Interestingly LM's movement perception impairment was mode specific. She was impaired only with visual movement perception, acoustic and tactile movement perception caused her no such problems. Zihl et al's evidence supports the existence of a separate processing channel for movement, which is dissociable from those processing routes involved in form and colour perception.

McLeod, Heywood, Driver and Zihl (1989) have examined LM's movement perception impairment in greater detail. LM could successfully identify a moving 'X' in an array of static 'X's and identify a static 'X' in an array of static dashes, thus demonstrating that she can search in parallel for targets defined by movement alone and form alone. However, given a conjunction of these features, eg. searching for a moving X amongst moving dashes and stationary Xs, LM could not restrict her search to the moving items. If she could, then the target letter could have been detected by form (an X amongst dashes). McLeod et al believed this suggested that LM has a damaged movement filter. They added that her problem is not with performing a conjunction search in particular, but with performing a conjunction search involving movement, as she was able to search for a green X among red Xs and green dashes. They concluded that LM's problems are not concerned with detecting the presence and form of moving stimuli, but represent an inability to filter by motion.

LM's lesion is in the region corresponding to the area MT (medial temporal lobe) in the monkey brain. Single cell recordings from this region have shown that area MT in the monkey brain is involved in the filtering of movement and McLeod et al's account of LM suggests that this region in the human brain has a similar function. (See McLeod, Driver and Crisp, 1988, for a further account of the role of the cells in MT in filtering movement and Hess, Baker and Zihl, 1989, for a psychophysical examination of LM).

Vaina (1989), provided further support for the claim that motion and form are processed by independent cognitive processing channels. She gave unilateral brain damaged patients Julesz random dot stereograms, a form-from-motion task, a speed discrimination task and a structure from motion task and observed a double dissociation in the performance of the right hemisphere lesion group, on the motion and stereopsis tasks. The right occipito-parietal lesion group were impaired on the stereopsis task, the speed discrimination task and the structure from motion task but performed within the normal range on the form from motion task. The right occipito-temporal lesion group were also impaired on the stereopsis task but they were impaired on the form from motion task as well, while their performance on the speed discrimination and structure from motion tasks was normal. Vaina hypothesised that motion and stereopsis are processed by independent processing routes, and that such deficits are associated with right occipito-parietal lesions.

Heywood, Wilson and Cowey (1987) provided further psychological evidence for the functional dissociation of colour, movement and form in their account of CB, a brain-injured patient who showed a selective colour impairment (greater for chromatic than achromatic stimuli) despite showing normal perception of movement, shape and familiar faces. (See Warrington, 1987 for further evidence for the dissociation of acuity, shape, colour and location perception; and Meadows, 1974 for the dissociation of colour perception and familiar face recognition).

Collectively this evidence strongly supports the existence of distinct processing channels for movement, colour and form, albeit these processing channels may lie in close proximity and be capable of passing information between themselves and other processing channels. In particular it is possible that the movement processing channel could selectively feed into the form processing channel, providing further information to aid the recognition of the form. It was hypothesised in this thesis that the movement processing channel should be able to selectively feed into various facial information processing channels, but in particular the facial expression analysis channel, providing supplementary information to the structural/configural information available in photographs of facial expressions. This supplementary dynamic information should facilitate the recognition of facial expressions, as it allows the unfurling of the "successive facial muscle actions" involved in the production of each facial expression. Facial expressions are by their very nature dynamic. They involve extensive facial movement, where the face may change from a neutral pose into an expression, maintain this expression for some time or fluctuate between various other expressions, and then return to a neutral pose. Also during the production of facial expressions there may or may not be other facial movement. For example, facial expressions are commonly produced in conjunction with mouth articulation, seen during the production of speech. The production of these facial movements is dependent upon an extensive network of muscles found on the face and neck. This description, "successive facial muscle actions" referred to above, shall therefore, be used throughout this thesis to refer to the movement of the underlying facial muscles used during the production of facial expressions. Different facial expressions will utilise different facial muscles, but all will involve the sequential unfurling of an array of different muscle actions in their production. The reader is referred to this description where ever this term is used throughout the remainder of this thesis. However, in emphasising the dynamic nature of facial expressions it is not intended to infer that facial expressions can not be recognised from static photographic displays. There is substantial evidence in the literature to support the fact that normal subjects are able to accurately recognise expressions from photographs. What shall be argued throughout this thesis however, is that facial expression recognition should be more accurate from dynamic than static stimuli.

Movement information may also be able to feed into the other facial information processing channels, with facilitative consequences upon recognition. The validity of these hypotheses was assessed. (A more detailed account of the experimental hypotheses can be found towards the end of this introduction).

Before we go any further, it is probably best to clarify exactly what is meant by structural/configural information, which was described above as being available in photographs of facial expressions. Firstly, structural/configural information forms the underlying source of information available not only in static images such as photographs, slides and pictures, but also during our perception of faces under normal circumstances. It is not specific to facial expressions, but is available during the processing of any facial information. Configural information refers to the arrangement of the facial features (eyes, nose, mouth, etc.) and specifically the relationship which one feature's position, plays with respect to the position of another facial feature. Bruce (1988), stated that configuration means "the spatial inter-relationship of facial features" p.38, adding that the facial features can be arranged to any configuration and that changing any feature will change the overall configuration of the face. Structural information, on the other hand, refers to the contours of the face (eg. cheek bones, dimples and wrinkles). Shading, produced from the different ways in which light is reflected from these different surfaces, provides structural information giving a face its 3D form. As Bruce (1988) has pointed out, a demonstration of just how important shading is in our perception of faces, can be seen by the way in which make-up and lighting are used to enhance the structure of a face. For other evidence supporting the role of shading in our perception of form, see Davies, Ellis and Shepherd (1978b). This structural/configural information is readily available and utilised in our processing of faces, enabling us to makes judgements about amongst other things, a faces identity and its facial expression and the reader is referred to this description where ever the term structural/configural information is used throughout this thesis.

1.5 Examination of the Bruce and Young (1986) functional model of face recognition.

1.5.1 Description of the model.

The development of Cognitive Neuropsychology brought with it a revival of the use of "mental models" which were previously popular at the end of the last century. Information processing models as they are now known, map out proposed processing pathways for different cognitive functions and their relationship with one another. One such example of an information processing model is the Bruce and Young (1986) Functional Model of Face Recognition (see Figure 1). Bruce and Young proposed in their model of face recognition, four distinct channels for the processing of facial information. Familiar face identity recognition judgements (directed through the face

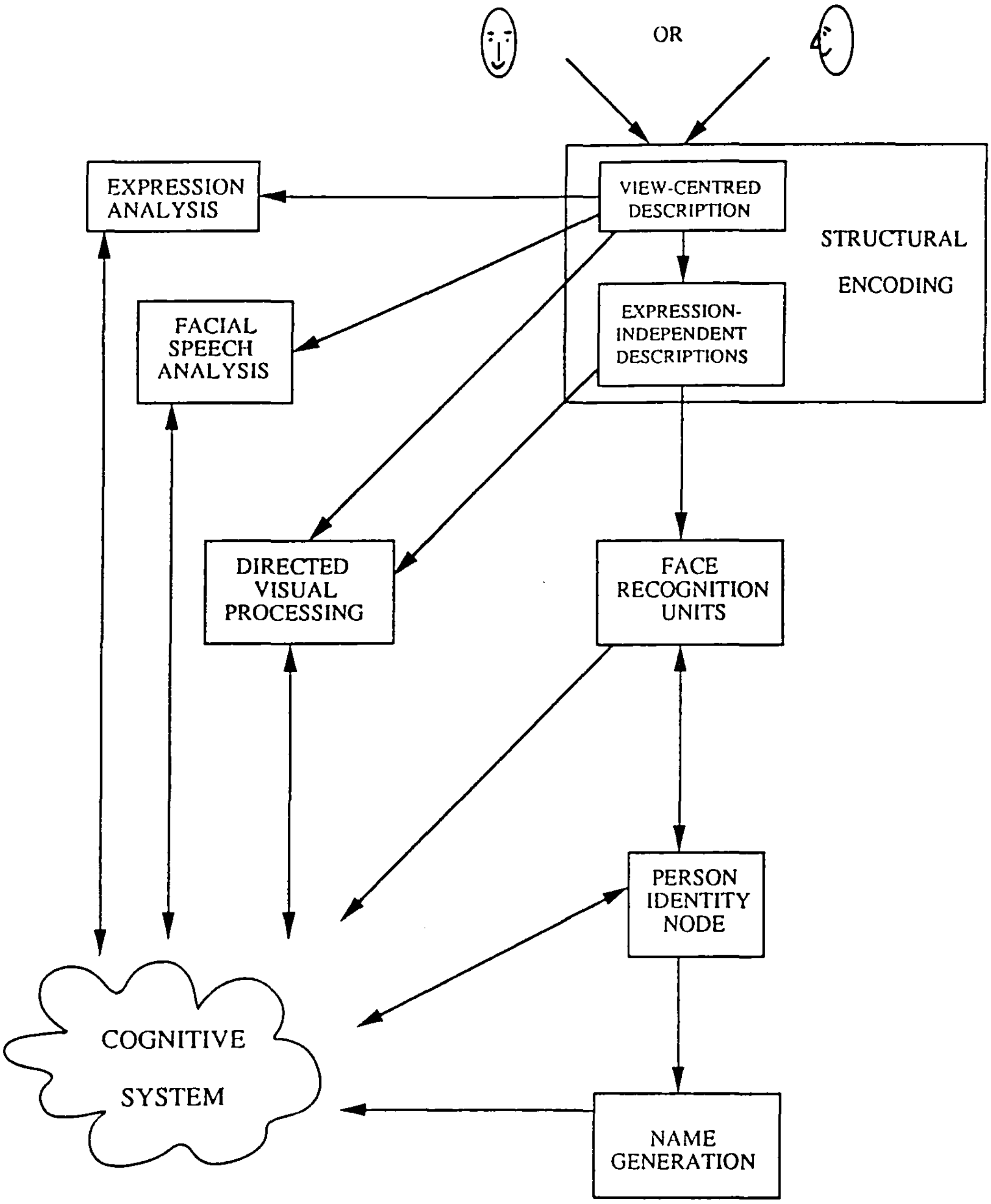

Figure 1: Bruce and Young's (1986) Functional Model of Face Recognition.

recognition units), are handled by a different processing channel to that which analyses facial expressions, both of these processing channels are distinct from the channel which processes facial speech information, which in turn is distinct from the processing of unfamiliar faces, which is handled by the directed visual processing module.

1.5.2 The importance of case studies.

The development of Bruce and Youngs and other information processing models has been associated with an increased popularity and acceptance of "case studies." Here a single patient's processing capacities, for example, their ability to process the different sources of facial information, are examined in detail using carefully designed tasks, with different tasks testing different face processing capacities. The degree to which a patient is impaired on each of the tasks provides excellent support for the distinct processing routes proposed in the Bruce and Young model of face recognition. For example, one patient may be able to identify highly familiar faces, but not be able to say whether each person is for example, happy or sad. Another case study may reveal a patient who shows the opposite pattern of impairment, where they are not able to recognise highly familiar people, but are able to recognise the same person's facial expression. These single case studies and also the examination of specific patient's performance in group studies, provide strong support for the existence of distinct channels for the processing of familiar face identity, facial expressions and the processing of unfamiliar faces, as proposed by Bruce and Young (1986).

1.6 Functional independence of the face processing capacities.

Bruce and Young (1986) proposed in their functional model of face recognition that the analysis of facial identity, facial expressions, lip-read speech and unfamiliar faces involves four distinct processing channels. Support for their claims can be found in the current literature where there are reports of specific cerebral injury causing specific deficits in the processing of these sources of facial information. Cerebral injury can cause "global" face processing deficits, where a patient is impaired at processing all sources of facial information or "dissociable" impairments, where a patient is selectively impaired at processing one or more source of facial information, whilst their processing of other sources of facial information remains relatively intact. A brief review of the literature which supports the existence of these distinct facial information processing channels, as proposed by Bruce and Young follows. Firstly, evidence for a dissociation between familiar face recognition and facial expression analysis will be reported, followed by evidence for the dissociation of unfamiliar face matching and facial expression analysis. Reports of a dissociation between familiar face recognition and unfamiliar face matching and other evidence for the independence of facial expression recognition, familiar face recognition and unfamiliar face matching reported when measuring these three face processing tasks at one test session, will then be considered, whilst finally concluding with evidence for the dissociation of lip-reading and familiar face recognition.

1.6.1 Evidence for the dissociation of identity and expression recognition.

Evidence for a dissociation between the recognition of familiar faces and the processing of facial expressions has been reported by Tranel, Damasio and Damasio (1988). Four patients with severe impairments on facial identity recognition were given tests for facial expression, gender and age recognition. Tranel et al found that three of the patients showed a dissociation between their poor processing of facial identity and their relatively intact facial expression, age and gender judgement performance. Damasio, Damasio and Tranel (1989) pointed out that a deficit affecting the processing of expression, gender and age as well as identity is caused by lesions in the same sector as those found with prosopagnosia. However, there is significant damage to the inferior association cortices rather than just undercutting their connectional systems.

Kurucz, Feldmar and Werner (1979) examined impairments of facial expression perception in disoriented elderly chronic organic brain syndrome patients, oriented elderly patients with non-organic psychiatric disorders and normals. The disoriented patients were impaired at affect recognition relative to both the well-oriented patients and the normal subjects. This work was extended by Kurucz and Feldmar (1979), who showed that the disoriented patients were impaired at recognising American Presidents, but this impairment did not correlate with their impairment for facial affect. The existence of these dissociable impairments for expression processing and familiar face recognition in the disoriented patient group, further support the independence of these two face processing abilities. Evidence for the dissociation of the underlying functional components involved in facial expression recognition and familiar face recognition has also been reported when testing normals. (See Bruce, 1986; and Young, McWeeny, Hay and Ellis, 1986.)

1.6.2 Evidence for the dissociation of expression and unfamiliar face processing.

The literature also provides evidence for distinct processing pathways involved in the recognition of facial expressions and the matching of unfamiliar faces. Bowers, Bauer, Coslett and Heilman (1985) tested patients with left hemisphere damage (LHD), right hemisphere damage (RHD) and patients with no neurological disease (NHD). They were given a series of perceptual and associative facial affect and identity judgement tasks and naming of emotions and pointing to named emotions tasks. The RHD patients were significantly impaired on all the affect and identity tasks compared to the LHD and NHD groups. However, their observed affect impairment remained even when their perceptual identity performance was statistically partialled out. Bowers et al thus showed that the RHD patients' affect impairment is not due to a visuoperceptual deficit, but is instead dependent upon different cognitive processes to those necessary for face recognition.

Comparable results obtained using a normal population were reported by Strauss and Moscovitch (1981). In two separate experiments they required subjects to match either emotional expressions (happy, sad and surprised) as being the same or different, or to match the identity of unfamiliar faces as being the same or different. A left visual field superiority was observed for both tasks, with differences in the overall processing time. The processing of facial expression took longer than the processing of facial identity. Consistent with Bowers et al's (1985) findings, Strauss and Moscovitch maintained that although facial expression and face recognition require independent processing, both are right hemisphere tasks.

For other reports of dissociable impairments on facial expression recognition and unfamiliar face matching see Cicone, Wapner and Gardner (1980) and Pizzamiglio, Zoccolotti, Mammucari and Cesaroni (1983).

1.6.3 Evidence for the dissociation of familiar and unfamiliar face processing.

The literature also supports Bruce and Young's (1986) proposal of distinct pathways for the processing of familiar and unfamiliar faces. Benton and Van Allen (1972) reported a case of prosopagnosia in which performance on an unfamiliar face matching task (cf. Benton and Van Allen, 1968) was well within the normal range. As Benton (1980) has emphasised, the independence of the familiar face recognition impairment in this and other patients suggests it is misleading to consider prosopagnosia as a purely visuoperceptual deficit.

Malone, Morris, Kay and Levin (1982) reported a double dissociation between the recognition of familiar and the matching of unfamiliar faces in two cases of prosopagnosia. Case one was initially unable to recognise familiar faces by face alone, he was also impaired on the matching of unfamiliar face photographs. Later testing revealed that the familiar face recognition impairment had improved significantly, while his unfamiliar face matching problem remained. Case two was unable six weeks after an initial testing to recognise both relatives and various familiar personalities by their face alone. There was a significant improvement, however, in his initially impaired unfamiliar face matching performance, which now fell within the normal range.

Warrington and James (1967) administered familiar and unfamiliar face recognition tasks to groups of patients with unilateral cerebral lesions. Relatively more errors were made on both tasks by the patients with right hemisphere damage. Interestingly though, the right temporal lesion group made more errors on the familiar face test, whilst the right parietal lesion group made the most errors on the unfamiliar face test. This again suggests the existence of distinct cognitive processing pathways for these two face processing capacities, although both could be considered to be primarily mediated by the right hemisphere.

For further evidence supporting the independence of the cognitive processes utilised in familiar face recognition and unfamiliar face matching tasks see Assal (1969), Rondot, Tzavaras and Garcin (1967), and for an additional report of Rondot et al's patient see Tzavaras, Hécaen and Le Bras (1970).

The studies considered so far have provided evidence of dissociable face processing abilities when examining various permutations of two of the three face processing pathways of interest (facial expression, familiar face recognition and unfamiliar face matching). It is very important however, if one wants to develop a clear picture of the underlying functional capacities involved in the processing of these different sources of facial information, to measure a patient's ability to process all sources of facial information. Farah (1991), has emphasised the importance of such a technique, in her examination of the underlying processing capacities involved in the the processing of faces, words and objects. Only by comparing various patients' performance on face, object and word processing tasks, was she able to conclude that there are in fact two (and not three), distinct visual recognition capacities underlying the processing of these three distinct sources of information.

Very few studies to date have actually considered a patient's ability to process all aspects of facial information and those that have have used different task demands, across different test sessions. Yet as Farah (1991) has demonstrated, the benefits of using such a technique are enormous. Bruyer, Laterre, Seron, Feyereisen, Strypstein, Pierrard and Rectem's (1983) study is one of the few studies which reports evidence for the existence of the distinct processing pathways involved in the processing of identity, expressions and unfamiliar faces, found when measuring all three face processing capacities in one test session. They reported details of a prosopagnosic male farmer who despite his human face agnosia was able to make other perceptual discriminations, including identifying his cows and dogs. He showed intact perception of faces, performing perfectly on sex identification judgements. He obtained a normal score on the matching of unfamiliar faces and had normal perception of facial expressions. Bruyer et al believed the specificity of this case of impaired familiar human face recognition, without any significant underlying perceptual deficit, supports the interpretation of prosopagnosia as a memory rather than a perceptual deficit.

1.6.4 Evidence for the dissociation of identity and lip-reading.

Campbell, Landis and Regard (1986) provided evidence for the existence of distinct processing channels for the processing of facial identity and lip-read speech. They reported details of two patients D and T with unilateral lesions, positioned in the right and left hemisphere respectively. Each patient had to repeat lip-read sounds, classify pictures of speech and non-speech sounds and classify vowel sounds across different faces. They were also given a test measuring their susceptibility to the McGurk and MacDonald (1976) blend illusion. D who was prosopagnosic, was also grossly impaired at making expression and sex judgements and had topographical amnesia. She was able to imitate buccofacial actions, including emotionally meaningful actions, but was unable to define them. She performed normally on all the lip-reading tasks. T who was alexic (without agraphia), was able to identify faces, facial expressions and categorise faces according to their sex. She was also able to imitate buccofacial actions and define them. T however, was impaired at lip-reading. Campbell et al claimed that this double dissociation between D and Ts' ability to recognise familiar faces and lip-read speech, not only suggests that there must be distinct processing channels for these two sources of facial information, but also that lip-reading is a left hemisphere processing ability.

From this review we are able to see that there is substantial evidence to support Bruce and Young's (1986) proposals of distinct processing channels for the different sources of facial information. However, there are two distinct criticisms which can be made regarding the nature of these studies, which it is felt demand further specific investigation.

Firstly, whilst there is a substantial amount of evidence supporting the existence of distinct channels involved in the processing of facial expressions, familiar face identity and unfamiliar face matching, very few studies have examined these face processing capacities at the same test session. Test session variation can have vast implications upon performance, which is independent of the variation often observed in a patient's processing abilities across time. Those studies that have measured all three processing capacities at the same test session, have failed to use a common task demand and have also failed to demonstrate all the possible face processing dissociations predicted by Bruce and Young (1986), in their model. It is felt that the ultimate evidence supporting Bruce and Young's claims, would therefore be obtained using a common forced-choice task procedure, tested at a single test session. If brain-injured patients were individually matched to normal subjects on gender, age at date of testing, age on leaving full time education and premorbid intelligence level, then differences observed in task performance could not be attributed to either a general intellectual impairment, a difference in task demands or test session variables. Instead they would have to be accounted for in terms of the patient's existing cerebral damage. Such a study has been conducted and has been described in chapter two.

The other criticism of these findings for dissociable face processing impairments currently reported in the literature, is that they are mostly derived from studies using static, black and white stimuli such as photographs, slides or pictures etc., in their tasks. For example, photographs are commonly used in identity recognition (Warrington and James, 1967) and unfamiliar face matching tasks (Benton and Van Allen, 1972). They are also used in facial expression tasks where photographs depict actors posing various facial expressions (DeKosky, Heilman, Bowers and Valenstein, 1980). The Ekman and Friesen (1976) pictures of facial affect are commonly used as stimuli (for example, Weddell, 1989). Slides are also used as stimuli in facial expression recognition tasks, primarily in divided visual field studies. Sometimes the slides depict emotional scenes eg. a baby picking flowers, for a positive emotion (Borod, Koff, Perlman Lorch and Nicholas, 1986) and others depict actors posing various emotions (Landis, Assal and Perrett, 1979). Slides are also used in identity recognition tasks (Young and De Haan, 1988). Pictures are similarly used, primarily in expression recognition tasks, depicting both emotional scenes (DeKosky, Heilman, Bowers and Valenstein, 1980) and line drawings of emotional faces (Ley and Bryden, 1979), and line drawn caricatures and cartoons are commonly used in identity recognition tasks (Hoptman and Levy, 1988). Lip-reading tasks by their very nature however, do go some way to incorporating dynamic information into their design, in getting subjects to imitate facial actions and use of the video based McGurk and MacDonald (1976) blend illusion lip-reading tasks. Although these various types of stimuli are perfectly adequate for use in face processing tasks, they do provide a qualitatively different type of information to that which we are use to processing in our everyday recognition of facial information and as a result may provide inaccurate measurements of an individual's face processing capacities. See below for discussion.

1.7 Why study the role of movement in the processing of facial information ?

Very few studies to date have actually considered the role of movement in the processing of facial information. Movement information however, is readily available when faces are viewed in real life, with the majority of us normally perceiving a dynamic world. Only occasionally is one asked to recognise a familiar person or describe how an individual is feeling from a static black and white photograph and hardly ever to decide what a person is saying from a photograph of an unfamiliar actor/actress mouthing a lip-reading gesture. We are accustomed to (more often than not) recognising moving faces. We are use to recognising facial expressions by watching a sequential unfurling of many facial muscle actions and to analysing lip-read information taken from dynamic faces. But although movement is a very important source of information in our normal perception of the world, successful face recognition judgements are not necessarily dependent upon it. The mere fact that black and white photographs can be recognised (in terms of who they depict, whether the person is happy or sad and what lip-reading gesture the person is mouthing), without too much difficulty is sufficient to demonstrate this.

The fact still remains that those studies that have considered the role of dynamic information in the processing of facial information, by directly comparing static and moving faces at the same test presentation, are few and far between and have primarily involved infants. For example, Kaufmann and Kaufmann (1980) claimed that movement is a very important source of information, finding for example that infants prefer moving to static faces and a moving responsive person to a static unresponsive person. Biringen (1987), wanted to find out what source of information infants preferentially attend to when given a moving face; information of facial expression or pure dynamic information? Infants viewed a neutral or happy face, during three different motion conditions; still, with internal feature motion and with whole object movement. The infants preferred happy to neutral facial expressions in the internal motion and still modes only. Happy and neutral were equally preferred in the whole object motion condition and the whole motion condition was preferred for both happy and neutral, to the internal motion and still mode conditions. Biringen claimed firstly that the infants must have been able to perceive motion as they preferred internal motion to the still condition and secondly, that facial expressions are as important to the infants as facial motion. These results contrast with those of Wilcox and Clayton (1968) who found that infants did not show a preference for facial expressions in the moving over the still mode of presentation.

Bruce and Valentine (1988) and Bassili (1978, 1979), have taken the issue one step further, by examining the role of pure dynamic information (absent of the underlying structural/configural information), in the processing of facial information, available using the point light display technique (see chapter five for further details). They have demonstrated that normal subjects are able to use this pure dynamic information, in the recognition of various sources of facial information, including facial expressions and to a lesser extent facial identity and gender judgements. However, even this technique has had little application in the examination of brain-injured patients' ability to process facial information.

Probably one of the simplest ways to examine the role of dynamic information in the processing of facial information, is to use the video technique, which enables one to compare static and dynamic clips of facial information. Despite the relevant simplicity of this technique, there remains a dearth in the literature of studies which have examined the role of movement in the processing of facial information, using such a technique, which is especially evident in the examination of brain-injured patients' face processing capacities.

It is important to understand how movement contributes to face processing. If as we are led to believe movement, colour and form do depend on different neural mechanisms, then studying performance on various face processing tasks provides us with an interesting opportunity to explore the interaction of these separable neural mechanisms in "higher-order" visual tasks for which people have become highly skilled. The literature concerning both normals and patients' recognition of familiar faces, facial expressions and their ability to comprehend speech using lip-read information is both varied and extensive, but its failure to consider the role that movement may play in the processing of such facial information, could have vast implications. It could be that some of the milder face processing impairments reported in the literature to date are an artifact of the unnaturalness of the task stimuli used, namely static photographs.

1.8 The experimental hypotheses.

1.8.1 Brain-injured patients group study.

Before consideration was given to the role of dynamic information in the processing of facial information, Bruce and Young's (1986) proposals for the distinct processing routes involved in the processing of familiar face identity, facial expressions and unfamiliar faces was examined in a matched population of brain-injured patients and normal subjects, using a common forced-choice procedure, at a single test session. A significant difference was hypothesised between the performance of the patients and the normal subjects on the three forced-choice face processing tasks and it was hoped that individual differences would be observed between the patients' performance on each of the three recognition tasks.

Given our knowledge that form and movement are processed by independent processing channels and that these channels may be capable of passing information between themselves and also our acceptance of the integral role that dynamic information plays in our everyday perception of facial information, it was proposed that dynamic information has an important role to play in our recognition of various sources of facial information. An account of the experimental hypotheses tested in this thesis which specifically outline the predictions for the role of dynamic information in the processing of familiar face identity, facial expression and lip-read speech follows.

1.8.2 Familiar face identity.

Firstly, in terms of the prediction for the role of dynamic information in the processing of facial identity, it was hypothesised that there will be no significant difference between the recognition accuracy of familiar persons seen in static and dynamic mode of presentation. The underlying basis for this hypothesis is that Bruce and Valentine (1988), found little evidence of their normal subjects being able to use pure dynamic information in the recognition of familiar persons. Also the fact remains that normal subjects are highly accurate at recognising a person's identity from static photographic stimuli (much more so than they are at recognising facial expressions), which is regardless of whether the photograph seen is colour or black and white and whether the face is seen in full or three-quarters pose view. Secondly, the identity of a face, unlike it's expression, is not dependent upon dynamic information. Faces obviously do articulate and move during our observation and interaction with them, but the movements do not tell us specifically anymore about the identity of the face, unlike the movements observed during the production of a facial expressions, which tell us a lot about the nature of the given expression. Therefore, it hardly seems plausible that a patient with a specific impairment in the recognition of familiar face identity, should experience any significant facilitation in his/her identity recognition judgements with the introduction of dynamic information. However, this is not to say that dynamic information is a redundant source of information in the recognition of a person's face, as obviously there is the possibility that someone may be "known" for a particular facial mannerism or someone else may have a particularly dynamic, expressive face. In these instances it is possible that the inclusion of dynamic information in the test stimuli may facilitate the recognition of that person, as it is possible that this may enable the recognition of the specific facial mannerism, which may facilitate the recognition of the identity of the face. However, the instances where this type of dynamic information facilitation may occur, are probably few and far between.

1.8.3 Facial expression.

The role of dynamic information in the recognition of facial expressions is believed to be quite different. Its hypothesised that there should be a facilitation in the recognition of facial expressions with the introduction of dynamic information. That is to say, patients with static facial expression recognition deficits (as measured by tasks composed of photographic stimuli), who are nevertheless able to process movement information, may, when given the more natural, dynamic "video clips" of expression, experience a facilitation in their otherwise impaired processing of static facial expressions.

The underlying basis for this hypothesis is firstly, that facial expressions by their very nature are dynamic and are dependent upon movement for the unfurling of their successive facial muscle actions involved in their production. Therefore, recognition judgements based upon photographic stimuli are severely limited by the fact that photographs are essentially only providing the perceiver with a single frame, taken from the normal array of successive facial muscle actions involved in the production of each facial expression. Video sequences of facial expressions on the other hand, not only provide the perceiver with the "whole" facial expression, but in doing so they are also providing more information for the perceiver to base their expression recognition decision upon and a more natural and in effect identifiable expression. Secondly, dynamic video clips of expressions are not only providing the perceiver with the structural and configural information available in a photograph, but also with a "movement pattern" which supplements this structural/configural information.

It is known that pure movement patterns as provided by point light displays are very informative sources of information (see chapter five for discussion), enabling amongst others, judgements of expression and to a lesser extent sex and identity (Bruce and Valentine, 1988). It is possible that facial expressions are stored not only in terms of their structural and configural information but also in terms of their specific movement pattern and therefore, dynamic video expressions provide the perceiver with two sources of information upon which an expression recognition judgement can be based and thus, could be seen to facilitate the expression recognition judgement.

Consideration will also be given to the role of other variables in the processing of facial expressions. Ley and Bryden (1979) described how normal subjects show a degree of affect preference in making emotion judgements. Subjects found extremely positive/negative displays of emotion preferential to mildly positive/negative or neutral displays. The question arose as to whether PH would show a similar degree of affect preference, but in particular whether the degree of affect seen would play a significant role in his processing of facial expressions. Intuitively, one would believe that if a patient experiences a facial expression recognition deficit, then the degree of facial affect seen, should have an influential effect upon their recognition judgements. It was hypothesised that PH should make less expression recognition errors for strong than moderate degrees of facial affect, which in turn should be less than those made when given weak displays of affect.

Another factor which has been shown to influence normal subject's recognition of facial expressions, is the region of the face in which the facial expression is seen to be displayed. Ekman and Friesen (1975) in their detailed description of six universal emotions, have divided the face into three regions; the brow, eyes and mouth and described how each facial expression utilises these different regions to different extents in its production. Bassili (1979), has examined the role of the different regions of the face in the recognition of facial expressions, finding that normal subjects prefer whole face presentations, to lower face presentations, which in turn are preferred to upper face presentations, in the recognition of facial expressions.

Examining the role of the different regions of the face in the processing of facial expressions could also throw some light on the nature of a patient's processing deficit. It was proposed that if PH experiences a visual configural processing deficit preventing him from structurally encoding the "whole" image, which extends to his processing of facial expressions, then a facial expression recognition task, which examines recognition of facial expressions from different regions of the face, should highlight such a deficit. It was hypothesised that if PH does experience a visual configural processing deficit which extends to his processing of facial expressions, then he should make less expression recognition errors when recognising facial expressions seen in the upper and lower regions of the face, than on those expressions seen in the whole region of the face.

1.8.4 Lip-read speech.

Speech by its very nature is a dynamic process requiring the articulation of the mouth, lips and tongue in its production. Thus, movement is seen to play a fundamental role in the processing of lip-read speech. The concept of lip-reading static lip-mouthed speech is not only very unnatural, but also ambiguous. It maybe possible that normal subjects could lip-read static lip-mouthed sounds, like ee, oo or ah, but the notion of lip-reading static lip-mouthed words is incomprehensible, primarily because it would be extremely difficult to get a meaningful baseline measurement from a population of normal subjects. Therefore, the role of dynamic information in the processing of speech is somewhat less clear cut, but suffice to say no facilitative role was hypothesised for dynamic information in the processing of lip-read words. Instead dynamic information was seen to play a more fundamental role. It was hypothesised however, that movement may possibly play a facilitative role in the recognition of lip-mouthed sounds, where one should be more accurate at recognising these lip-mouthed sounds from dynamic, than static video sequences.

1.9 Overview of the investigation.

This thesis addresses the question of how prosopagnosic and other brain-injured patients utilise the different categories of facial information. One aim was to test the validity of Bruce and Young's (1986) claims for the existence of dissociable face processing pathways. It was hoped to improve upon the previous studies reported in the literature to date, by producing three forced-choice recognition tasks; a facial expression recognition task, a familiar face recognition task and a unfamiliar face matching task. Each task had the same response alternatives (either top or bottom), ensuring the subject was drawing upon information sources of equivalent complexity. By controlling the task complexity, any observed dissociable impaired performances could be attributed to the existence of discrete functional processing pathways for the different sources of facial information, rather than to differences in task demands or response requirements. Patients were observed who showed specific dissociable impairments on one of the face processing tasks, whilst maintaining intact performance on the other two tasks. However, similar differences were observed in the performance of a group of normal subjects. Therefore, it was argued that if specific dissociable impairments are to provide support for the independence of each processing route, much larger impairments are needed in the patient group. Having established this, the extent to which agnosic patients are able to process facial information was then examined. A pilot study was conducted examining a small group of agnosic patients' ability to process facial movement and facial expressions. The main core of the thesis however, has concentrated upon one agnosic patient, whose performance in the above mentioned pilot study was most interesting. He showed, not only an ability to process movement information, but also a facilitation from dynamic information in his otherwise impaired processing of static facial expressions. His ability to process different sources of facial information including facial expressions, familiar face identity and lip-read speech was examined in detail. A very important addition was made to the current literature by examining for the first time, the extent to which dynamic information may play a facilitative role (if any) in the processing of these three sources of facial information. For this purpose a large battery of video face processing tasks was produced, where the role of dynamic information could be determined by keeping the face processing capacity being measured constant (recognition of identity, processing of expression or lip-read speech) and systematically varying the movement variable, producing both static and moving images. By this controlled manipulation of dynamic information, the role of movement in the processing of these various categories of facial information was determined. Dynamic information did not facilitate his processing of identity, for which he was severely impaired, but he was able to use movement in his processing of lip-read speech, as well as facial expressions.

At present the Bruce and Young (1986) model does not account for the role of movement in the processing of facial information. One aim therefore, was to develop Bruce and Young's (1986) model in terms of mapping out at what stage (if at all) movement information feeds into the distinct processing channels for facial identity, facial expression and facial speech analysis.

It is very important to observe in detail brain-injured patients' deficits of facial information processing, not only to aid our understanding of the human brain, in terms of how and where the various cognitive functions are handled, but also in terms of developing possible remediation techniques for brain-injured patients, in an attempt to improve their quality of life. Considering the role of movement in the processing of facial information could have specially important consequences, as if movement information does facilitate the recognition of any source of facial information then it can be easily applied to the remediation of patients with face processing impairments.

Chapter Two

Dissociable Face Processing Impairments

2.1 Introduction.

Bruce and Young (1986) proposed that when the face processing system is functioning normally one is able to access and utilise several distinct information codes. These allow us to process such properties as how an individual may be feeling (from the expression on their face), whether a person is familiar or unfamiliar to us, with what we associate the person and their name. However, for certain brain-injured patients these face processing abilities can be selectively impaired, which can cause considerable social interaction problems.

It is important to try to account for the different types of face processing ability in terms of their underlying cognitive analyses and it is also valuable to try to build up a picture of the kind of face recognition impairments that can result from cerebral injury and use these to refine our understanding of the mechanisms responsible for face processing in the human brain.

Bruce and Young (1986) endeavoured to do just this in their functional model of face recognition (see Figure 2). They proposed that the processing of facial expressions, the recognition of familiar faces and the matching of unfamiliar faces (deciding if two photographs are of the same or different people) involve different cognitive processes and that each utilises a distinct and functionally independent pathway in the model.

Facial expression analysis is held to be dependent upon view-centred descriptions created at the structural encoding stage and proceeds through a different processing route to that involved in the recognition of familiar faces. Familiar face recognition requires the access of face recognition units via expression-independent descriptions. Unfamiliar face matching is dependent upon both view-centred and expression-independent descriptions, which are utilised by the directed visual processing module. Thus, according to Bruce and Young (1986), the unfamiliar face matching pathway is distinct from that used in facial expression recognition, which in turn is distinct from the pathway used in familiar face recognition.

In terms of the Bruce and Young (1986) model it is thought that cerebral injury can cause specific face processing impairments, including dissociable impairments for expression recognition, familiar face recognition and unfamiliar face matching. Some support for these claims has been found in the existing clinical literature. In chapter one it was noted that Tranel, Damasio and Damasio (1988), Kurucz, Feldmar and Werner (1979), Kurucz and Feldmar (1979), Bruce (1986), and Young, McWeeny,

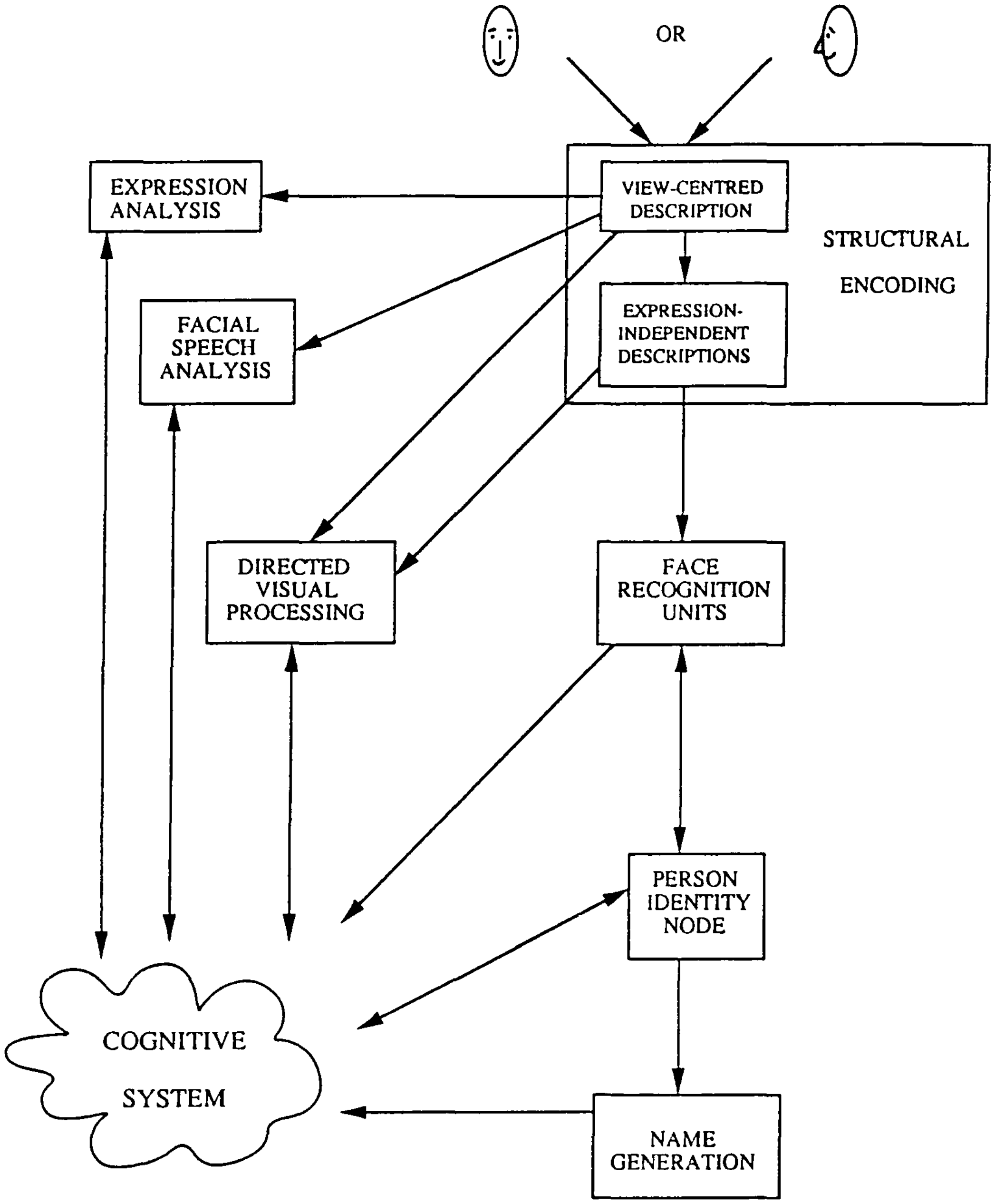

Figure 2: Bruce and Young's (1986) Functional Model of Face Recognition.

Hay and Ellis (1986) all reported evidence for a dissociation between the recognition of familiar faces and the processing of facial expressions. Evidence for the distinct processing pathways involved in the recognition of facial expressions and the matching of unfamiliar faces has been provided by Bowers, Bauer, Coslett and Heilman (1985), Strauss and Moscovitch (1981), Cicone, Wapner and Gardner (1980), and Pizzamiglio, Zoccolotti, Mammucari and Cesaroni (1983). Evidence for the distinct processing channels involved in the processing of familiar and unfamiliar faces has been reported by Benton and Van Allen (1972), Malone, Morris, Kay and Levin (1982), Warrington and James (1967), Assal, (1969), Rondot, Tzavaras and Garcin (1967), and for an additional report of Rondot et al's patient see Tzavaras, Hécaen and Le Bras (1970). All these studies provided evidence of dissociable face processing abilities when examining various permutations of two of the three face processing pathways of interest (facial expression, familiar face recognition and unfamiliar face matching). However, Bruyer, Laterre, Seron, Feyereisen, Strypstein, Pierrard and Rectem (1983) provided evidence for these distinct processing pathways when measuring all three face processing capacities in one test session.

In summary, whilst there is evidence of dissociable impairments affecting facial expression recognition, familiar face recognition and unfamiliar face matching, to date only a few studies have measured all three face processing abilities in the same investigation and a lot of studies have only considered two out of the three possible face processing capacities, in any one patient. Farah (1991) has argued that in order to clearly map out the underlying functional capacities involved in the processing of various sources of information, one needs to measure each patient's ability to process all sources of information under question. The few studies in the literature which have examined all three face processing capacities, have used differing task demands and have as yet failed to demonstrate all the possible face processing dissociations predicted by the Bruce and Young (1986) functional model of face recognition. In particular, there are as yet no reports of a patient who is impaired on facial expression recognition, but not impaired on familiar face recognition and unfamiliar face matching. Neither are there any reports of a patient who is impaired on familiar face recognition, but not impaired on facial expression recognition and unfamiliar face matching. Or of a patient who is impaired on unfamiliar face matching, but not impaired on facial expression recognition and familiar face recognition.

One of the main weaknesses of previous work has been its failure to equate task demands across the different face processing abilities being measured. For example, facial expression recognition is often measured by asking the patient to identify (i.e. name) expressions drawn from a small set of "universal" emotions. Familiar face recognition, in contrast, usually requires the patient to name familiar face photographs which can be of any familiar or famous person. In contrast, unfamiliar face matching tasks often require the patient to decide if two photographs are of the same or different people. These task demands are quite different and the influence of changes in such, are as yet largely undetermined. Farah, McMullen and Meyer (1991) have identified one of the problems of comparing performance on tasks whose demands vary. They give an example often reported in the literature, where a generic category response is often sufficient for the recognition of nonliving things, but a within-category response is often required for living things. Using such tasks, it becomes impossible to state whether a patient shows a dissociation between the recognition of living and nonliving things, as any difference in performance could be due to these underlying differences in task demands. It is possible therefore, that some of the dissociations reported in the literature might actually reflect the effects of different task demands, rather than the existence of dissociable face processing pathways.

In order to equate task demands as far as possible a common forced-choice procedure was used. This enabled the testing of the three suggested independent processes (facial expression recognition, familiar face recognition and unfamiliar face matching) via a common test procedure, that demands a single standard response pattern (eg. top or bottom) for all tasks. This ensures that for each task the subject is drawing upon information sources and response alternatives of equivalent complexity. This is an important control for memory load. The task requirements imposed by forced-choice are easy to comprehend, which makes them particularly suitable for certain clinical groups and encourages answering and completion of the task. The design also helps to reduce subject response bias.

A matched population of brain-injured patients and normal subjects completed three forced-choice face recognition tasks, testing facial expression recognition, familiar face recognition and unfamiliar face matching. A significant difference was hypothesised between the performance of the patients and the normal subjects on the tasks. It was also hoped that individual differences would be observed in the patients' performance across tasks.

Stimuli and procedure

Patients and normal subjects were tested on three forced-choice recognition tasks and the National Adult Reading Test (NART), produced by Nelson (1982). Each task consisted of 60 presentations of black and white photographs, each measuring 12.5 cm. * 9.0 cm. Details of each task follows.

2.2 Forced-choice face processing tasks.

2.2.1 Facial expression recognition task.

This task consisted of pairs of photographs from the Ekman and Friesen (1976) series. These photographs depicted six woman and four men posing facial expressions of happiness, anger, sadness, surprise, disgust or fear. They were chosen for their accuracy in portraying each of the six facial expressions, using the norms published by Ekman and Friesen (1976). The mean percentage accuracy score was calculated for each category of facial affect, these were as follows; happiness 99.1 %, anger 89.5 %, sadness 92.4%, surprise 90.7 %, disgust 93.1% and fear 89.5 %.

The task was symmetrical in design. The first 30 presentations consisted of each of the six universal expressions paired once with each of the other five expressions (each actor posed each facial expression once). Each pair of photographs was presented on an A4 piece of paper, one at the top, one at the bottom, with a target word in the centre. There were six target words, one representing each of the six universal expressions. The target word corresponded to the expression shown on one member of the pair of faces. There were five presentations of each target word in the first 30 presentations, arranged in a pseudo-random order. The subject had to respond either top or bottom to the photograph which they felt was the best representation of the target word. The second half of the task used identical face stimuli with the same top/bottom presentation order, but the target word presentation was changed to that depicting the other facial expression. It used a different randomised presentation order of stimuli, target word presentation order and response order (top/bottom). For an example of the stimulus presentation format see Figure 3.

2.2.2 Familiar face recognition task.

This task consisted of pairs of highly familiar faces. The familiar faces were drawn from six semantic categories; politicians, television personalities, sports personalities, royalty, comedians and film stars. The task was symmetrical in design. The first 30 presentations involved an equal number of individuals from each of the six semantic categories. The two photographs were presented on an A4 piece of paper, one at the top and one at the bottom, with a target word in the centre. There were six target words, one representing each semantic category. There were five presentations of each target word in the first half of the task. Each pairing consisted of individuals drawn from two of the six semantic categories. One member of the pair was drawn from the semantic category associated with the target word, the other was drawn from a different semantic category. Each of the faces was matched as closely as possible for gender, age and general appearance. In the second half of the task the same pairings were presented, this time with a different target word representing the other member of the matched pair. The pairings were selected so that even with the

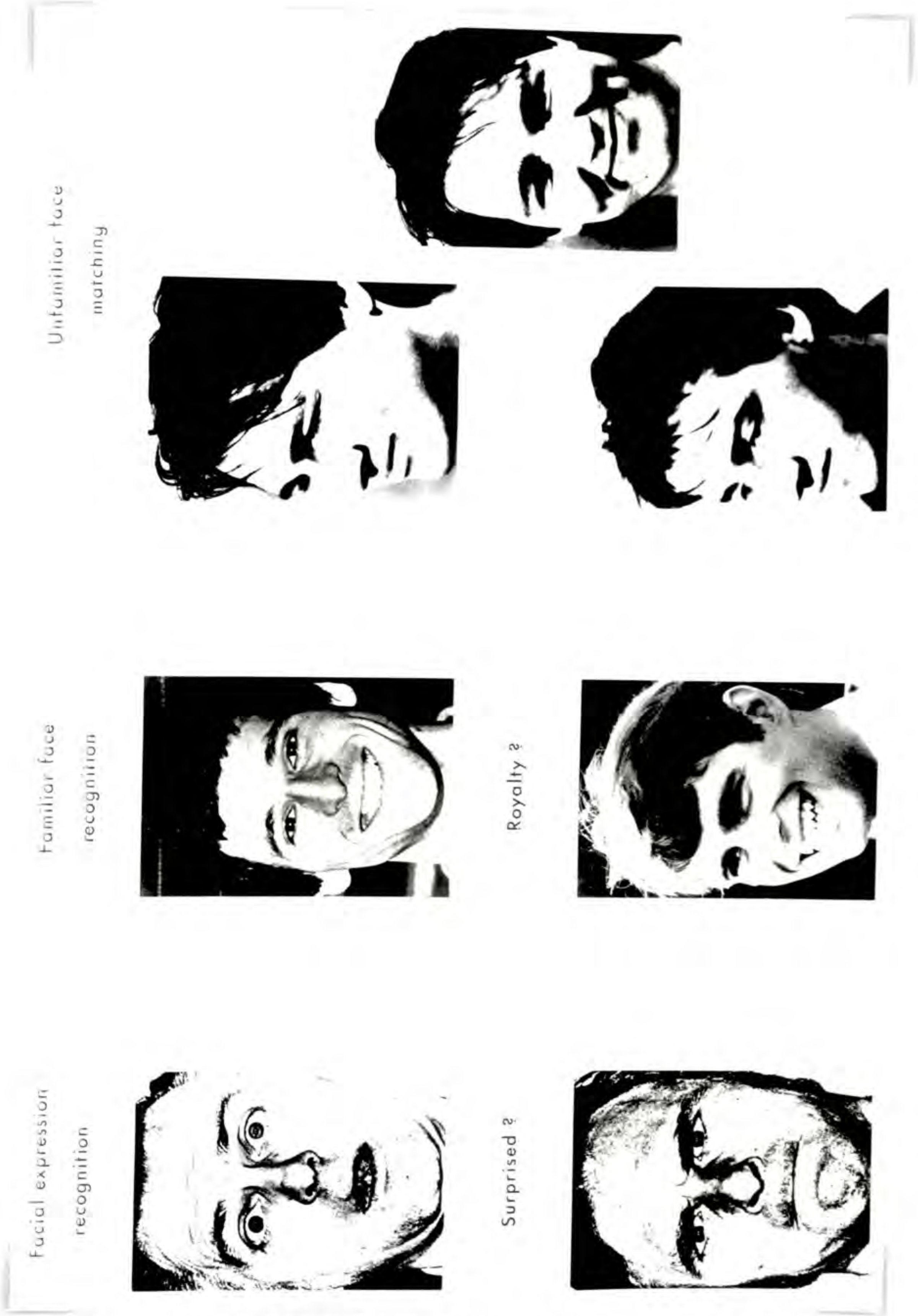

Figure 3. Examples of the stimulus presentation format from the facial expression recognition task (copyright Paul Ekman; reproduced with permission), the familiar face recognition task and the unfamiliar face matching task.

reversal of the target word in the second half of the task, there was still an equal number of presentations of each of the six semantic category target words. The presentation order and response order was randomised throughout the whole task. The subject had to respond either top or bottom to the face which they believed to be associated semantically with the target word. For an example of the stimulus presentation format see Figure 3.

2.2.3 Unfamiliar face matching task.

This task consisted of pairs of photographs of matched unfamiliar faces. There were 15 male and 15 female pairs of faces matched for gender, age, face structure, direction of illumination, hair/beard style and tone and glasses. The task was again symmetrical in design. In the first 30 presentations a full face pose of one member of the matched pair was presented as a target in the middle right hand side of an A4 piece of paper. Another photograph of the same person in 3/4 pose, taken looking either to the viewer's left or right was presented, together with a corresponding 3/4 pose of the matched person, on the left hand side of the page, one at the top one at the bottom. In the first half of the task there were eight male and seven female presentations looking to the left, and seven male and eight female presentations looking to the right. This order was reversed in the second half of the task. The male and female, left/right 3/4 pose presentations remained the same, except one female right pose presentation was changed to a female left pose, and one male left pose presentation was changed to a male right pose. In the second half of the task the second member of each matched pair was presented as the full face target, with a left/right, 3/4 pose of this person and the corresponding pose of the matched person presented on the left hand side of the page; one at the top, one at the bottom. Throughout the task the subject was asked to match the full-face target to one member of the pair of left/right 3/4 face photographs. Their response was therefore to choose either the top or bottom 3/4 view face. There were 30 left pose, 30 right pose presentations and 30 top, 30 bottom correct response presentations in total. Throughout the task the male/female presentations, top/bottom response order and left/right pose presentation was randomised. For an example of the stimulus presentation format see Figure 3.

The three recognition tasks were administered in succession; firstly the expression recognition task, then the unfamiliar face matching task and finally the familiar face recognition task. The patients were given concise instructions explaining exactly what each task involved and what they were required to do. Each subject agreed upon the form of answering they would use eg. verbal reporting of top/bottom, or verbal reporting with simultaneous pointing to the corresponding photograph. The patients were told to work through each book at their own pace, turning the page as and when necessary. The experimenter recorded the patients' responses on the task response sheet. At the end of each task the patient was questioned further regarding any task associated problems they experienced and the types of strategies they employed in completing the task. The NART was administered in accordance with the test's standardised instructions after the three recognition tasks were completed.

The same procedure was used for the normal subjects, except that they worked through the three tasks in succession, with no questioning in-between tasks. Neither subject group received feedback during testing.

Subjects

Fifteen brain-injured patients (13 male, 2 female), with post-traumatic amnesia greater than 24 hours were tested. Eleven of the male patients had suffered closed head-injury, one had suffered a cerebral haemorrhage, the other an aneurysm. The two female patients were both closed head-injury patients. The mean age of the patients at date of testing was 39.2 years. Their mean age on leaving full time education was 16 years and their mean NART error score was 22.46.

Each of the patients was matched to a normal subject on gender, age at date of testing, age on leaving full time education and NART error score. The fifteen normal subjects were drawn from a population of maintenance and office workers. Their mean age at date of testing was 38.6 years. Their mean age on leaving full time education was 15.93 years and their mean NART error score was 20.33.

Three separate correlated t-tests were performed on the patients and normals' age at date of testing, age on leaving full time education and NART error scores. The two groups were not significantly different on any of these measures, confirming the validity of the matching; (age at date of testing, $t = 1.03$, d.f. = 14, $p > 0.1$; age on leaving full time education, $t = 0.56$, d.f. = 14, $p > 0.1$; NART errors, $t = 1.54$, d.f. = 14, $p > 0.1$).

Results and discussion

The means and standard deviations for the patients and normal subjects on the three forced-choice tasks are presented in Table 1.

Table 1: Means and standard deviations for errors made by the patients and normal subjects on the three forced-choice face processing tasks.

	Facial Expression Recognition	Familiar Face Recognition	Unfamiliar Face Matching
Patients:			
Mean	3.87	3.20	6.00
SD	1.88	3.76	4.49
Normal subjects:			
Mean	2.73	0.93	3.00
SD	1.94	1.28	2.65

A two factor analysis of variance was carried out on the accuracy data, to determine the effects of subject Group and Task (repeated measure). Significant main effects of each factor were observed. First an effect of subject Group (F = 7.15, d.f. = 1, 28, $p < 0.05$). The patients made significantly more errors than the normal subjects on the forced-choice face recognition tasks. Second an effect of Task (F = 8.20, d.f. = 2, 56, $p < 0.001$). This was further analysed by a post hoc Newman-Keuls test ($\alpha = 0.05$) which revealed that the performance of the subjects as a whole on the familiar face recognition task was significantly different from their performance on both the expression recognition task and the unfamiliar face matching task. The Group $*$ Task interaction effect was not significant, (F = 1.22, d.f. = 2, 56, $p > 0.1$), which indicated that, as a group, the patients were equally impaired for all three face processing tasks.

In addition to comparing the performance of the matched groups of subjects, impairments shown by individual patients were also examined. The patients' performance on these tasks was compared to the mean and standard deviation of the normal subjects. The mean and standard deviation were used to derive cut-off scores which differed from the normal subjects' mean at .05 ($z>1.65$), .01($z>2.33$) and .001($z>3.10$) levels of statistical significance. This method of determining impaired performance on each task has been used throughout the remainder of this thesis (unless stated otherwise) and the reader is referred to these z scores, a copy of which can be found at the end of the first table of each chapter.

Using these cut-off scores, specific dissociable impairments were observed in the patient group. Table 2 shows the error scores of patients who were significantly impaired on one or more of the forced-choice face recognition tasks.

Table 2: Error scores of patients who were significantly impaired on one or more of the forced-choice face processing tasks. Their NART error scores are included for comparison.

	Facial Expression Recognition	Familiar Face Recognition	Unfamiliar Face Matching	NART Error Score
Patients:				
JP	7 *	0	3	21
AB	3	7 ***	3	12
HI	4	7 ***	7	23
VS	4	1	9 *	27
DH	5	5 ***	10 **	29
DS	3	8 ***	14 ***	27
ID	7 *	4 **	9 *	23
JT	6 *	12 ***	15 ***	17
Normals :				
Mean	2.73	0.93	3.00	20.3
SD	1.94	1.28	2.65	7.3

*** $z > 3.10$, $p < .001$
** $z > 2.33$, $p < .01$
* $z > 1.65$, $p < .05$

Patient JP was significantly impaired ($z = 2.20$, $p < .05$), only on the expression recognition task. Patient VS was significantly impaired ($z = 2.26$, $p < .05$), only on the unfamiliar face matching task and patients AB and HI were significantly impaired ($z = 4.74$, $p < .001$) only on the familiar face recognition task. The observed dissociable impairments of patients JP, AB and VS are particularly impressive, as their performance on the tasks on which they were "unimpaired" was never more than 0.65 standard deviations below the normal subjects' mean and was usually as good as or better than that of the normal subjects.

A further two patients, DH and DS were significantly impaired on both the unfamiliar face matching (DH, $z = 2.64$, $p < .01$ and DS, $z = 4.15$, $p < .001$) and the familiar face recognition tasks (DH, $z = 3.18$, $p < .001$ and DS, $z = 5.52$, $p < .001$). Two other patients (ID and JT) were significantly impaired on all three tasks; facial expression recognition (ID, $z = 2.20$, $p < .05$ and JT, $z = 1.68$, $p < .05$), familiar face recognition (ID, $z = 2.40$, $p < .01$ and JT, $z = 8.65$, $p < .001$) and unfamiliar face matching (ID, $z = 2.26$, $p < .05$ and JT, $z = 4.53$, $p < .001$).

Although cases of dissociable impairment were observed in the brain-injured patient group, it is important to note that even the most severely impaired patients were able to perform all the face processing tasks at well above chance level (see Tables 1 and 2; chance performance = 30 errors on each task). Hence, the impairments are relatively mild compared to those often cited in neuropsychological studies, which can be severe and longstanding. As such, one may question whether the four patients who actually showed dissociable impairments on the different face processing tasks are not actually performing in line with normal subjects, who, it could be argued, may also show natural variations in their ability to process different sources of facial information. As individuals we may develop abilities to preferentially process certain sources of information. For example, we may be particularly skilled at using the feature matching strategies necessary in the matching of unfamiliar faces and may also be able to accurately differentiate between different facial expressions, yet we may not be very accurate at recognising familiar faces. For this reason, the performance of the normal subjects on the three face processing tasks was also examined, specifically questioning whether the normal subjects showed any similar differences in performance which might be comparable to the specific dissociable impairments found in the group of brain injured patients. Table 3 shows the error scores of the normal subjects on the three forced choice face recognition tasks.

Using the conservative procedure of comparing each normal subject's error score on each task to the mean and standard deviation of the group of normal subjects on that task, specific dissociable performance differences were also observed in the group of normal subjects (although it should be noted that there are considerably fewer dissociable performance differences in the normal subjects group). Normal subjects number five and seven were significantly below the mean for normal performance ($z = 1.68$, $p < .05$ and $z = 2.20$, $p < .05$ respectively) only on the expression recognition task. Normal subject number six was significantly below the mean for normal performance ($z = 2.26$, $p < .05$) only on the unfamiliar face matching task and normal subject number 15 was significantly below the mean for normal performance (z = 2.40, p < .01) on the familiar face recognition task only.

Table 3: Error scores of the normal subjects on the three forced-choice face processing tasks.

	Facial Expression Recognition	Familiar Face Recognition	Unfamiliar Face Matching
Normal subject's errors:			
1	2	0	2
2	0	1	4
3	3	2	6
4	0	0	1
5	6 *	0	3
6	2	2	9 *
7	7 *	0	0
8	3	0	4
9	2	1	1
10	2	0	3
11	2	3	0
12	2	0	1
13	2	0	7
14	5	1	3
15	3	4 **	1
Mean	2.73	0.93	3.00
SD	1.94	1.28	2.65

From this separate analysis it is clear that those brain injured patients who showed specific dissociable impairments on the face processing tasks were actually performing in a similar way to some members of the group of normal subjects. Therefore, in order to argue that specific dissociable impairments on the different face processing tasks provides evidence for independent processing channels, one really needs to observe much greater impairments on the given face processing task.

In summary, one can see that despite having accurately matched the clinical and normal populations on gender, age at date of testing, age on leaving full time education and intelligence (NART), a significant difference was found between the patients and normals' face processing capacities, which cannot therefore be attributed to a general intellectual impairment. The significantly greater number of errors the patients made on the three face processing tasks must therefore, be accounted for in terms of their existing cerebral damage.

Although the patients made more errors than the normals, both groups showed a similar pattern of performance in terms of the relative difficulty of the three tasks. The patients and normals made significantly fewer errors on the familiar face recognition task than on the expression recognition and the unfamiliar face matching tasks.

As hypothesised, specific dissociable impairments on the three forced-choice face processing tasks were observed in the patient group. Of special interest was the observation of patients with impaired performance on one of these tasks, whilst maintaining intact performance on the other two tasks. Such dissociable impairments were observed for each of the three face processing tasks. However, similar patterns of performance were also observed in the group of normal subjects. It is therefore possible that the brain injured patients' performance may actually reflect a pre existing variation in normal ability to process the different sources of facial information. It was concluded that in order to provide support for Bruce and Young's (1986) functionally independent channels for the processing of expression, identity and unfamiliar faces, one needs to observe much greater impairments on the respective face processing tasks by the brain injured subjects.

Bruce and Young's (1986) functional model of face recognition can account for impairments (providing they are large enough) affecting a single task and for the observed patterns of co-occurrence of impairment on more than one task. It thus, provides a parsimonious description of the underlying patterns of impairment, since combinations of dissociable deficits which would demand the postulation of multiple deficits in the model (for example, impaired processing of facial expressions and familiar faces, with preserved unfamiliar face matching ability) did not occur. Since there are several such potential combinations, their non-existence in the present patient group demonstrates further the effectiveness of the model as an economical description. That is not to say of course that multiple deficits could never occur. The point is simply that had they been found to be common, one would have to ask whether a more efficient description could be achieved.

Chapter Three

Examination of Agnosic Patients' Ability to Process Movement and Facial Expression

3.1 Introduction.

Disorders of recognition are referred to in the literature as "agnosias" and are commonly associated with brain-damage in the region of the occipital lobes. Generally speaking agnosic patients can sense forms and objects but cannot recognise and interpret what they see. Within this broad category of agnosia there are several sub categories defining the various forms of agnosia including object agnosia, where visual recognition is impaired, but recognition by others means eg. touch is fine. Colour agnosia, of which there can be three forms; visual agnosia for colours, colour naming deficits and achromatopsia, an inability to differentiate between hues. Finally, there is face agnosia, commonly referred to as prosopagnosia, where one is unable to overtly recognise once highly familiar faces, although recognition can be achieved by other means, eg. voice, gait, etc. Commonly patients with face agnosia recognise the face as a face, the parts are easily identifiable and the face gestalt can be easily recognised and distinguished from other non-face stimuli (Blanc-Garin, 1986). Agnosia for human faces can exist independently of the ability to process other categories of faces. For example, Bruyer, Laterre, Seron, Feyereisen, Strypstein, Pierrard and Rectem (1983) described a prosopagnosic patient who could identify his cows and dogs. In contrast, Assal, Favre and Anderes (1984) described a patient who could not recognise his herd of cows with whom he was very familiar, but was able to recognise the faces of famous celebrities. There are also however, cases where prosopagnosia exists alongside agnosia for animal faces (Bornstein, Stroka and Munitz, 1969).

Agnosia is normally seen in the absence of a general intellectual deterioration, perceptual impairments and language deficits, although agnosic patients can experience several agnosias simultaneously. For example, object agnosia can be accompanied by both colour and face agnosia (see Damasio, Damasio and Van Hoesen, 1982, case 2).

The three agnosic patients which shall be discussed in this chapter have various permutations of the different types of agnosias discussed above. However, they all have a single problem in common, prosopagnosia. Prosopagnosia refers to an inability to recognise overtly, once highly familiar faces despite being able to perceive the face as such and name the facial features accurately. Although prosopagnosia is a rare complaint, it does have devastating effects. There is even evidence of prosopagnosic patients who are unable to recognise themselves when looking in a mirror (De Romanis and Benfatto, 1973 and Shuttleworth, Syring and Allen, 1982). Emphasis is placed on the ability of not being able to overtly recognise faces. De Haan, Young and

Newcombe (1987b) for example, have reported details of a prosopagnosic patient, who was able to perform within the normal range on a number of face processing tasks that did not require explicit identification (eg. matching, interference and learning tasks). De Haan et al concluded that in prosopagnosia many of the processes involved in face recognition can remain intact and that it is the awareness that recognition has occurred, that is affected. Bauer (1984), was one of the earlier researchers to demonstrate these covert recognition abilities (despite overt recognition failure), which he described as occurring at the "psychophysiological level." He described a prosopagnosic patient who showed greater electrodermal skin conductance responses to correct than incorrect names of photographs of famous personalities and members of his family, despite being unable to recognise them overtly.

As can be seen from the evidence presented in chapter two, brain-damage can cause "specific" face processing impairments (although it is also important to acknowledge, that individuals may also have pre existing variations in their ability to process different sources of facial information, see chapter two). That is to say a patient may experience a specific impairment in the processing of one source of information, but remain able to process normally other sources of facial information. For example, they may show a specific impairment in the processing of face identity, but remain able to process facial expressions and match unfamiliar faces. (The reader is referred to this description of what is meant by specific face processing impairments, wherever this term is used again throughout the remainder of this thesis). There is evidence presented in the literature for the functional independence of the processing capacities involved in the analysis of facial identity, facial expression and unfamiliar face matching. However, this evidence is based on tasks composed of static, black and white photographs as stimuli, yet our normal everyday perception of facial information is from dynamic, articulating faces. Therefore, although this evidence has been very informative about the brain's ability to process different sources of facial information, it may not in actual fact be providing a very accurate representation of the underlying nature of the cognitive processes.

It is known that form, movement and colour are handled by independent processing pathways (Livingstone, 1988 and Livingstone and Hubel, 1988), and that these processing pathways are probably capable of passing information amongst themselves. It is also known that movement plays an integral role in our everyday perception of people and their facial expressions. Therefore, it does not appear to be the most sensible strategy in assessing face processing impairments, to rely exclusively on tasks composed of black and white photographs. One can never be sure in adopting this methodology, of the underlying nature of the deficit. It could be that some of the milder face processing impairments reported in the literature to date are an artifact of the nature of the task demands and are not due to an underlying face processing deficit. It is very important to reconsider all aspects of facial information processing (identity, expression and lip-read speech) in terms of the possible role of dynamic information in such analyses.

The aim of this chapter is to question the current literature's failure to consider the role of dynamic information in the processing of facial information, by initially examining three agnosic patients; PH, NR and MS. Firstly, an assessment of the extent to which these agnosic patients are able to process facial movement information will need to be made, as some agnosic patients, eg. Bodamer's (1947) patient 'A' also experienced a movement perception deficit (see Ellis and Florence, 1990 for a translation of Bodamer's paper). After which PH's, NR's and MS's ability to process emotional facial information will be considered. An important addition will be made to the current literature by the production of video recognition tasks which compare dynamic with static (where the clip will be recorded whilst being held on pause) clips of facial information. By comparing each agnosic patients' performance on static and dynamic clips of facial information, an assessment of the extent to which movement facilitates (if any) their processing of that source of facial information can be made. As it has already been pointed out, dynamic information plays an integral role in our everyday recognition of facial information. Facial expressions by their very nature are dynamic and in essence dependent upon movement for their accurate portrayal, requiring the unfurling of their successive facial muscle actions involved in their production. Therefore, it was hypothesised that there will be a facilitation in the recognition of facial expressions with the introduction of dynamic information. Thus, patients with static facial expression recognition deficits, but normal perception of movement may see an improvement in their expression recognition performance when given tasks consisting of dynamic video sequences of facial expression. The introduction of dynamic information should provide the perceiver not only with more information to base their expression recognition judgement upon, but also a more "natural" example of a given facial expression (see chapter one, for a more detailed account of this hypothesis).

The television provides a wealth of suitable information, including spontaneous facial movements and facial expressions. A large library of video clips of the upper part of the body only, of male and female unfamiliar persons was collected from various recorded television programmes. These clips have as much hand and body movement eliminated as possible, so as to reduce the possibility of judgements being based upon "external" cues and not upon pure facial information. A detailed description of each task follows, but firstly a brief case descriptions of each of the agnosic patients is provided.

3.2 Case descriptions.

3.2.1 PH.

In 1982, at 19 years of age, PH was involved in a road traffic accident in which he sustained a severe closed head-injury. A full case description has been given by De Haan, Young and Newcombe (1987b), so only a summary of the main results shall be provided here. PH's intellectual abilities were reduced on the performance sub tests, but in the average range on the verbal sub tests of the Revised Wechsler Adult Intelligence Scale. His language functions were relatively preserved and he could read without difficulty. PH's visual and verbal short term-memory was intact, but his long term-memory was severely reduced in both domains. He had a variety of problems in visual and spatial perception, showing reduced contrast sensitivity for the middle and high spatial frequencies. He was however able to read very small print and experienced no problems with the perception of colour. Faces were recognised as such and easily distinguished from animal faces. However, matching photographs of unfamiliar faces, recognition of emotional facial expressions and race and gender discriminations were all at least moderately impaired. PH's overt recognition of familiar faces was very poor, but he was able to recognise people from their name or voice. He was poor at making other within-class recognition judgements (Damasio, Damasio and Van Hoesen, 1982) including cars and flowers and showed evidence of a mild degree of object agnosia on object recognition tasks. A recent MRI scan shows bilateral abnormal signal in the temporo-occipital junction, mainly in the inferior surface. In summary, PH experiences long term memory problems, a mild degree of object agnosia and is prosopagnosic. He is however, able to read and perceive colour.

3.2.2 MS.

In 1970, at the age of 23 MS contracted a febrile illness. He was believed to have herpes encephalitis although this was never confirmed by viral antibody studies. A detailed case description has been given by Ratcliff and Newcombe (1982), so only a summary of the main results will be provided here. MS's visual acuity is normal but he does have a left hemianopia. He has impaired colour vision and severe object agnosia, affecting both real objects and pictures of objects. He can however, make accurate line by line copies of drawings of objects and he is able to read normally. MS is completely unable to recognise familiar faces and is poor at matching photographs of unfamiliar faces and facial expressions. A CT scan carried out in 1980 and subsequent MRI showed extensive bilateral infarction mainly in the occipital lobe, but extending forward into the parietal and temporal lobes. This was especially evident in the right hemisphere. In summary, MS shows object agnosia, prosopagnosia and impaired colour perception, but remains able to read.

3.2.3 NR.

In 1982, NR aged 25 years, was involved in a motor car accident, receiving a severe closed head-injury. A detailed case description has been given by De Haan, Young and Newcombe (in press, a), so only a summary of the main results will be provided here. NR has reduced visual acuity in the left eye and depressed contrast sensitivity functions affecting the left more than the right eye. He is however, able to read small print. His colour vision is also moderately impaired. NR has severe memory problems, affecting both the verbal and visual domains. He is very poor at processing facial information, including making age and sex judgements, matching photographs of unfamiliar faces and facial expressions and he is unable to recognise familiar faces. NR also showed visual recognition difficulties for objects. CT scans performed in 1982 show a shallow extra-cerebral collection of blood and cerebro-spinal fluid in the right parietal lobe. A repeat scan in 1983, showed infarction in the left parieto-temporal lobe. In summary, NR shows gross memory problems, impaired visuospatial perception, mild object agnosia, severe prosopagnosia, but relatively well preserved reading.

3.3 Test methodology.

Each agnosic patient completed three video recognition tasks; two movement recognition/judgement tasks and one emotion recognition tasks. Each task consisted of 48 test clips approximately six seconds in length, interspersed by a blank clip of equal duration. The clips were edited from various recorded television programmes depicting both male and female unfamiliar persons. A detailed description of each task follows shortly.

The television programmes were recorded, edited and the finished task was presented using Betamax video cassette recorders. The patients viewed the video tasks on a colour receiver/monitor (screen size 20 cm * 25 cm). The normal subjects viewed the video tasks on a colour television/computer monitor (screen size 22 cm * 29 cm).

For each task the patients were seated approximately 90 cm away from the television monitor. They were given precise instructions regarding exactly what they would be viewing and what judgement they would be required to make. They were informed that if they were unsure about a particular clip it could be replayed as and when requested and that if they were still unsure they should have a guess at the answer. They were instructed to watch each clip to the end and then respond verbally during the following blank clip, where the experimenter recorded their response. At the end of the video task they were given appropriate feedback and were questioned about any task difficulties that they appeared to show. The same general procedure was used in administering the video tasks to the normal subjects, except the normal subjects received no feedback or inter-task questioning.

3.4 Movement recognition tasks.

3.4.1 Spontaneous facial feature movement task.

This task involved the detection of internal facial feature movement, eg. muscle twitches, eye blinks and in some clips mouth articulation.

Stimuli

This task compared an equal number of clips depicting "head static, internal features static" (produced by editing a video clip of a moving face held on pause) with clips depicting "head static, internal features moving." In all the clips the head was static and the subject had to detect internal feature movement. The test clip presentation order was randomised with the only constraint that the same presentation mode (internal features static/moving) did not occur in more than four consecutive trials.

Subjects had to decide whether the internal features were "static" or "moving."

Normal subjects

Ten normal adult male and female subjects were paid for completing this task. They included undergraduate and postgraduate students of Lancaster University and members of the general public.

Results and discussion

Table 4: PH, NR, MS and the normal subjects' error scores on the spontaneous facial feature movement task.

	PH	NR	MS
Error score	1/48	2/48	2/48
Normal subjects			
Mean error score	0.5		
SD	0.7		
Range	0-2		

Perhaps the first point to note from Table 4 is the fact the the normal subject's performance is close to ceiling level and as such it would be dubious to compare the patient's performance to that of the normal subjects, where the normal subjects' standard deviation is curtailed by the ceiling effect. Instead, the normal subjects' range is included for comparison, where we can see that both PH's, NR's and MS's performance falls within the normal range. It was concluded that they are all therefore able to detect internal facial feature movement normally.

A Binomial test (Siegel, 1956) was also used to calculate the probability of NR and MS making two errors by chance, (as extrapolated from the normal subject's performance). $z = 1.48$ which was not found to be significant, thus, further supporting the above claim that NR's and MS's performance did not differ significantly from the normal subjects.

3.4.2 Speed of facial movement task.

This task involved the judgement of the speed of facial feature articulation.

Stimuli

This task compared an equal number of clips of "facial movement with talking recorded at normal forward playback speed," with clips of "facial movement with talking recorded at double the normal playback speed." The test clip presentation order was randomised with the only constraint that the same category of facial movement (normal speed/double normal speed) did not occur in more than four consecutive trials.

Subjects had to decide if the facial features were moving at their normal speed or twice their normal speed. Their possible response alternatives were either "normal" or "not normal" speed.

Normal subjects

Ten normal adult male and female subjects were paid to complete this task. They included undergraduate and postgraduate students from Lancaster University and members of the general public.

Results and discussion

As Table 5 shows, NR's error score is significantly above the normal subjects' mean ($z = 3.43$, $p < .001$). He is grossly impaired at making speed of facial feature articulation judgements. The large number of errors that NR made on this task could however, possibly reflect a conceptual misunderstanding of the task demands. MS and PH can both accurately judge the speed of facial feature articulation.

Table 5: PH, NR, MS and the normal subjects' error scores on the speed of facial movement task.

	PH	NR	MS
Error score	4/48	15/48 ***	8/48
Normal subjects			
Mean error score	4.7		
SD	3.0		

*** $z > 3.10$, $p < .001$
** $z > 2.33$, $p < .01$
* $z > 1.65$, $p < .05$

The results of this task and the facial feature articulation task taken together show that NR appears to have a specific facial movement processing impairment affecting his ability to make speed of facial feature articulation judgements. PH and MS however, perform normally on both the internal facial feature and speed of facial feature movement judgement tasks.

Now that the extent to which the agnosic patients are able to process certain types of facial movement has been determined, consideration can be given to the extent to which they are able to process facial emotion and the role that dynamic information may play in the processing of this source of facial information.

3.5 Facial expression recognition task.

3.5.1 Dynamic/static spontaneous facial expression task.

This task involved the recognition of three facial expressions presented in both moving and static mode of presentation.

Stimuli

This task compared an equal number of "static" and "dynamic" clips of the facial expressions happiness, anger and sadness. All the dynamic clips were of facial movement with talking. The static clips were recorded from the apex of a dynamic clip held on pause, (but not from the apex of the clips used in the dynamic condition, they were all unique clips). The test clips were arranged in four blocks of 12 (two blocks of static facial expressions and two blocks of dynamic facial expressions), with an equal number of each of the three facial expressions presented in each block. The blocks were presented in an ABAB design, with static expressions presented first. The presentation order of the facial expressions was randomised (within blocks) with the only constraint that the same category of facial expression did not occur in more than three consecutive trials.

Subjects had to decide whether the faces were either "happy," "angry" or "sad."

Normal subjects

Ten normal adult male and female subjects were paid for completing this task. They included undergraduate and postgraduate students of Lancaster University and members of the general public.

Results and discussion

Table 6: PH, NR, MS and the normal subjects' error scores on the dynamic/static spontaneous facial expression task.

	Facial Expressions	
	Static clips	Moving clips
PH	8/24 ***	5/24
NR	5/24 *	5/24
MS	14/24 ***	15/24 ***
Normal subjects		
Mean error score	2.2	4.6
SD	1.4	1.5

Table 6 shows that PH's error score for static facial expressions is significantly above the normal subjects' mean ($z = 4.14$, $p < .001$), while for dynamic facial expressions his error score is normal. Therefore, PH is significantly impaired on static facial expression recognition, while showing normal recognition of moving facial expressions. This result is very interesting; not only does it confirm that PH is able to process movement (see tasks 3.4.1 and 3.4.2), but it strongly suggests that he is able to use dynamic information to facilitate his impaired recognition of static facial expressions. NR's error score for static facial expressions was also significantly above the normal subject's mean ($z = 2$, $p < .05$), while his dynamic facial expression error score was normal. His performance is in line with PH's performance, suggesting that for NR too, dynamic information facilitates his recognition of static facial expressions, although his impairment on static facial expressions is not as convincing. NR appears to be able to successfully use the dynamic information available in this task, whilst he showed a significant impairment on the speed of facial movement task discussed earlier. This provides further support for the claim that NR's gross impairment on the speed of facial feature articulation task may actually have been due to a conceptual misunderstanding of the task demands, as he clearly shows that he is able to use the dynamic information available in this task. MS was significantly impaired on both the static ($z = 8.43$, $p < .001$) and dynamic ($z = 6.93$. $p < .001$) facial expressions. He appears to have a gross impairment in the recognition of facial expressions and gains no facilitation from the inclusion of dynamic information.

In summary, it appears that for the agnosic patients PH and NR, dynamic information is somehow able to feed into the analysis of facial expressions, with facilitative consequences upon recognition. These results have important implications. Not only do they support the claim that the current literature is limited by its failure to consider the role of dynamic information in the processing of facial information, but they add weight to the suspicion that possibly some of the milder facial expression recognition impairments reported in the literature to date, are an artifact of the nature of the test stimuli used, namely photographs. It is important to maybe re-consider some of these milder facial expression recognition deficits in terms of the extent to which the observed errors are due to a pure deficit in the analysis of facial expressions and not due to other related factors such as the nature of the task stimuli. This is especially important in light of the conclusions drawn about PH's and NR's ability to process facial expressions, given the observed improvement in their expression recognition performance with the introduction of dynamic information.

Suffice to say, it would be wrong to assume that the facilitative consequences of dynamic information upon PH's and to a lesser extent NR's recognition of facial expressions will be observed for all other patients with mild static facial expression recognition impairments. However, it is felt that the evidence reported here for a significant role of dynamic information in the recognition of facial expressions, should be given careful consideration in the designing of facial expression recognition tasks in the future.

This initial examination of these three agnosic patients' ability to process both facial movement and facial expressions has proved very interesting. It appears that for some agnosic patients (PH and NR) with static facial expression recognition impairments, dynamic information can facilitate their recognition of such facial expressions. PH's performance is particularly impressive as he demonstrated that he is clearly able to process two types of facial movement (internal feature and speed of articulation), and that despite showing a significant impairment in the recognition of static facial expressions ($z = 4.14$, $p <.001$) he is able to use this dynamic information to facilitate his otherwise impaired processing of facial expressions (so that his performance now falls in line with that shown by the normal subjects).

It is a clearer understanding of PH's facial information processing capacities which shall be developed in the rest of this thesis. Initially the aim was to reconsider the observation that PH is able to successfully process facial movement information, after which the aim is to measure the extent to which dynamic information can feed into other face processing channels including, facial identity and lip-read speech, and also facial expression. The aim is to not only try and replicate the observation reported here of a facilitation in the recognition of static facial expressions with the introduction of dynamic information, but also to consider the role which other factors play in the recognition of facial expressions, such as the degree of affect seen and the region of the face in which the facial expression is displayed.

The following two chapters have been broken down into those sources of facial information which PH showed no facilitation in his recognition performance with the introduction of dynamic information, namely familiar face identity recognition and those sources of facial information which PH did experience a facilitation in his recognition performance with the introduction of dynamic information, namely facial expressions and lip-read speech.

Chapter Four

Examination of PH's Identity Recognition

4.1 Introduction.

PH's familiar face identity recognition abilities have been extensively examined; a brief overview of which shall be provided. Basically though, these behavioural studies have demonstrated that although PH cannot overtly recognise a previously familiar face (even on recognition tests requiring the simplest of judgements, like a familiarity decision), he nevertheless shows an extensive degree of covert recognition on tests that do not require him to recognise explicitly, the faces seen.

This striking effect of successful covert recognition despite an inability to overtly recognise faces, has been demonstrated in several prosopagnosic patients in the literature. It has been found not only when using behavioural techniques, but also when using electrophysiological measures, for example, electrodermal responses, see for example, Bauer (1984), Tranel and Damasio (1985, 1988) and Bauer and Verfaellie (1988).

PH's familiar face identity recognition abilities have been extensively examined. De Haan, Young and Newcombe (1987b) reported how PH, despite being unable to recognise familiar faces overtly, performs within the normal range when explicit recognition is not required. He thus, demonstrated a clear degree of covert recognition despite showing a complete failure to recognise familiar persons overtly. De Haan et al's examination included matching, learning and interference tasks. They found that although slower than normals, PH could match pairs of familiar faces faster than unfamiliar faces. In the interference tasks, PH was required to categorise names as belonging to politicians or not. He was slower when the seen face and name were incongruous, thus demonstrating that he could covertly identify the familiar faces seen in the photographs. This effect even existed when the incongruous face and name were matched on physical appearance (De Haan, Young and Newcombe, 1987a). PH also demonstrated that he was more able to learn true than untrue occupations and names to familiar faces and this naming effect was also observed for faces which PH had met since his accident. De Haan et al (1987b) claimed that covert recognition can be demonstrated for the different stages in the processing of facial information and that the face processing system continues to store covertly, new information pertaining to faces observed since the damage to the system. They suggested that covert recognition represents a breakdown in the "awareness" of recognition, rather than a breakdown in the face processing system itself.

Young and De Haan (1988) questioned further what sources of information PH could access covertly. Using De Haan et al's (1987b) task 1 stimuli, they found that

PH was at chance level at making forced-choice familiarity decisions, yet was more accurate (but still not within the normal range) for names. Thus, PH is clearly not able to access even a sense of face familiarity overtly. In a further task requiring the learning of "precise" semantic information to faces, PH showed no difference between true and untrue pairings, demonstrating that not only is he not able to covertly access precise semantic information, but that the semantic information accessed in De Haan et al's (1987b) learning tasks, must have been rather more general semantic information. Even using face stimuli with which PH is more knowledgeable (eg. sports personalities), he is still not able to demonstrate covert access to precise semantic information. Young et al claimed that PH's covert recognition effects are largely dependent upon the nature of the tasks. They claimed that PH shows a dissociation between identity judgements which demand "explicit" and "implicit" recognition, where he is impaired at the former and not the latter. However, they also pointed out that PH does not demonstrate covert recognition for all implicit recognition tasks.

PH not only experiences problems in identifying faces but also experiences other within-category classification problems including identifying cars and flowers. De Haan, Young and Newcombe (in press, b) described how despite PH's poor overt identification of cars and flowers, he nevertheless showed a covert ability to identify cars and flowers, performing at above chance level on a forced-choice task in which he had to choose the correct name for the picture he saw. He also showed a superior ability to learn true than untrue names, to pictures of cars and flowers. De Haan et al claimed that PH clearly demonstrated covert recognition (despite his overt recognition deficit) for cars and flowers, as well as faces.

It is important to point out that these covert recognition effects which have clearly been found to exist for PH are not always found in prosopagnosia. Newcombe, Young and De Haan (1989) for example described how MS, who has both face and object agnosia, was at chance level at making forced-choice face familiarity decisions and demonstrated no degree of covert recognition. De Haan, Young and Newcombe (in press, a) described how NR on the other hand differs significantly from both PH and MS. He was well above chance on the forced-choice face familiarity task, but showed no evidence of covert recognition except however, when he was given a task involving stimuli which he showed recognition for in the forced-choice task. De Haan et al claimed that this suggests NR's "store" of familiar faces is severely reduced, thus limiting the number of faces which he can recognise, rather than representing an access problem, where the store remains intact but retrieval is impaired. Bauer (1986), described how the prosopagnosic patient GY (case two of Ross, 1980) failed to show any electrodermal discrimination of correct facial identity. Bauer claimed this was a result of a severe apperceptive disorder preventing GY from forming adequate perceptual images necessary for such discriminations. Sergent and

Villemure (1989), reported details of a right hemispherectomy patient with prosopagnosia, who showed no signs of covert recognition of known faces, whilst Young and Ellis (1989), reported a case of childhood prosopagnosia with no overt or covert recognition of faces.

To date a similar story exists in the identity recognition literature as in the expression recognition literature, where the majority of the tasks reported consist of static stimuli, namely photographs and slides. However, there has been a rather greater attempt at introducing dynamic information into identity recognition tasks. A popular technique for doing this is the point light display technique (see the introduction of chapter five, for a description of the point light display technique) where pure movement patterns absent of any structural/configural information are used in various recognition judgements; including judgements of sex, identity and expression. However, it is felt that "video" still provides the easiest way of assessing the role of dynamic information in the processing of facial information. Here dynamic information is provided in conjunction with the structural/configural information available in static photographic images. By comparing static and dynamic clips of familiar faces, one can determine the extent to which dynamic information facilitates such recognition judgements.

There are a few studies in the literature where the role of dynamic information in the processing of familiar face identity has been assessed, using the video and point light display techniques. Bruce and Valentine (1988) for example, made a video of 15 male actors performing various facial movements and produced slides of stills from these video sequences. On a separate occasion, other slides of each actor in three-quarters view were taken and a further 15 slides of unfamiliar persons, also taken in a three-quarters view, acted as distracter faces. Normal subjects were shown a combination of faces presented as either video sequences or slides of stills taken from these sequences and one hour later, recognition memory for these faces was tested. Subjects were now presented with the three-quarters view of the target and distracter faces and were required to say whether they had seen each face previously. Bruce and Valentine found no significant advantage in identity recognition memory for the dynamic faces.

In a further experiment Bruce and Valentine (1988) examined the ability of normal subjects to judge amongst other things, the identity of 3 actors and 3 actresses (with whom the subjects were highly familiar) from point-light displays. Subjects were presented with both moving and static point-light display clips and were asked to identify each person seen from a list of six possible alternative names. Identity recognition judgements based on static point-light display clips did not differ significantly from chance. However, moving point-light display identity recognition judgements were significantly better than chance, although not brilliant (accuracy = 33.5, chance = 16.7, p <.01) and were significantly better than identity recognition judgements from static point-light displays. Bruce and Valentine claimed that pure movement information (although being no where near as informative as movement information seen in conjunction with the underlying structural/configural information, seen during our normal perception of faces), can be informative about identity.

Thus, it appears that dynamic information in the form of pure movement patterns can be informative about the identity of an individual. However, this effect reported by Bruce and Valentine is not very dramatic, despite the fact that the task demands were relatively easy requiring only a six way forced-choice decision. In light of these findings, pure movement information should maybe be thought of as playing a relatively minor role in the recognition of familiar face identity.

PH's demonstration of covert recognition abilities despite an inability to overtly recognise any familiar faces is very interesting. However, it is important to bear in mind that all the tasks demonstrating this covert recognition effect have been composed of static stimuli, namely photographs or slides. The possible role of dynamic information in PH's processing of facial identity has been ignored and although a significant difference in his severely impaired overt processing of identity with the introduction of dynamic information was not hypothesised (see the main introduction and the discussion of task 4.2.2 for a detailed explanation of this hypothesis), it is nevertheless important to address the question of whether there is a possible role for dynamic information in the processing of this source of facial information, especially in light of the interesting facilitation in PH's static facial expression recognition performance with the introduction of dynamic information.

However, before the role of dynamic information in PH's familiar face identity recognition judgements can be measured, the claim that PH can successfully process movement information needs to be considered further. Another two movement recognition tasks were designed and produced; a replication of the spontaneous internal facial feature movement detection task using posed clips of movement and a non facial movement recognition task. The result from one of the tasks (the spontaneous internal facial feature movement detection task), did support the initial conclusions drawn about PH's ability to process movement information (see tasks 3.4.1 and 3.4.2), the other task was considered in retrospect to be too easy, creating a ceiling effect in both PH and the normal subjects' performance. These tasks and their results shall be discussed in the appendix (see appendix one, tasks 8.2.1 and 8.2.2). It is important to point out that although PH makes very few errors on the movement recognition tasks discussed in this thesis, these results cannot really be generalised to the psychophysical measurement of movement perception. Therefore, it is proposed that PH can process movement normally as indicated by his performance on the movement perception tasks given here. It is not proposed however, that PH's perception of movement is normal.

We shall now turn to consider the extent to which dynamic information facilitates (if any) PH's processing of facial information, including facial identity, facial expressions and lip-read speech. A comprehensive assessment of PH's ability to process these sources of facial information was conducted, designing tasks that specifically compared static and dynamic clips. The remainder of this chapter will be put aside to discussing PH's performance on two identity recognition tasks. It was observed that identity is a source of facial information that for PH at least, is not facilitated by the inclusion of dynamic information.

Identity Recognition

4.2 Identity recognition tasks.

PH was given two forced-choice video identity recognition tasks, each comparing static and moving clips. Each task was played without sound. A description of each task follows.

4.2.1 Moving faces line up task.

This task required a face familiarity decision based upon faces seen in both static and moving mode of presentation.

Stimuli and procedure

This task, kindly leant by Ms. B. Flude (Lancaster University), compared an equal number of static and moving clips of an equal number of familiar and unfamiliar faces. The static clips were recorded from the moving clips held on pause. The task consisted of 40 faces; 20 familiar and 20 unfamiliar faces, whose presentation order was randomised with the only constraint that the same type of face; familiar/unfamiliar did not occur in more than three consecutive trials. Each clip was approximately 10 seconds long and interspersed by a blank clip approximately four seconds in length. The task consisted of all the faces seen once in dynamic mode of presentation, followed by the same faces seen in the same presentation order, only this time they were stationary. The faces were presented in four blocks of 20 arranged in an ABBA design with moving faces presented first. There were 12 practice trial clips consisting of three familiar and three unfamiliar faces, arranged in a random order. Each face was presented in both static and moving mode of presentation.

PH was required to view each clip to the end and respond in the following blank clip. He was required to say whether he thought the face he had seen was familiar or unfamiliar. If he thought the face was familiar, the tape was stopped and he was questioned further regarding why the face was familiar to him, eg. if he knew the person's occupation. He was informed that he would first view some practice trial clips, to which he would be told whether he had made the correct judgement and that he would not receive feedback during the test clips.

Apparatus

The tape was edited (from recorded television programmes) and later presented using a VHS video cassette recorder. PH viewed the video tasks on a colour receiver/monitor (screen size 20 cm * 25 cm).

Results and discussion

PH's performance was compared to chance.

Table 7: PH's accuracy score on the moving faces line up task.

	Static faces		Moving faces	
	Familiar	Unfamiliar	Familiar	Unfamiliar
PH				
Accuracy score	3/20	19/20	3/20	19/20

Table 7 shows how PH performs at chance level when deciding whether a face is familiar or unfamiliar, which is regardless of whether the face seen was static or moving. Thus, it appears that dynamic information does not facilitate PH's face familiarity judgements, which supports the experimental hypothesis. PH was however, heavily biased towards saying a face was unfamiliar. Of the 80 test clips seen PH only said six of the faces were familiar, of these two were recognised as familiar in both static and moving mode of presentation; Victoria Wood and Esther Rantzen. Terry Wogan was recognised as familiar when stationary but not when moving and Neil Kinnock was recognised as familiar when moving but not when static. Two different unfamiliar people were misidentified as being familiar, one when presented in static mode and the other when presented in moving mode. When questioned further about why he thought a person was familiar, PH said that he thought Victoria Wood when seen in moving mode of presentation was a "news-reader." He thought Neil Kinnock was a "labour bloke," that Terry Wogan was a "politician," and he described one of the unfamiliar faces as being a "weather bloke."

The nature of these answers clearly demonstrates the extent of PH's familiar face recognition impairment.

PH has profound problems in recognising familiar faces and he has also just demonstrated that he has extreme difficulty making even the simplest of identity decisions, a face familiarity judgement. However, in order to accurately determine the role of dynamic information in PH's identity recognition judgements, his identity recognition performance really needs to be raised off floor level. One way of doing this is to produce a forced-choice identity recognition task (see Sergent and Poncet, 1990 and De Haan, Young and Newcombe, in press, b). Forced-choice identity recognition tasks involve providing for each familiar face seen, two possible names; one name being the name of the person whose face was actually seen and the other, a distracter name of a person matched as closely as possible to the seen face on gender, age and occupation. The subject has to decide which of the two names is the name of the person seen in the clip. Sergent and Poncet found that using this forced-choice identity recognition procedure they could raise their prosopagnosic patient's ability to name familiar persons off chance. Forced-choice identity recognition tasks of this nature are known to tap covert recognition abilities. Using this procedure another identity recognition task was designed and produced.

4.2.2 Forced-choice identity recognition task.

This task required identity recognition judgements for faces seen in both static and moving mode of presentation. The judgement is made easier by providing PH with two possible names for each face seen, one of which is correct.

Stimuli and procedure

This task compared an equal number of static and moving clips of highly familiar persons. The static clips were recorded from the moving clips held on pause. A large video library of familiar persons was compiled from various recorded television programmes. The majority of the clips were of the upper half of the body only and included no information in the background which could possibly cue an identity recognition judgement. A list of the names of all those familiar persons was given to five independent judges (age range 22-58 years), who were asked to indicate which of the people on the list they were familiar with. The judges were asked to tick as being familiar only those names of people who they were absolutely positive they knew. They were asked not to tick those names that they had only heard of and were not sure what the person looked like. From these ratings, those names of people which were not recognised as familiar by all five judges were discarded. From the remaining names 60 people were selected for the forced-choice identity recognition task.

The task consisted of 120 clips, comprising 60 familiar persons each person presented twice, once in static and once in moving mode of presentation. The faces were arranged in four blocks of 30; two static and two moving mode of presentation blocks. The blocks were arranged into an ABBA design with the static faces being presented first. The faces were arranged so that in the first two blocks (static followed by moving) all of the 60 faces were seen once, the third block of moving faces consisted of all those faces that were seen in the first block of static faces. The final static block consisted of all those faces seen in the first moving block. The faces were so arranged in an attempt to prevent PH from remembering his first response to a given face when he saw the same face a second time. There were 12 practice trial clips consisting of six familiar faces. The faces were arranged in four blocks of three, in an ABBA design, with static faces presented first. All the clips were approximately eight seconds in length and were interspersed by a blank clip approximately five seconds in length. The name of each familiar person used in the task was matched as closely as possible to the name of another familiar person on gender, age and occupation (eg. politician, comedian, quiz show host etc.) resulting in pairs of "matched" familiar persons names (see appendix two, 9.1 for a full list).

PH was seated approximately 90 cm away from the television monitor and was instructed to view each clip to the end, whereupon the tape was paused and he was read two names of matched familiar persons, one of the names belonged to the person whose face he had just seen in the clip, the other was the matched distracter name. PH was required to say which of the two names belonged to the person he had just seen. PH was told that the clips could be replayed as and when requested and that after a replay if he was still unsure then he should have a guess. PH was also told that he would first view some practice trial clips, to which he would be informed whether he had made the correct judgement and that he would not receive feedback during the test clips. The presentation order in which the correct name was read (either first or second) was randomised. At the end of the task PH was read the names of all the people he had seen in the task and their corresponding matched name and asked which of these people he knew. Of the 120 familiar persons names used in the task, PH said that he definitely knew who 32 of the people were. A further 28 of the names he thought sounded familiar to him and he claimed he did not know who the remaining 60 people were. The experimenter recorded the verbal responses on the task response sheet.

Apparatus

The same apparatus as used in the moving faces line up task was used in the production and presentation of this task.

Results and discussion

PH's performance on this task was compared to chance.

Table 8: PH's accuracy score on the forced-choice identity recognition task.

	Static faces	Moving faces
PH		
Accuracy score	39/60	41/60

The aim of using a forced-choice identity recognition procedure was to raise PH's identity recognition accuracy off chance, thus allowing one to see whether dynamic information plays a facilitative role in his identity recognition judgements. z scores were calculated for PH's accuracy scores for static and moving faces (see Table 8) and both were found to be significantly above chance; static face recognition accuracy ($z = 2.20$, p, $<.05$) and dynamic face recognition accuracy ($z = 2.71$, p, $<.01$). Using this forced-choice design therefore, has been successful as it has raised PH's identity recognition performance off chance and he is at least 65% accurate at recognising familiar faces when given this forced-choice procedure. However, in comparing his performance on static and moving faces it is obvious that there is no real difference between the two, which suggests that movement does not play a facilitative role in his identity recognition judgements.

However, a significant improvement in PH's identity recognition judgements with the introduction of dynamic information was not hypothesised. This is because firstly, Bruce and Valentine (1988) found little evidence of their normal subjects being able to use pure dynamic information, as provided in point light displays (see the introduction of chapter five, for a description of the point light display technique), in their recognition of facial identity. Secondly, normal subjects are able to make accurate identity recognition judgements from photographs, much more so than they can recognise facial expressions from photographs. Therefore, because normal subjects show little room for improvement in their identity recognition judgements with the introduction of dynamic information, it is unlikely that patients with brain-injury causing an impairment in the processing of face identity, will show a significant improvement in their identity recognition judgements, when introduced to dynamic information. Thirdly, identity recognition unlike facial expression recognition is not dependent upon a sequential unfurling of successive facial muscle actions. Identity judgements are usually based upon a "single frame" (like the information available in a photograph) whereas the production of facial expressions involves the sequential unfurling of successive frames of facial muscle action. Facial expressions should therefore, be easier to recognise from dynamic than static displays, where the whole pattern of facial movements can be processed, whereas identity recognition judgements in being less dependent on dynamic information, should show less of a facilitative effect from the inclusion of dynamic information. Obviously it would be wrong to claim however, that dynamic information is redundant in identity recognition judgements. As for example, an individual maybe be known for their particular facial mannerism, the portrayal of which involves successive facial muscle actions. Therefore, recognition of this individual may well be aided by the inclusion of dynamic information, enabling the possible perception of their facial mannerism, which may trigger the recognition of the correct identity of that individual.

It is concluded, that dynamic information does not facilitate PH's severely impaired overt recognition of familiar faces. This evidence presented here clearly supports the experimental hypothesis.

It is possible to further analyse PH's performance on this task, by considering which of those faces (that is to say the face actually seen and not its matched name) correctly identified, did he later when asked, claim to know. Of the 39 static faces which PH correctly identified, he claimed he knew who 14 of them actually were. Another 13 faces, he thought seemed familiar to him, whilst 12 of the faces, which he correctly identified, he claimed he did not know. This would suggest that at least 31% of PH's correct static face identifications were in fact guesses. Of the 41 dynamic faces which PH correctly identified, he claimed he knew who 17 of them actually were. Another 13 faces he claimed seemed familiar to him and another 11 faces, which he correctly identified, he claimed he did not know. This would suggest that at least 27% of PH's correct dynamic face identifications were in fact guesses. This separate analysis clearly demonstrates the extent of PH's familiar face identity recognition impairment.

In summary, it appears that although PH can successfully process movement information (see results of the movement recognition tasks in chapter three), he is not able to use this information to facilitate his severely impaired processing of familiar face identity. PH's performance clearly supports the experimental hypothesis, as no role was hypothesised for movement in the processing of identity.

The following chapters discuss PH's ability to process facial expressions and lip-read speech; two sources of facial information that for PH at least, <u>are</u> facilitated by the inclusion of dynamic information.

Chapter Five

Expression Recognition

5.1 Introduction.

When we perceive a face we process it not only in terms of whose face it is, but also in terms of whether the face is for example, happy or sad and in terms of what the person is verbally saying to us. Expression and lip-read speech thus form the two other main sources of information which can be extracted from a face along with its identity. As we have already seen, Bruce and Young (1986) proposed in their functional model of face recognition (see chapter one) that these three sources of facial information (expression, identity and lip-read speech) are processed by three independent processing channels, support for which can be found in the literature describing the various patterns of face processing deficits observed after specific brain-injury. Campbell (1989) for example, claimed that expression, identity and lip-reading are dissociable processes, believing that lip-read speech is essentially a left hemisphere process and expression and identity recognition are essentially right hemisphere processes. Ellis (1989) extended this notion further identifying six distinct processing channels, where the left hemisphere is involved in phonetic voice and face processing and the right hemisphere is involved in identity and face processing using both the face and voice. (See chapter one for an account of the evidence which supports the existence of distinct processing channels for expression, identity and lip-read speech).

This thesis examines amongst other things the prosopagnosic patient PH's ability to process these various sources of facial information, but in particular the extent to which, dynamic information facilitates his processing of facial expressions, identity and lip-read speech. In chapter four it was found, that PH's overt processing of familiar faces was not facilitated by the introduction of dynamic information; that is to say PH showed no significant difference between his recognition of static and dynamic familiar faces. PH's performance thus fell in line with the experimental hypothesis. This chapter examines PH's ability to process facial expressions and the extent to which dynamic information facilitates (if any) his processing of facial affect, whilst chapter six examines PH's ability to process lip-read speech, where some consideration has also been given to the role of movement in the processing of this source of facial information.

Facial expressions by their very nature are dynamic, being dependent upon movement for the sequential unfurling of their successive facial muscle actions involved in their production. Rinn (1984) pointed out in his review of the mechanisms involved in the production of facial expressions, that facial expressions result from "stereotyped movements of the skin and connective tissue" p. 52. Ekman and Friesen

(1975) have provided a detailed account of the different types of facial movement involved in the expression of happiness, angriness, sadness, surprise, disgust and fear. They claimed that each expression has its own unique pattern of facial movements. For example, during happiness the "corners of the lips are drawn up and backwards sometimes exposing the teeth, a wrinkle (naso-labial fold) runs down the nose to the edge of the lip corners and the cheeks are raised upwards, wrinkles form below the lower eye lid and crows feet extend from the corners of the eyes." From their accounts, one can see that there are large differences between the extent of the facial movements involved in the production of each expression. However, as it has already been pointed out (see chapter one), very few facial expression recognition tasks consider the importance of the "movement variable" in their design, instead they tend to be composed of static photographic stimuli. Thus, a dichotomy exists between the nature of the stimuli which we base our expression judgements on under everyday circumstances and the nature of the stimuli used in explicit expression recognition tasks. The unnaturalness of the task demands created when using static stimuli in expression recognition tasks, could it is felt, contribute to some of the facial expression recognition deficits reported in the literature to date.

Obviously before the role of movement in PH's processing of facial expressions could be measured, it was important to make sure that PH could process movement successfully. PH has previously been given a series of movement recognition tasks (see tasks 3.4.1, 3.4.2 and appendix one respectively) from which it was concluded that overall PH is able to process movement sufficiently accurately, for it to be worth while to measure the role of dynamic information in his processing of facial expressions. However, it is also worth pointing out that having normal perception of movement and in particular facial movement, does not necessarily presuppose that one will be able to successfully recognise dynamic facial expressions, as Bodamer (1947) in his detailed account of a head-injured patient S, pointed out. S, who was prosopagnosic, also found that faces had no expressions. He could see the facial movements produced during the expression of an emotion, yet could not interpret what they meant (see Ellis and Florence, 1990, for a translation of Bodamer's paper).

The role of dynamic information in the processing of facial expressions can be examined using two quite different techniques. The first, which for want of a better label, shall be referred to as the "video" technique, provides the perceiver with video clips of various facial expressions (generally the clips are of head and shoulders only), which include not only the structural and configural information available in photographic displays of facial expressions, but also the specific pattern of facial muscle movements associated with the production of each facial expression. The other method, known as the point light display technique (which shall be referred to as PLD in the remainder of this thesis), essentially provides the perceiver with a "pure movement pattern" absent of any structural or configural information (see below for detailed description of the PLD method). The PLD technique has been fairly widely used in the face processing literature, producing tasks which require judgements of age, sex, identity and expression from pure movement patterns, a brief overview of which follows shortly. In comparison, the video technique, which methodologically is comparatively simple compared to the PLD technique, has to date had surprisingly little application within the face processing literature.

Berry (unpublished manuscript) in her study of social event perception, claimed that the PLD method was one of the best ways to provide stimuli in which the dynamic visual transformations are isolated from the underlying structural/configural information. The PLD method involves the application of small pieces of reflective material to a completely blackened body or face. The person is then recorded in a dark room where a spotlight forms the only source of lighting. The video is then viewed on a television set whose contrast has been adjusted so that all that can be seen is an array of moving patches of white material against a completely black background. Essentially this produces a pure dynamic movement pattern absent of any structural/configural information, from which successful recognition judgements can be based. If individuals are presented with static clips taken from these moving patterns, recognition accuracy falls to chance level, confirming that this technique provides pure movement information absent of structural/configural information. This technique was originally introduced by Marey (1895), (cited in Cutting and Proffitt, 1981) and has been widely used since. However, the PLD technique does have its limitations and draw backs. Its methodology is very cumbersome and intrusive and tends to produce unnatural clips of behaviour, as the actor is aware of the importance of "movement" and as a result exaggerates their normal behaviour to accentuate their actions.

Various reports using the PLD technique have emerged, examining the usefulness of pure dynamic information in various recognition judgements, the majority of which detail normal subjects' recognition abilities using this pure movement information. For example, Bassili (1978) found that normal subjects were able to recognise an array of white dots as representing a face significantly more accurately when the dots were moving, than when they were static. Thus, movement is able to provide information about form. In the same study Bassili examined the role of pure movement information in the recognition of facial expressions. Specifically, he was concerned with whether PLDs could provide enough information to enable normal subjects to distinguish between six universal emotions. Actors were recorded under two separate conditions; normal illumination and PLD, posing the following emotions; happiness, angriness, sadness, surprise, disgust and fear. Bassili found that recognition accuracy for faces displayed under normal illumination, although not as accurate as he predicted, differed significantly from chance and that recognition accuracy from PLDs, although less than that for normal illumination, was greater than that expected by chance. Surprise obtained the highest recognition accuracy scores in both the normal illumination and PLD condition, whilst anger and fear obtained the lowest recognition accuracy scores in the PLD mode of presentation and happiness obtained the lowest recognition accuracy score under the normal illumination condition. Bassili claimed that although PLDs are not as informative as normally illuminated face displays, they can provide some information which is valuable and utilised in the recognition of faces and discrimination of facial expressions.

Bassili (1979) extended his study of the role of pure movement information in normal subjects' recognition of facial expressions, by using the same design as above except this time he also compared the specific region of the face in which the emotion was seen and displayed, including whole, upper and lower face presentations. Bassili found that moving PLDs obtained higher recognition accuracy rates than static PLDs and that normally illuminated face displays obtained higher recognition accuracy rates than dynamic PLDs. There was a trend in the recognition accuracy rates for the specific regions of the face; for both the normal illumination and the PLDs, the whole face presentations obtained higher recognition accuracy rates than the lower face presentations, which in turn were higher than the upper face presentations. Bassili also found that specific regions of the face were preferential for the recognition of specific emotions. Thus, pure dynamic information is informative not only about facial emotion, but is also able to provide specific information allowing the recognition of distinct facial emotions from the specific regions of the face.

Bruce and Valentine (1988) were interested in the extent to which pure movement information would be informative in the processing of various sources of facial information. They produced a PLD task which compared dynamic clips of the three facial expressions smiling, frowning and surprise with three rigid head movements, nodding, shaking and rocking. They also produced a tape comparing static clips of these three facial expressions and neutral, to ensure that the dynamic PLD clips contained only pure dynamic information and no structural/configural information. Normal subjects were required to judge whether each clip was of a facial expression or rigid head movement, naming each from the six possible alternatives listed above. Subjects were highly accurate at distinguishing between the three rigid head movements and they were above chance at recognising static PLD expressions ($p < .01$), suggesting that there was some structural/configural information available in the dynamic PLD clips. However, they were highly accurate at recognising the moving PLD expressions ($p < .001$). Thus, it appears that dynamic information is very useful in the processing of facial expressions. It also suggests that facial expressions are maybe stored not only in terms of their structural/configural arrangement, but also in terms of their pattern of facial muscle movements.

The evidence presented by Bassili (1978, 1979) and Bruce and Valentine (1988) demonstrated that neither structural/configural or pure movement information are exclusively essential in the processing of certain aspects of facial information. Instead however, it appears that both form and movement information are important and that they are able to supplement one another, facilitating recognition judgements.

The PLD technique has, it is felt, a more interesting application in the examination of the face processing capacities of brain-injured patients who are impaired at processing one or more source of facial information, as measured by the more traditional tests, composed of static photographic stimuli. The PLD technique, in providing the perceiver with pure movement information, may aid recognition judgements which are essentially impaired when only structural/configural form information is provided for inspection.

In light of these interesting findings reporting normal subjects' ability to use pure dynamic information in the recognition of various sources of information, it was felt important to consider PH's ability to use pure dynamic information, especially as he has demonstrated some ability to use movement in conjunction with form to aid his expression recognition judgements. This was examined and shall be discussed later in this chapter.

This chapter attempts to not only measure the extent to which dynamic information facilitates PH's recognition of facial expressions, but also examine the effect of other variables upon his processing of facial expressions. For example, whether the degree of affect displayed has any diverse effects upon his recognition of facial expressions and whether the region of the face in which the facial expression is seen to be displayed, has any effect upon the ultimate recognition of that expression. Ekman and Friesen (1975) provided a detailed breakdown of how the different regions of the face are involved in the production of different facial expressions including happiness, angriness, sadness, surprise, disgust and fear. Essentially they divided the face into three distinct regions; the brow, (including the forehead), the eyes, (including the eye lids and the region just above the bridge of the nose) and the mouth, (including the lower nose, cheeks and chin). They described the role which each of these regions plays in the production of each facial expression and clearly there is some variation. For example, happiness is considered to primarily involve the lower half of the face, whilst surprise is considered to encompass the whole face. Therefore, it is possible that particular facial expressions could be recognised from selected areas of the face without it being necessary to see the whole face.

There are some studies cited in the literature which have already examined the effect of these different variables (namely degree of affect and region of facial display) upon normal subjects' recognition of facial expressions. For example, Ley and Bryden (1979), in a divided visual field task, presented subjects with cartoon drawings of five males. Each male was drawn displaying five different emotional states; either extremely positive, mildly positive, neutral, mildly negative or extremely negative. Subjects were presented with one face in either the left or right visual field followed by another face located centrally. Subjects had to judge whether the two faces seen displayed the same degree of emotion, i.e. extremely/mildly, positive or negative, or neutral and whether the two faces were of the same individual. For each decision a same/different response was required. Ley and Bryden found a left visual field (LVF) superiority for both expression and identity judgements, but more interestingly they also observed a 'degree of affect' preference. The LVF effect was highly significant for both the extremely positive and negative emotions, but was not significant for the mild degrees of affect and the neutral faces. Ley and Bryden claimed that the right hemisphere is preferentially involved in the processing of both identity and expression and that this LVF advantage for expressions is independent of that for identity, but is dependent upon the degree of affect.

This preference shown by Ley and Bryden's (1979) normal subjects for the degree of a given affect is particularly interesting and may have important applications in the examination of brain-injured patients' ability to process facial expressions. One would intuitively believe that if a patient experiences a relatively mild impairment in the processing of facial expressions, then the extent of this impairment could either be increased or decreased depending upon the nature of the stimuli presented for recognition. In particular one would feel that the stronger the degree of affect presented, the easier its recognition should be, as strong displays of a given affect are more obvious and in a sense recognisable, than the possibly ambiguous, mild displays of a given affect. Therefore, it was considered important to assess the extent to which, altering the given degree of affect would have an effect upon PH's recognition of facial expressions. It was hypothesised, given the fact that PH only experiences a relatively mild facial expression recognition impairment for static and not dynamic displays of facial expressions, that one should see a trend in PH's ability to recognise different degrees of dynamic displays of facial expressions, observing less errors on strong displays than on moderate displays, which in turn would be less than the number of errors observed for weak displays.

Consideration has already been given to one study which examined the importance of the different regions of the face in normal subjects' recognition of facial expressions, namely the study by Bassili (1979). There is however other evidence based upon reports of brain-injured patients, who it is claimed, showed a tendency to focus upon one specific feature eg. the eyes, when perceiving faces. It is possible that these patients are actually exhibiting signs of an underlying configural processing deficit, where by the patient is no longer able to process the face image as a whole, but instead processes it "bit by bit." This kind of deficit is commonly referred to as a "visual configural processing" deficit and its use as a potential explanation of some prosopagnosic conditions has been examined in the literature, a brief overview of which follows.

Perrett and his co workers, in their extensive examination of the face processing capacities of the macaque monkey, located a region in the monkey brain where the cells are specialised in the processing of many facial attributes, like eye gaze and face feature configuration, known as the superior temporal sulcus (STS). Perrett, Mistlin, Chitty, Harries, Newcombe and De Haan (1988) proposed that if prosopagnosia results from damage in the human brain to a system similar to the one they have studied in the STS of the monkey brain, then one would expect some prosopagnosic patients to show face processing deficits of a similar nature to the monkey. They examined the prosopagnosic patient RB on a gaze direction sensitivity task and a forced-choice face configuration task, where he had to decide if the configuration was normal or jumbled. RB was at chance level at judging gaze direction and showed the reverse pattern of reaction times to the normal subjects on the configuration task, where he was quicker to reject the jumbled arrays than to accept the normal patterns. Perrett et al believed RB's performance was indicative of an impairment in the ability to process facial configuration. He was forced to search each feature in turn checking whether it was in the correct position. He would have to continue this procedure until he failed to find a match, thus enabling him to respond faster to jumbled than normal face arrays.

Levine and Calvanio (1989) described how the prosopagnosic patient LO, was able to perceive faces in terms of their specific parts, but was unable to piece these parts together to form the whole and hence recognition could not be achieved as the perceived facial features, are common to all faces. They agreed with Perrett et al's explanation that some prosopagnosic disorders are essentially due to a defect in visual configural processing.

Associated evidence for this notion that some prosopagnosic patients experience configural face processing impairments is found in the reports of prosopagnosic patients who experience problems with particular regions of the face, in particular the eyes. Bodamer (1947) described how the prosopagnosic patient S in looking at faces was attracted to the eyes and found it hard to look at the other facial features. However, Ellis and Florence (1990) pointed out that this configural processing deficit demonstrated by S cannot explain all identity recognition deficits, as non agnosic patients with small visual fields (which in effect only see small sections of the face image), are nevertheless able to recognise individuals successfully. It would seem therefore, that although a configural processing deficit cannot wholly account for the prosopagnosic condition, it is still possible that some prosopagnosic patients experience deficits in the processing of face configuration, which add to their face processing deficits. (For further evidence of the importance of the eye region in prosopagnosic patients' processing of faces, see Gloning, Gloning, Hoff and Tschabitscher, 1966).

De Renzi, Faglioni and Spinnler (1968) also examined the role of the different areas of the face in the processing of facial information. They were specifically interested in the extent to which three fragments of the face; eyes, mouth and half faces, could discriminate between different experimental groups. They administered a fragmented unfamiliar face matching task to unilateral brain-damage patients both with and without visual field defects. They found that neither the eyes or the mouth discriminated between the groups; only the half faces showed discriminating powers. During this study they also examined a prosopagnosic patient, whose performance on the eyes was lower than on the other fragments. De Renzi et al conclude that observed difficulties associated with the eyes could be specific to the prosopagnosic condition, although they emphasise that their evidence for this hypothesis is small in comparison to that presented by Gloning et al (1966).

This notion that some prosopagnosic patients may experience configural face processing problems along with their face processing deficits, seemed an interesting proposition to study. In particular the question arose as to whether the existence of an underlying configural information processing deficit could also affect the processing of facial expressions. Facial expressions are known to involve the different regions of the face; eyes, brow and mouth, to different extents (Ekman and Friesen, 1975), yet we also know that normal subjects prefer whole face presentations to lower face presentations, which in turn are preferred to upper face presentations in the recognition of facial expressions (Bassili, 1979). It could be that prosopagnosic patients with configural face processing deficits may find the recognition of facial expressions easier from displays involving either the upper or the lower region of the face, than whole face displays, as in the former two regions less demands are placed upon configural processing capacities. It is not known whether the prosopagnosic patient PH has a configural face processing deficit, but it is believed that by giving PH an expression recognition task where he has to recognise facial expressions from both upper, lower and whole face presentations, should throw some light on his ability to process facial configuration. It was hypothesised that if PH does experience a difficulty in processing facial configuration which extends to his processing of facial expressions, he should make less expression recognition errors on the upper and lower face presentations than on the whole face presentations.

To bring this introduction to a close it seems sensible to provide a brief overview of PH's ability to process affective facial information. Other work (De Haan, Young and Newcombe, 1987b) has shown that PH is mildly impaired at processing static, black and white photographs of facial expressions, a finding which has also been confirmed in this present examination (see task 3.5.1), where PH was impaired at processing static video clips of facial expressions. In light of the evidence presented above and the observation that PH experiences a facilitation in his processing of spontaneous facial expressions with the introduction of dynamic information (see task 3.5.1), it was felt that further consideration should be given to PH's analysis of facial expression. In particular it was considered important to examine further the role of dynamic information in PH's processing of facial expressions and also to consider other factors which may influence his processing of facial affect. For example, the role of pure movement information, the degree of affect seen and the region of the face in which the expression is displayed.

It was hypothesised that dynamic information should play a facilitative role in PH's processing of facial expressions. The underlying basis for this hypothesis is briefly that facial expressions are by their very nature dynamic, requiring the unfurling of successive facial muscle actions in their production. Ekman and Friesen (1975) claimed that each facial expression has its own specific pattern of facial movements involved in its production. Also the fact remains that we are only occasionally asked to recognise how someone is feeling from a photograph. Therefore, recognition tasks which are composed of such static stimuli namely photographs, present quite unnatural task demands. However, that is not to say that these task demands are impossible. Normal subjects are able to recognise facial expressions from photographs reasonably accurately. The point is that dynamic stimuli in the form of video sequences, provide the perceiver not only with a more natural looking stimuli upon which to base an expression recognition judgement, but with an additional source of information to the structural/configural information available in static photographic stimuli. Therefore, it was hypothesised that recognition judgements based on these more natural looking and informative dynamic clips, should have a higher recognition accuracy than recognition judgements based on static stimuli (see chapter one for more detailed explanation of this hypothesis).

It was hypothesised that the accuracy with which facial expressions are recognised is maybe dependent upon the degree of affect displayed. In particular recognition accuracy for strong displays of facial affect, should be higher than that for moderate displays, which in turn should be higher than that for weak displays of facial affect.

It was also hypothesised that if PH experiences a visual configural processing deficit which extends to his processing of facial expressions, then when given a facial expression recognition task presenting expressions in the upper, lower and whole region of the face, he should make less recognition errors for expressions presented in the upper and lower region of the face than those presented in the whole region of the face.

A total of five video facial expression recognition tasks were administered to PH. These included "posed" dynamic facial expression recognition tasks and PLD expression recognition tasks. Tasks looking specifically at the effect of certain variables on the recognition of facial expressions, like the degree of affect displayed and the region of the face in which the facial expression is displayed. A full description of each task follows shortly.

It was considered important before assessing PH's ability to process facial expressions to be sure that he has an adequate understanding of what each expression label actually means. For this reason PH was asked to verbally describe a situation in which he would experience each of the following facial expressions; happiness, angriness, sadness, surprise, disgust and fear, in that order, providing enough detail so that the experimenter was convinced that he understood what constituted each category of emotion. PH was given feedback at the end of each verbal description as to the accuracy of his verbal report. PH provided acceptable descriptions of happiness, angriness, sadness, surprise and fear, but was unable to describe the emotion disgust. For example, he described happiness as something you would feel if you had "won the pools" or when you were "at a party and enjoying yourself" or when you were "down at the pub." He described angriness as an emotion you might experience, "if you were at a football match and your team was losing," or "when the other teams supporters started to celebrate." PH described the feelings of sadness as "the death of someone close to you" and he described surprise as "receiving a present when you did not expect one" or an emotion you might experience when "watching a horror movie." He described the feelings of fear as something which you might feel again "when watching a horror movie" or as a feeling which "soldiers in the Gulf war" might have felt. He was unable to provide any description of the emotion disgust.

Facial Expression Recognition

5.2 Test methodology.

Unless stated otherwise each task consisted of 48 test clips, each clip was six seconds long and was interspersed by a "blank" clip of equal length, during which the experimenter recorded the subject's verbal response on the task response sheet. All the video tasks were recorded without sound.

Professional actors (two actors and two actresses) were hired to produce various facial movements and facial expressions. There were several aims to using professional actors/actresses in the production of the stimuli for the majority of the following tasks. Firstly, it was hoped that the clips of facial movement and facial expressions would be of a higher quality than those obtained from the television. Not only would it now be possible to control the length of each clip (it was hard to obtain television clips of a suitable length), but the clips themselves may represent more accurate examples of a given expression (an actor's training should obviously enable them to produce authentic facial expressions), than spontaneous clips obtained from the television, where there was quite a degree of variation amongst different clips of the same category of facial expression. It was also felt that clips obtained from the television were much more open to subjective misidentification than clips posed by professional actors/actresses. Using actors/actresses would also enable the manipulation of the content of certain clips eg. the region of the face in which the facial expression was displayed, or the degree of facial affect portrayed. It was also hoped in using only two actors and two actresses to reduce the effects of individual differences in the portrayal of facial expressions. Using clips obtained from the television created the problem that each clip was portrayed by a different person and therefore, there are many variations in the reliability and validity of each facial expression.

Each clip consisted of the head and shoulders only, with as much hand and body movement eliminated as possible. A large video library of clips of facial movements and expressions was collected and unless stated otherwise, all the following tasks were edited from these clips posed by the professional actors/actresses.

The clips were filmed using a colour video camera. Both Betamax and VHS video cassette recorders were used in the production of these tasks. Those tasks recorded on Betamax were later copied to VHS tape. All the tasks were presented using VHS video cassette recorders. PH viewed the video tasks on a colour receiver/monitor (screen size 20 cm * 25 cm), the normal subjects viewed the video tasks on a colour receiver/monitor (screen size of 19 cm * 24 cm).

The procedure was the same as used with the agnosic patients (see test methodology 3.3), except this time the subjects were also provided with response cards bearing all the possible response alternatives and were instructed to either verbally report the answer, or point to the appropriate card, or to simultaneously point and verbally respond. They were also informed that they would first view some practice trial clips, to which they would be informed whether they had made the correct judgement and that they would not receive feedback during the test clips.

5.3 Facial expression recognition tasks.

5.3.1 Dynamic/static posed facial expression task (a).

This task required the recognition of the facial expressions happiness, angriness and sadness from both static and moving faces. By comparing static and dynamic versions of each facial expression one is able to measure the extent to which dynamic information facilitates the processing of facial affect.

Stimuli and procedure

This task compared an equal number of static and dynamic clips of the three facial expressions happiness, angriness and sadness. Due to technical editing difficulties preventing satisfactory recording of static clips from the apex of the moving clips held on pause, the static clips were produced by the actor/actress maintaining their head and facial features in one position for the duration of the clip. All the dynamic clips were of facial movement with talking. It was felt to be more ecologically valid to ensure that each clip included mouth articulation, as during our perception of facial expressions under everyday circumstances, we generally perceive dynamic faces, which are more often than not talking whilst expressing an emotion. Each actor/actress provided four clips of each facial expression; happiness, angriness and sadness, including two dynamic versions and two static versions. The task was arranged in four blocks of 12 (two blocks of static and two blocks of dynamic facial expressions). Each block included one example of each emotion from each actor/actress. The blocks were arranged in an ABBA design with static facial expressions presented first. There were six practice trial clips (randomly assigned to a combination of actors) providing three examples of static facial expressions and three examples of dynamic facial expressions, including one example of each emotion respectively. The practice and test clip presentation order was randomised (within blocks) with the only constraint that the same category of facial emotion did not occur in more than two consecutive trials and the same actor/actress did not occur in more than one consecutive trial. The practice trial clips were also blocked with static clips being presented first.

Subjects were required to decide whether they had seen a "happy," "angry" or "sad" facial expression.

Normal subjects

A matched population of 10 normal subjects were paid for completing this task. These subjects were matched to PH on gender, age at date of testing and age on leaving full time education. They were all members of Durham University technical and maintenance staff. Their mean age at date of testing was 35.1 years. Their mean age on leaving full-time education was 15.9 years. PH was 26 years of age at date of testing and left full time education at 16 years of age.

Results and discussion

Table 9: PH and the normal subjects' error scores on the dynamic/static posed facial expression task (a).

	Facial Expression	
	Static clips	Moving clips
PH		
Error score	6/24 ($p < .001$)	3/24
Normal subjects		
Mean error score	1.3	1
SD	0.7	1.05
Range	0-2	0-3

Perhaps the first point to note from Table 9 is the fact that the normal subjects' performance is close to ceiling level. Therefore, for the reasons already discussed in chapter three (see task 3.4.1), the range of the normal subjects' performance is included for comparison with PH's performance.

PH's error score on the static facial expressions falls well outside the range of the normal subjects, whilst on the dynamic facial expressions his error score falls within the normal range. Thus, he appears to be showing a deficit in the processing of static facial expressions whilst showing normal processing of dynamic facial expressions.

A Binomial test was used to calculate the probability of PH making the number of errors he did, on both static and dynamic facial expressions by chance, (as extrapolated from the respective performances of the normal subjects). For static facial expressions PH's error score was significantly different from that expected by chance, ($z = 4.02$, $p < .001$). Thus, it was concluded that he showed a highly significant impairment in the recognition of static facial expressions. For dynamic facial expressions PH's error score did not differ significantly from that expected by chance, ($z = 1.60$, $p > .05$). Therefore, it was concluded that PH is able to recognise dynamic facial expressions normally, although it should be noted that his z score is bordering on the $p < .05$ significance level cut off point.

This result supports those results observed earlier (see chapter three, task 3.5.1), where PH was impaired at recognising static spontaneous facial expressions, but was able to recognise dynamic spontaneous facial expressions normally. It was concluded therefore, that for PH dynamic information does facilitate his impaired recognition of static facial expressions, but produces a greater and more significant facilitative effect for spontaneous than posed facial expressions.

This finding taken in conjunction with the result of task 3.5.1, not only questions the validity of other facial expression recognition deficits (measured by the more traditional tasks composed of photographic stimuli) reported in the literature to date, but has important implications for the design of remediation techniques for patients with expression analysis impairments (see chapter seven for a discussion of this point).

5.3.2 Dynamic/static posed facial expression task (b).

This task required the recognition of the facial expressions happiness, angriness, sadness, surprise, disgust and fear from both static and moving faces. Again by comparing static and dynamic clips it allows one to measure the role of dynamic information in the recognition of a larger group of facial expressions.

Stimuli and procedure

This task compared an equal number of static and dynamic clips of the facial expressions happiness, angriness, sadness, surprise, disgust and fear. These clips were actually the "whole face" presentation clips, edited from the "expression recognition in the upper, lower and whole face task" (see task 5.3.6). All the clips used in the final version of the expression recognition in the upper, lower and whole face task, had been rated for accuracy by five judges (see task 5.3.6 for details.) We can see from Table 16 therefore, that 83% of the whole face presentation expression clips, used in this posed facial expression task were correctly identified by all five judges. From Table 17 we can see the mean rating scores given by the judges for each of the whole face presentation clips used in this task. They are respectively; happiness, 6.48, anger, 6.24, sadness, 6.24, surprise, 5.48, disgust, 6.08 and fear, 6.48. As the maximum accuracy rating score for each expression was 7.00, we can see that the clips of facial expressions used in this posed facial expression task are on the whole, very accurate representations of a given affect.

The static clips were recorded from the apex of the dynamic facial expression held on pause. All the moving clips were of facial feature movement without talking. There were 12 practice trial clips, providing an example of each category of facial expression during both static and dynamic mode of presentation. The test clips were arranged in four blocks of 12 (two static and two dynamic blocks of facial expressions) with two examples of each of the six facial expressions (each actor posing three facial expressions), randomly presented in each block. The practice and test clip presentation order was randomised (within blocks) with the only constraint that clips of the same category of facial expression and actor/actress did not occur in more than two consecutive trials. The blocks were arranged in an ABBA design with static facial expressions presented first. The practice trial clips were also blocked with static facial expressions being presented first.

Subjects were required to decide whether they had seen the facial expression "happy," "angry," "sad," "surprise," "disgust" or "fear."

Normal subjects

A matched population of 10 normal subjects were paid for completing this task. These subjects were matched to PH on gender, age at date of testing and age on leaving full time education. They were all members of Durham University technical and maintenance staff. Their mean age at date of testing was 32.9 years. Their mean age on leaving full-time education was 15.7 years. PH was 27 years of age at date of testing and left full time education at 16 years of age.

Results and discussion

Table 10 shows that PH's error score on the dynamic facial expressions is significantly above the control mean (z = 3.53, p < .001), while his performance on the static facial expressions although not brilliant (z = 1.59), is normal. This result seems to contradict the conclusions drawn from the results of the spontaneous and posed facial expression recognition tasks (see tasks 3.5.1 and 5.3.1 respectively), in that now PH seems to be able to process static facial expressions normally, finding that dynamic information impairs his processing of facial expressions.

Table 10: PH and the normal subjects' error scores on the dynamic/static posed facial expression task (b).

	Facial Expression	
	Static clips	Moving clips
PH		
Error score	8/24	8/24 ***
Normal subjects		
Mean error score	4.5	2.0
SD	2.2	1.7

*** z > 3.10, p < .001

** z > 2.33, p < .01

* z > 1.65, p < .05

There are several possible explanations for this effect, one of which could be the performance of the normal subjects. They make a greater number of errors on the static facial expressions than on the dynamic expressions. Thus, the normal subjects performance supports the experimental hypothesis, where they experience a facilitation in their recognition of facial expressions with the introduction of dynamic information. PH on the other hand not only makes significantly more errors on this task than on either the spontaneous or posed facial expression recognition tasks (see tasks 3.5.1 and 5.3.1), but he makes an equal number of errors on the static and dynamic facial expressions. Therefore, his performance could be said to neither fall in line with the normal subjects performance shown here, the hypothesised performance or show any experimental effect, as his recognition accuracy does not differ between static and dynamic facial expressions.

There does however, appear to be a more plausible explanation for PH's performance. In this task PH has been introduced to three new facial expressions with which he has had little test experience before. Not only is he therefore, more highly practised at half the facial expressions used in this task compared to the other half, but it is also felt that the introduction of these new facial expressions has "overloaded" PH in terms of task demands. Although PH was given response cards for all the facial expressions used in this task, it was felt that his performance deteriorated, as he has been use to having a three way forced-choice task demand and this new task, with six possible response alternatives confused him, to the extent that he made an equal number of errors on both static and dynamic clips. One possible way of assessing whether the task demands have actually caused the deterioration in PH's dynamic facial expression recognition performance, is to extract PH's performance on the three facial expressions with which he is highly practised; happiness, angriness and sadness, from his overall performance and compare this to the normal subjects' performance on the equivalent facial expressions.

This extraction was completed and the results can be seen in Table 11 below. Perhaps the first point to note from this table is the fact that the normal subject's performance is close to ceiling level. Therefore, for the reasons discussed in chapter three (see task 3.4.1) the range of the normal subject's performance is included for comparison with PH's performance. PH's performance falls within the normal range for both static and dynamic clips of facial expressions, thus suggesting that he is now able to recognise both static and dynamic facial expressions normally. However, using a Binomial test the probability was calculated for PH making three errors on the static facial expressions by chance, (as extrapolated from the normal subject's performance). PH's error score was significantly different from that expected by chance ($z = 2.17$, $p < .05$). Thus, it was concluded that PH is impaired at recognising static facial expressions, whilst not making a single error when recognising dynamic facial expressions. His performance now falls in line with that observed in tasks 3.5.1 and 5.3.1, where he made less errors on the dynamic than on the static clips of facial expressions.

Table 11: PH and the normal subjects' error score on task 5.3.2 - comparing happiness, anger and sadness performance only.

	Facial Expression	
	Static clips	Moving clips
PH		
Error score	3/12 ($p < .05$)	0
Normal subjects		
Mean error score	0.7	0.3
SD	1.2	0.5
Range	0-4	0-1

It is important to note that the performance of the normal subjects changes across tasks 3.5.1, 5.3.1 and 5.3.2. On task 3.5.1 (spontaneous expressions) the normal subjects made more errors on the moving than on the static clips (suggesting that dynamic information does not facilitate expression recognition), whereas on tasks 5.3.1 and 5.3.2 (posed facial expressions) they made more errors on the static than on the moving clips (suggesting that dynamic information does facilitate expression recognition.) Maybe, dynamic spontaneous clips of expression provide a qualitatively different kind of information to dynamic posed clips of expression, because after all it is hard to believe, that dynamic information could selectively facilitate posed and not spontaneous facial expressions. This could well be so as the very nature of a spontaneous expression implies that the expression has not been produced to demand, but is spontaneous and is therefore, more likely to consist of "multiple expressions" in comparison to a posed expression, where an actor is specifically requested to pose one given expression. This, combined with the fact that normal subjects are able to recognise facial expressions very accurately, suggests that dynamic spontaneous clips of expression, could possibly, in actually providing the perceiver with an array of multiple expressions for analysis, confuse the viewer's expression recognition judgement, causing them to make more errors on dynamic than static spontaneous clips of emotion. There is another possible explanation for this observed variation in the normal subjects' performance, which is the fact that three different groups of normal subjects completed the three different tasks.

So far we have considered PH's ability to use movement in conjunction with the structural/configural information available in static images, to facilitate his processing of facial expressions. Consideration will now be given to the extent to which PH is able to use pure movement information, absent of any structural/configural information, in the processing of facial expressions. This involves the use of the PLD technique previously discussed.

However, it was considered worth while before going to the trouble of making these very cumbersome PLD tasks, that PH's ability to process pure movement information of this nature should be measured. PH was given a short PLD task adapted from the Johansson (1973) technique, a discussion of which follows.

5.3.3 Pure movement recognition task.

A biological motion task requiring the detection of form from motion.

Stimuli and procedure

This task consisted of an actor dressed completely in black clothing with small pieces of reflective tape attached to his main joints. He was recorded performing a variety of body movements (jogging and walking, both forwards and backwards) in a completely darkened room, where spot lights formed the only source of lighting. The clips were played back on a television monitor where the brightness was adjusted, so that the patches of reflective tape were all that could be seen from a completely black screen. PH simply had to interpret what he saw in these pure movement patterns.

Results and discussion

PH was able to recognise and identify the moving pattern of dots as being a human body and was able to make judgements as to whether the body was walking or jogging, forwards or backwards.

Having determined that PH can process form from motion alone, it was then possible to consider his ability to process facial expressions from similar pure movement patterns. A description of the PLD tasks follows.

5.3.4 Point light display task.

This task, kindly leant by Professor V. Bruce (Nottingham University), is the Bruce and Valentine (1988) task, which has been discussed in the introduction of this chapter. It requires the recognition of three "non-rigid" facial expressions smiling, frowning and surprise and the three "rigid-rotational" head movements rocking, shaking and nodding, from PLD clips. This task allows one to measure the extent to which PH is able to use pure dynamic information (absent of any structural/configural information) in the recognition of facial expressions and rigid-rotational head movements.

Stimuli and procedure

This task consisted of two parts, the first part (a) compared an equal number of non-rigid facial expressions (frowning, smiling and surprise) with an equal number of rigid-rotational head movements (nodding, shaking or rocking the head from side). These clips were produced by three actors and three actresses, who had 100 self adhesive white dots (8 mm diameter) randomly applied to the surface of their face, with the exception of their eyelids and lips. Their hair was concealed in a swimming cap. During the recording of the clips a contrast box was used to produce an image where the white spots on the face were all that could be seen from an entirely black background. Each actor/actress produced six clips of each of the three facial expressions and the three types of rotational head movement, producing a total of 216 clips. The presentation order of the clips was randomised with the only constraint that the same experimental condition (expression or rotational head movement) did not occur in more than three consecutive trials and the same actor/actress did not occur in more than two consecutive trials. Each clip was approximately five seconds in length and was interspersed by five seconds of colour bars.

Subjects were required to make an expression/rotational head movement identification judgement. Their possible response alternatives were either "frowning," "smiling" or "surprise," for the expression category, or "nodding," "shaking" or "rocking," for the rotational head movement category.

The second part of the task (b) compared an equal number of static PLD clips of non-rigid facial expressions (frowning, smiling, surprise and neutral). The frowning, smiling and surprise clips were recorded from the apex of the moving clips used in part (a) held on pause. The same three actors and three actresses used in part (a) produced nine replications of a neutral facial expression to add to these expressions. There was a total of 216 test clips whose presentation order was randomised with the only constraint that the same facial expression did not occur in more than three consecutive trials and the same actor/actress did not occur in more than two consecutive trials. Each clip was approximately five seconds long and was interspersed by five seconds of colour bars.

PH had to decide whether he had seen the expression "smiling," "frowning," "surprise" or "neutral."

Part (b) of the task was administered to ensure that the dynamic PLD clips of part (a) contained no structural/configural information. This can be measured by asking the subject to make an expression recognition decision based on a static PLD clip recorded from the apex of the moving PLD clip held on pause. If the dynamic PLD clip truly contains no structural/configural information one would expect the subjects expression recognition performance based on the static PLD clips to be close to chance.

Normal Subjects

The same normal subjects who completed the posed facial expression recognition task (b) (see task 5.3.2) also completed this task.

Results and discussion

As can be seen from Table 12, PH is significantly impaired (z = 3.78, p < .001) at recognising the rigid rotational movements in the PLD task, compared to the normal subjects' performance. Although significantly impaired his recognition accuracy for rotational head movements is well above chance (chance accuracy = 36, PH's accuracy = 88) and actually differs significantly from that expected by chance z = 10.63, p < .001. PH is not significantly impaired at recognising facial expressions from the PLDs compared to the normal subjects, although his performance (z = 1.57) is bordering on the edge of the normal subjects' cut off point. However, his accuracy score for facial expressions actually differs significantly from that expected by chance (chance accuracy = 36, PH's accuracy = 75), z = 7.96, p < .001.

Table 12: PH and the normal subjects' error scores on part (a) of the point light display task.

	Point Light Display	
	Non-rigid facial expression	Rigid rotational head movements
PH		
Error score	33/108	20/108 ***
Normal Subjects		
Mean error score	20.1	2.6
SD	8.2	4.6

PH was 29% accurate at recognising static versions of the PLD clips in part (b) of the task. As chance performance was 25% correct (Bruce and Valentine, 1988) it was concluded that the dynamic PLD facial expression clips provided only pure movement information, virtually absent of any structural/configural information.

PH's unimpaired performance at recognising the dynamic PLD facial expressions allows one to draw two conclusions. Firstly, it confirms that PH is able to perceive movement and secondly suggests he is able to use pure movement information (dynamic information absent of any structural/configural information) in the recognition of facial expressions.

This result taken together with PH's performance on tasks 3.5.1, 5.3.1 and 5.3.2 suggests that dynamic information plays an important role in PH's recognition of facial expressions. Movement information is able to supplement structural/configural information and it is also able to provide a pure movement pattern from which expression recognition judgements can be achieved in the absence of any structural/configural information. This strongly suggests that the movement processing channel is able to selectively feed into the facial expression analysis channel with facilitative consequences upon expression recognition.

5.3.5 Degree of facial affect task.

This task involved the explicit recognition of the three facial expressions happiness, angriness and sadness, each of which was displayed in three different degrees of affect including strong, moderate and weak displays. This task allows one to measure whether the degree of affect displayed has any effects upon the recognition of the given expression.

Stimuli and procedure

This task compared an equal number of "weak," "moderate" and "strong" displays of the facial expressions happiness, angriness and sadness. All the clips were of facial feature movement with talking.

In this task all the clips produced by the four actors/actresses were rated for accuracy by five judges (three male and two female) whose age ranged between 25 and 64 years. Each actor/actress provided examples of happiness, angriness and sadness in weak, moderate and strong displays of affect. All the clips produced by each actor were edited into a randomised presentation order, with the only constraint that each category of facial expression and the same degree of affect, did not occur in more than three consecutive trials. Each clip was separated by a blank clip a few seconds long. This procedure was carried out separately for each actor/actress. The judges were required to view the clips produced by each actor/actress in succession. They were asked to view each clip to the end and then write their response down on the task response sheet in the following blank clip, indicating whether the facial expression they had seen was happiness, anger or sadness. They were also asked to judge the degree of affect seen, indicating whether they thought it was weak, moderate or strong and to indicate the extent to which they felt each clip was an accurate portrayal of that given facial affect, using a seven point rating scale where a score of one represented a poor example of a given emotion and a score of seven represented a highly accurate example of a given emotion.

These ratings were analysed, calculating the number of judges who correctly identified each clip and the total accuracy rating score for each clip. Because each clip had to be identified not only in terms of the type of facial expression portrayed but also in terms of the degree of facial affect seen, the number of clips correctly identified by all five judges was small. From these ratings only those clips that were correctly identified by as many of the five judges as possible and which obtained the highest mean accuracy rating scores were used in the final version of this task. Table 13 shows the number of clips used in the final version of this task which were correctly identified by either one, two, three, four or five judges.

Table 13: Number of judges who correctly identified the degree and category of facial affect in the clips used in the final version of the degree of affect task.

	Degree of Facial Affect								
	Happiness			Anger			Sadness		
	weak	moderate	strong	weak	moderate	strong	weak	moderate	strong
Number of judges									
1	1	0	0	0	0	0	0	0	0
2	1	0	0	1	1	0	2	1	0
3	1	0	0	2	3	0	2	3	0
4	4	5	2	3	1	3	5	1	4
5	2	4	7	3	4	6	0	4	5

As we can see from Table 13, 43% of the clips used in the final version of the degree of affect recognition task were correctly identified by all five judges.

Table 14 provides the mean rating scores for each weak, moderate and strong version of happiness, anger and sadness used in the final version of this task.

Table 14: Mean rating scores for each weak, moderate and strong display of facial affect used in the final version of the degree of affect task.

	Facial Expression		
	Happiness	Anger	Sadness
Degree of Affect			
Weak	2.44	2.05	2.34
Moderate	3.07	2.65	2.84
Strong	3.44	3.34	3.21

The maximum rating score in each condition is seven, so although there is some variation amongst the mean ratings, we can see that the clips used in the final version of the degree of affect task are on the whole reasonably accurate.

There were 72 test clips in the final version of this task. Each actor/actress provided six clips for each category of facial affect, including two versions of weak, moderate and strong displays of each facial affect respectively. There were nine practice trial clips providing three examples of each category of facial affect including a weak, moderate and strong version of each. The practice and test clip presentation order was randomised with the only constraint that the same category of facial affect did not occur in more than two consecutive trials and the same degree of any category of facial affect and the same actor/actress, did not occur in more than three consecutive trials.

PH was required to decide whether he had seen a "happy," "angry" or "sad" facial expression.

Normal subjects

The normal subjects who completed the posed facial expression recognition task (a) (see 5.3.1) also completed this task.

Results and discussion

Perhaps the first thing to note from Table 15 is that both PHs and the normal subjects' performance goes some way to falling in line with the hypothesised pattern of performance, namely that strong degree displays of facial affect should be more easily recognised than moderate degree displays of affect, which in turn should be easier to recognise than weak degree displays of affect. It can be seen from Table 15, that there is a difference in the error rate between the recognition of strong and weak and moderate and weak displays of facial affect, but no difference between the recognition of moderate and strong displays of facial affect and this response pattern is demonstrated by both PH and the normal subjects.

Table 15: PH and the normal subjects' error scores on the degree of affect task.

	Facial Expression		
	Weak	Moderate	Strong
PH			
Error score	6/24 ($p < .01$)	1/24	1/24
Normal subjects			
Mean error score	2.1	0.1	0.1
SD	2.7	0.3	0.3
Range	0-9	0-1	0-1

From Table 15 we can also see that the normal subjects' performance is close to ceiling level and therefore, for the reasons discussed in chapter three (see task 3.4.1) the range of the normal subjects' performance is included for comparison with PH's performance. PH performs within the normal range for the weak, moderate and strong degree displays of facial affect. Thus, PH appears to be able to recognise the different degrees of affect normally. However, a Binomial test was used to calculate the probability of PH making the number of errors on weak, moderate and strong displays of affect respectively by chance (as extrapolated from the normal subject's performance). For weak degree displays of facial affect (despite the fact that PH's error score fell within the normal range), PH's error score was significantly different from that expected by chance, ($z = 2.38$, $p < .01$). Thus, it was concluded that PH is impaired at recognising weak displays of facial affect. For the moderate and strong displays of facial affect $z = 1.29$, which was not significantly different from that expected by chance thus, it was concluded that PH is able to recognise both moderate and strong displays of facial affect normally.

This pattern of impaired performance goes some way to supporting the experimental hypothesis, as PH is impaired at recognising weak, but not moderate and strong displays of facial expression. This suggests that PH does gain a considerable amount of facilitation from the degree of affect displayed. It is important to consider PH's performance in terms of what it can tell us about how he processes facial expressions and how his strategies may differ from those employed by normal subjects. His performance suggests that the strategies he uses in processing facial expressions are similar to those used by normal subjects, as he does show a similar pattern of performance to the normal subjects and does experience a considerable degree of facilitation in his recognition judgements from the degree of facial affect displayed.

5.3.6 Expression recognition in the upper, lower, and whole face.

This task required the explicit recognition of the three facial expressions happiness, angriness and sadness from different regions of the face including the whole face, the upper half of the face only and the lower half of the face only. This task allows one to measure the extent to which the different regions of the face play a role in the recognition of different facial expressions. It also enables one to possibly see the extent to which a facial expression recognition impairment could be accountable to an underlying visual configural processing deficit.

Stimulus and procedure

This task compared an equal number of clips of "upper," "lower" and "whole" face presentations of the facial expressions happiness, angriness, sadness, surprise, disgust and fear. The upper and lower face presentations were produced using a screen made of card, positioned so that it masked off the appropriate half of the face at the mid-line of the nose.

The clips produced by the four actors/actresses were rated for accuracy by the same judges who rated the clips in the degree of affect recognition task (see task 5.3.5). Each actor/actress provided examples of happiness, angriness, sadness, surprise, disgust and fear presented in the upper, lower and whole face. All the clips produced by each actor were edited into a randomised presentation order, with the only constraint that each category of facial expression did not occur in more than three consecutive trials. Each clip was separated by a blank clip a few seconds long. This procedure was carried out separately for each actor/actresses clips. The same procedure was used as in task 5.3.5 only this time the judges had to indicate whether the facial expression they had seen was happiness, anger, sadness, surprise, disgust or fear. They were also asked to indicate the extent to which they felt each clip was an accurate portrayal of that given facial affect, using the same rating scale as used in task 5.3.5.

These ratings were later analysed, calculating firstly the number of judges who correctly identified each clip and secondly the total accuracy rating score for each clip. The judges found the task of recognising the facial expressions from the upper and lower region of the face only, quite demanding and as a result the clips used in the final version of this task were not necessarily accurately recognised by all five judges. Table 16 shows the number of clips used in the final version of this task which were recognised by one, two, three, four or five judges respectively.

From these ratings only those clips that were correctly identified by as many of the five judges as possible and which obtained the highest mean accuracy rating score were used in the production of the final version of this task.

As can be seen in Table 16, 63% of the clips used in the final version of this task were accurately recognised by all five judges.

Table 16: Frequency table of the number of judges who correctly recognised the clips used in the expression recognition in upper, lower and whole face task.

	Facial Expression																	
	Happiness			Anger			Sadness			Surprise			Disgust			Fear		
	U	L	W	U	L	W	U	L	W	U	L	W	U	L	W	U	L	W
No. of judges **1**	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
2	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
3	0	0	0	2	0	0	0	0	0	1	1	1	3	0	0	1	0	0
4	2	0	0	1	1	0	0	1	0	3	2	2	1	0	0	3	2	1
5	3	5	5	1	4	5	5	3	5	0	1	1	1	5	5	1	3	4

U = upper half of the face, L = lower half of the face and W = whole face presentation.

Table 17 shows the mean rating score for the clips used in the final version of this task.

Table 17: Mean rating score for the facial expressions presented in the upper, lower and whole face region as given by the five judges.

	Facial Expression					
	Happiness	Anger	Sadness	Surprise	Disgust	Fear
Region of face						
Upper	5.32	4.40	5.80	4.36	4.20	5.08
Lower	6.08	5.72	4.76	4.72	5.36	4.64
Whole	6.48	6.24	6.24	5.48	6.08	6.48

The maximum rating score for each facial expression in each region of the face is seven. Therefore, although there is some variation in the accuracy ratings given to the clips used in the final version of this task, they have still nevertheless been rated as being quite accurate representations of a given affect.

In making the upper and lower face clips each actor/actress was required to gently rest their nose against a screen, so that during the production of each facial expression no inappropriate facial information (information pertaining to the other half of the face) could be seen. There were 72 test clips. Each actor/actress provided three examples of each category of facial affect including one example of whole face, lower face and upper face respectively. All the clips were of facial movement without talking. There were 18 practice trial clips, randomly assigned to a combination of actors, providing three examples of each category of emotion including one example of whole, lower and upper face presentation respectively. The practice and test clip presentation order was randomised with the only constraint that the same category of facial affect did not occur in more than one consecutive trial and the same region of display and actor/actress did not occur in more than two consecutive trials.

Subjects were required to decide whether they had seen the facial expression "happy," "angry," "sad," "surprise," "disgust" or "fear."

Normal subjects

The same normal subjects who completed the posed facial expression recognition task (a) (see 5.3.1) also completed this task.

Results and discussion

It is worth noting that the normal subjects' performance falls in line with that observed by Bassili (1979). Bassili observed a trend in the recognition accuracy rates for the specific regions of the face, where whole face presentations obtained higher recognition accuracy rates than the lower face presentations, which in turn were higher than those for upper face presentations. The normal subjects' performance clearly supports Bassili's findings. They made more expression recognition errors when given upper face presentations, than either lower or whole face presentations, suggesting that overall the upper half of the face is not as informative about the nature of facial expressions as either the lower half or whole face. Thus, it appears that although the upper region of the face is useful as a conveyor of emotional facial information, it is not as useful as the lower half of the face.

Table 18: PH and the normal subjects' error score on the expression recognition task involving upper, lower and whole face presentations.

	Region of Facial Expression		
	Upper	Lower	Whole
PH			
Error score	13/24 ***	7/24 **	8/24 ***
Normal subjects			
Mean error score	6.1	2.4	1.5
SD	1.9	1.8	1.2

Table 18 shows that PH's performance goes some way to falling in line with Bassili's findings. PH despite being significantly impaired at making expression recognition judgements from upper ($z = 3.63$, $p < .001$), lower ($z = 2.55$, $p <.01$) and whole ($z = 5.42$, $p < .001$) face presentations, does make more errors on the upper face presentations than on the lower and whole face presentations. Thus, it appears that although PH is impaired at making expression recognition judgements from the upper, lower and whole face presentations, he nevertheless is using a similar recognition strategy to the normal control subjects, as he shows a similar pattern of recognition errors.

It is possible to consider the role which each specific region of the face plays in the recognition of each facial expression. Ekman and Friesen (1975), claimed that each facial expression has its own set of facial actions, which incorporate the different regions of the face to different extents. Tables 19 and 20, provide a breakdown of PHs and the normal subjects' errors made, when recognising each facial expression from the different regions of the face. These data essentially support Ekman and Friesen's claims that facial expressions are displayed to different extents in the different regions of the face. It also provides evidence to suggest that the information provided in either the upper or lower region of the face only, is sometimes sufficient to enable a correct expression recognition judgement to be made.

Table 19 shows PHs and the normal subjects' errors when recognising happiness, anger and sadness from the upper, lower and whole region of the face.

Table 19: PH and the normal subjects' error score when recognising happiness, anger and sadness from the different regions of the face.

	Facial Expression								
	Happiness			Anger			Sadness		
	U	L	W	U	L	W	U	L	W
PH									
Error score	**2	0	0	2	0	0	0	0	0
Normal subjects									
Mean	0.4	0.1	0.2	1.9	0	0	0.2	0.1	0.1
SD	0.52	0.32	0.63	1.37	0	0	0.42	0.32	0.32

As we can see from Table 19, overall PH is very accurate at recognising these dynamic displays of the facial expressions happiness, anger and sadness.

He is significantly impaired compared to the normal subjects at recognising happiness from the upper region of the face ($z = 3.08$, $p < .01$). Ekman and Friesen (1975) claimed that the facial expression happiness primarily involves facial movements in the lower half of the face and the lower eyelid region. The brow region is believed not to be involved in the production of happiness, which could account for PH's performance.

Ekman and Friesen claimed that anger is manifested in all three facial regions of the face and PH's performance falls in line with this, although he makes a couple of errors when recognising anger from the upper region of the face, his performance is still normal.

The facial affect sadness, Ekman and Friesen claimed, involves mainly the upper region of the face but the mouth can also be incorporated. Again PH's performance supports this, as he is clearly able to recognise sadness from the upper, lower and whole region of the face.

Table 20 provides a breakdown of the errors made by PH and the normal subjects' when recognising the facial expressions surprise, disgust and fear from the upper, lower and whole region of the face.

Table 20: PH and the normal subjects' error score when recognising surprise, disgust and fear from the different regions of the face.

	Facial Expression								
	Surprise			Disgust			Fear		
	U	L	W	U	L	W	U	L	W
PH									
Error score	*3	0	1	**4	***4	***4	2	*3	***3
Normal subjects									
Mean	1.4	0.6	0.7	1.1	0.3	0.2	1.2	1.3	0.3
SD	0.97	0.70	0.48	1.20	0.48	0.42	0.83	0.95	0.67

Firstly, Table 20 clearly shows PH's difficulties with recognising the facial expression disgust, which Ekman and Friesen claimed is primarily shown in the lower face and lower eyelid region. PH is significantly impaired at recognising this facial expression from all regions of the face; upper face presentations ($z = 2.42$, $p < .01$), lower face presentations ($z = 7.71$, $p < .001$) and whole face presentations ($z = 9.05$, $p < .001$). It was previously mentioned that before producing any of the affect recognition tasks reported in this thesis, PH's understanding of the six universally recognised facial expressions, used in the tasks was assessed. PH was unable to provide any description of the facial affect disgust. It appears that despite explaining to PH what constitutes the feeling of disgust and how it is portrayed in the face, he is still unable to recognise this facial expression.

Ekman and Friesen claimed that the facial expression surprise incorporates all three regions of the face. We can see from Table 20 that PH was just impaired compared to the normal subjects at recognising surprise from the upper region of the face ($z = 1.65$, $p < .05$). The nature of the facial movements involved in the upper region of the face during the production of surprise are very similar to those involved in the production of fear. Therefore, it is possible that PH found recognising these two facial expressions (surprise and fear) from the upper half of the face only, a little confusing.

PH found the recognition of fear particularly hard. He was significantly impaired compared to the normal subjects at recognising fear from the whole face presentations ($z = 4.03$, $p < .001$) and was also impaired at recognising fear from the lower region of the face ($z = 1.79$, $p < .05$). Ekman and Friesen claimed that the production of fear involves all three regions of the face, therefore, PH's impaired recognition performance cannot be accounted for in terms of having to make expression recognition judgements from regions of the face which contain no relevant facial information. PH's expression recognition deficits observed here seem to reflect a particular difficulty which PH experiences with processing the facial affect fear.

The results presented in Tables 19 and 20 respectively, support the claims made in task 5.3.2, where it was argued that PH has become highly practised at recognising the facial expressions happiness, angriness and sadness. In comparison he has had little test experience with the facial expressions surprise, disgust and fear and thus, their introduction into facial expression recognition tasks causes detrimental effects upon PH's expression recognition performance. We can see how the data presented in Tables 19 and 20 clearly support this argument. There is a noticeable difference between PH's performance in Table 19 (where error scores for happiness, anger and sadness are reported) and Table 20 (where error scores for surprise, disgust and fear are reported), where he makes significantly more errors in the latter table.

It was believed that producing a facial expression recognition task which compared recognition judgements made from whole face presentations with judgements made from either the upper or lower region of the face only, could possibly throw some light on whether a deficit in the processing of facial expressions is due to an underlying deficit in the processing of visual configural information. It was hypothesised, that if deficits in the processing of configural information could (at least go some way to) explain an impairment in the processing of expressions, then we would possibly expect patients to find recognition judgements based on either the upper or lower region of the face easier, than judgements based upon whole face presentations, ultimately making less errors on the former than the latter. We can see from Tables 19 and 20 that PH's performance at recognising the different facial expressions from the upper, lower and whole regions of the face, does not suggest that he has an underlying deficit in the processing of configural information. PH does <u>not</u> show an overall tendency to make less errors on either the upper or the lower region of the face than on whole face presentations. However, it should also be pointed out that

PH never actually makes fewer errors on the whole face presentations than on the lower half face presentations. Therefore, one could argue that when PH was making expression recognition judgements from whole face presentations he may have actually only been attending to the information in the lower region of the face, basing his judgement upon this and not the whole of the facial information. Thus, although PH did not show the predicted pattern of performance, where it was hoped he would make less errors on the upper/lower face presentation clips than on the whole face presentation clips it is still possible that PH may experience a deficit in the processing of configural information.

In summary, it appears that PH's recognition of static facial expressions is poor in comparison to the normal subjects, despite the fact that he is able to provide accurate descriptions of what constitutes happiness, angriness, sadness, surprise and fear. However, his facial expression recognition performance is facilitated by the introduction of dynamic information. This strongly suggests that the movement processing channel is able to feed into the facial expression analysis channel, with facilitative consequences upon PH's expression analysis.

PH is also able to successfully recognise facial expressions from pure movement information, which suggests that information pertaining to facial expressions is maybe also stored in the form of a pure movement pattern. If this were true then structural/configural information, could be thought of as a supplementary/complementary source of information, to pure dynamic information. It appears that both sources of information are useful, each being capable in its own right of providing enough information to enable the successful recognition of any given affect. However, a combination of these two sources of facial information maximises recognition.

PH does gain some facilitation in his expression recognition judgements from the degree of affect seen. He was able to recognise both moderate and strong displays of affect normally, whilst showing a significant impairment compared to the normal subjects, in the recognition of weak displays of facial affect.

Both PH and the normal subjects do show some ability to recognise various facial expressions from information provided in either the upper or lower half of the face only. This evidence not only supports Ekman and Friesen's claims that each facial expression has its own set of facial actions, which encompass the different regions of the face to different extents, but it also suggests that sometimes these different facial actions involving the upper and lower regions of the the face are sufficient to allow a successful expression recognition judgement. However, despite showing some ability to recognise facial expressions from the different regions of the face PH was significantly impaired compared to the normal subjects. PH also showed no overall preference for either the upper or lower region of the face to the whole face presentations, therefore, his expression recognition impairment does not seem to be accountable to an underlying configural processing deficit.

Chapter Six

Lip-read Speech Recognition

6.1 Introduction.

Lip-read speech forms the third and final source of facial information to be considered in this thesis. In particular, consideration will be given to the extent to which the prosopagnosic patient PH can analyse lip-mouthed speech information, including easily identifiable lip-mouthed sounds and "high frequency" words (Kucera and Francis, 1967). Some consideration will also be given to the role of movement in the processing of lip-mouthed speech, by comparing static and dynamic lip-mouthed sounds.

It is important however, to point out that speech by its very nature is a dynamic process, requiring the articulation of the mouth, lips and tongue in its production. When we lip-read we analyse these dynamic mouth articulations and thus, movement is seen to be a fundamental source of information. Although it has been argued that movement has an important role to play in the processing of facial expressions (see chapter five), the argument for the role of movement in the processing of lip-mouthed speech is some what different. Because speech is a dynamic process, the notion of lip-reading static lip-mouthed speech is extremely unnatural. It may well be possible that normal subjects are able to lip-read the more obvious and in a sense identifiable sounds, like "ee" or "oo" from a photograph or static video clip, but the notion of lip-reading static lip-mouthed words is incomprehensible. This is primarily because it would be extremely difficult to get a meaningful baseline measurement from a population of normal subjects. For this reason no facilitative role for dynamic information in the processing of lip-mouthed speech was hypothesised. The only facilitative role that dynamic information could be seen to play in the processing of lip-mouthed speech, would be when a patient, who is maybe impaired at processing static lip-mouthed sounds like "ee," makes less errors when given the same lip-mouthed sounds in dynamic mode of presentation. For this reason it is probably best to consider movement as playing a fundamental role in the processing of lip-mouthed speech. The only facilitative role that dynamic information may play, is in the recognition of lip-mouthed sounds, which although recognisable from static presentations, may actually be recognised with greater accuracy from dynamic displays.

Lip-read speech is a very informative source of facial information. As Ellis (1989) pointed out, speech provides information about identity (whose voice it is ?), emotion (is the person speaking in a happy manner ?) and phonetic information regarding the identity of specific words, which are in addition to the uses made of lip-read information in the comprehension of speech. During the comprehension of speech we are normally presented with both visual and auditory information. We tend however, to direct the majority of our attention to the auditory channel, except during less than perfect conditions, where the auditory channel of information is maybe masked by background noise. Under these conditions we direct our attention to the lips, a provider of supplementary/complementary speech information.

Lip-reading has many uses; normal hearing adults use it to aid the perception of speech masked by noise (Miller and Nicely, 1955), whilst lip-reading is also known to aid the comprehension of perfectly clear speech (Reisberg, McLean and Goldfield, 1987). Campbell (1987), pointed out that normal subjects are even able to lip-read single digits which are seen and not heard. However, it is important to emphasise that the nature of the task demands have significant effects upon lip-reading performance. Campbell's subjects knew that they had to recognise single digits, therefore, they had a good chance of guessing correctly. Similarly one can significantly increase a subject's ability to lip-read speech sounds by choosing what are generally considered to be highly "identifiable" sounds, which are not easily confused with other sounds, like for example ee, oo and ah all of which have distinct mouth, lip and tongue movements involved in their production. In general it is believed that lip-read information alone, cannot support speech comprehension, unless of course the individual receives special training, like that involved in teaching the deaf to lip-read. As Campbell (1989) pointed out, we are unable to successfully understand the news when we can only see and not hear the stories and the fact that many sounds share the same lip movements, restricts the successful identification of words from vision alone.

As we are already aware, specific brain-injury can cause dissociable face processing impairments and in particular it can cause a selective impairment in the processing of lip-read speech information, whilst leaving the processing of the other sources of facial information intact (Campbell, Landis and Regard, 1986). However, there are few reports in the current literature of brain-injury causing such selective lip-reading impairments. The majority of studies reported, actually focus upon the ability of normal subjects to process lip-mouthed speech and in particular their susceptibility to the "fusion illusion," a phenomenon reported by McGurk and MacDonald (1976). During the fusion illusion, subjects if asked to report what is heard whilst perceiving incongruous auditory and visual information, tend to report a fusion of what they have seen and heard (see below for detailed account). This illusion illustrates how auditory speech perception can be influenced by lip-read speech information. There are known to be at least two different forms of the McGurk fusion illusion. In one the sound that is reported was neither seen or heard and is known as a fusion illusion, eg., when you hear the consonant-vowel utterance ba and see the consonant-vowel utterance ga, individuals often report hearing da. The other illusion involves a blending of what is heard with what is seen and is known as the blend illusion, eg., when you see the consonant-vowel utterance ba and hear the consonant-vowel utterance ga or da, individuals usually report hearing bda.

The main study reported in the literature detailing the existence of a dissociable lip-reading impairment, with intact processing of other sources of facial information was reported by Campbell, Landis and Regard (1986), the full details of which have been given in the introduction (see chapter one). To recap briefly, Campbell et al reported details of two patients; (D) had right hemisphere damage, was prosopagnosic, was grossly impaired at making expression and sex judgements, but was however able to lip-read. (T) had left hemisphere damage, was alexic (without agraphia), was able to identify faces, facial expressions and categorise faces according to their sex, but was impaired at lip-reading. This double dissociation between D and Ts' ability to recognise familiar faces and lip-read speech suggests there are distinct processing channels for identity and speech analysis, a claim which Bruce and Young later incorporated into their functional model of face recognition (1986). Campbell et al claimed that this evidence also suggested that lip-reading is a left hemisphere processing ability. Support for this can be found in Campbell, Garwood, Franklin, Howard, Landis and Regard's (1990), examination of four patients; two with left hemisphere damage (LHD) and two with right hemisphere damage (RHD). They were examined on various lip-reading tasks comparing either congruent or incongruent heard and seen words, consonants and vowels. For each condition subjects had to repeat what was said. One of the LHD patients who was able to lip-read showed visual dominance in his audio-visual responses, while one of the RHD patients who was also able to lip-read showed no signs of using the visual channel during his perception of seen and heard speech. Campbell et al (1990) claimed that their evidence suggests a left hemisphere specialisation for the phonological integration of seen and heard speech. (See Critchley, 1938 for a further account of the left hemisphere's involvement in the processing of seen and heard speech).

The majority of studies in the literature however, have been concerned with normal subjects' ability to lip-read, primarily using lip-reading tasks like the fusion illusion tasks. McGurk and MacDonald (1976) were the first to report details of this previously unrecognised fusion illusion phenomenon, where visually lip-read speech information influences what is heard. They presented a broad age band of subjects with a video sequence of an actress mouthing various consonant vowel utterances, onto which an incongruous sound track of these utterances had been dubbed, producing the following clips; ba voice/ga lips, ga voice/ba lips, pa voice/ka lips and ka voice/pa lips. Subjects were tested whilst viewing the video and simultaneously hearing the sound track and whilst listening to the sound track only. For each condition they simply had to report what they heard. McGurk and MacDonald found that when given "ba" voice and "ga" lips, subjects "fused" what they saw with what they heard, reporting the utterance "da." A similar fusion occurred for the "pa" voice and "ka" lips, where "ta" was reported, although its effect was not as significant. McGurk and MacDonald claimed that this fusion illusion demonstrated the importance of vision upon speech perception. They felt that this observation demanded further questioning of the current theories of speech perception. (See also MacDonald and McGurk, 1978 for confirmation and elaboration of this effect).

This fusion illusion task provides a particularly impressive way to examine an individual's ability to lip-read. Its use of a small set of consonant-vowel utterances (ba-ga-da and pa-ka-ta), lend well to the task being run as a forced-choice paradigm, making it particularly suitable for use with the prosopagnosic patient PH whose performance, is optimised when given tasks with a small set of response alternatives (see task 5.3.2). For these reasons two fusion illusion tasks based on McGurk and MacDonald's (1976) design were produced for use in assessing PH's ability to lip-read, a discussion of which can be found later in this chapter.

Dodd (1977) was also concerned with the extent to which normal subjects could use lip-read speech information to aid their perception of auditory speech masked by white noise. She examined a group of school children who had to repeat words that they heard through head phones, whilst simultaneously hearing white noise. There were five distinct presentation modes; sound and visual information in synchrony, out of synchrony, sound only, vision only and dubbed, where a different word was seen to the one which was heard. Dodd found that subjects were able to use visual information to aid their perception of auditory information masked by white noise. When the auditory and visual sources of information were out of synchrony subjects made many errors. However, this mode of presentation proved to be more informative for the subjects than having either just the visual or auditory channels of information alone. The dubbed presentation mode also resulted in many errors, subjects were not able to ignore one source of information in favour of another, but when presented with this competition of inputs they did attend more to the visual input than the auditory. Dodd claimed that these results demonstrated that speech perception is not solely dependent upon the auditory channel of information. Visual information too is extremely important and very useful especially when sound is masked by background noise.

Dodd's white noise interference speech perception task provides another means of measuring the ability to lip-read, which seemed applicable to the measurement of PH's lip-reading abilities. A simplified version of Dodd's task, based upon the original technique of Miller and Nicely (1955), was designed and produced, a discussion of which follows later in this chapter.

It seemed therefore, in light of the evidence presented above that in examining PH's ability to process facial information and specifically questioning the role that dynamic information may play in this processing, that it was also important to consider PH's ability to lip-read speech, including both lip-mouthed sounds and words. No previous consideration has been given to PH's ability to lip-read speech, therefore, a variety of lip-reading tasks were designed. These compared the recognition of lip-mouthed sounds from both static and dynamic displays, the influence of vision upon the perception of speech as measured by the fusion illusion tasks, the use of lip-mouthed speech in the auditory perception of speech sounds and words, and the explicit recognition of lip-mouthed words. For reasons discussed above, no specific facilitative role for dynamic information was hypothesised in the processing of lip-read speech (i.e. words). Movement was deemed to be fundamental source of information in lip-reading, making the notion of lip-reading static lip-mouthed words, impossible to comprehend. What was hypothesised was that the recognition of lip-mouthed sounds like ee or oo, could possibly be facilitated by the inclusion of dynamic information. That is to say, one may make less errors when recognising dynamic lip-mouthed sounds than static lip-mouthed sounds. The lip-reading tasks were basically designed to measure the extent to which PH can lip-read speech sounds and words. A total of four lip-reading tasks were administered to PH, the details of which are given below. PH was also given a "McGurk" illusion task.

Lip-read Speech Recognition

6.2 Test methodology.

The clips for all the video tasks (except the McGurk task) were filmed using a colour video camera. These video tasks were edited and presented using VHS video cassette recorders. A Cardioid Microphone was used in dubbing the soundtrack onto the video recording in task 6.3.5. PH viewed the video tasks on a colour receiver/monitor (screen size 20 cm * 25 cm) and the normal subjects viewed the video tasks on a colour receiver/monitor (screen size of 19 cm * 24 cm).

Unless stated otherwise the same procedure as used in the facial expression recognition tasks (see test methodology 5.2) was used in the presentation of the following tasks.

6.3 Lip-read speech recognition tasks.

6.3.1 Forced-choice lip-reading task.

This task, kindly leant by Ms. B. Flude (Lancaster University), required the recognition of three lip-mouthed sounds ee, oo and ah, from static black and white photographs. These lip-mouthed sounds were chosen for their distinctiveness and the fact that they were not easily confused with one another.

Stimuli and procedure

This task compared pairs of black and white photographs (12.5 cm * 9.0 cm) depicting five actors and five actresses, posing three lip-mouthed sounds ee, oo and ah. The task consisted of six practice presentations and 48 test presentations. Each presentation consisted of two photographs, one positioned above the other on an A4 piece of paper, with one of the three lip-mouthed sounds (ee, oo or ah) printed in-between the two photographs. Each presentation consisted of one "target" photograph (eg. a photograph of the lip-mouthed sound which is written between the two photographs) and one distracter (a photograph of one of the other two lip-mouthed sounds). The 48 test presentations consisted of 16 target presentations of each of the lip-mouthed sounds ee, oo and ah respectively. Each target presentation lip-mouthed sound was paired with an equal number of each of the other two lip-mouthed sounds. For each presentation, the target photograph was positioned at the top of the page on half the trials and at the bottom of the page on the remaining trials. The presentation order of the target lip-mouthed sound was randomised with the only constraint that the same target lip-mouthed sound and the same distracter lip-mouthed sound photographs and the same response alternative (i.e. top or bottom) did not occur in more than two consecutive trials.

Both PH and the normal subjects were required to look at each test presentation and decide which photograph represented the lip-mouthed sound that was printed in-between the two photographs (the experimenter read out each lip-mouthed sound). They were asked to either point to the relevant photograph, or to verbally report top or bottom, or simultaneously point and verbally respond. Their responses were recorded on the task response sheet by the experimenter. No feedback was given.

Normal subjects

A matched population of ten normal subjects were paid for completing this task. These subjects were matched to PH on gender, age at date of testing and age on leaving full-time education. They were all members of Durham University technical and maintenance staff. Their mean age at date of testing was 33 years. Their mean age on leaving full-time education was 15.7 years.

PH was 27 years of age at date of testing and left full-time education at 16 years of age.

Results and discussion

Perhaps the first thing to note from Table 21 is that the normal subjects are surprisingly accurate at recognising static lip-mouthed sounds. It was predicted that because lip-reading is a dynamic process the recognition of lip-mouthed sounds would be easier from dynamic than static clips. However, the fact that the normal subjects demonstrate a high degree of accuracy for the recognition of the static lip-mouthed sounds, confirms that these chosen sounds are easily identifiable from one another.

Table 21: PH and the normal subjects' error scores on the forced-choice lip-reading task.

	Lip-mouthed Sounds
PH	
Error score	3/48 ($p < .001$)
Normal subjects	
Mean error score	0.1
SD	0.3
Range	0-1

From Table 21 we can also see that the normal subject's performance is close to ceiling level. Therefore, for the reasons discussed in chapter three (see task 3.4.1) the range of the normal subject's performance is included for comparison with PH's performance. As one can see from the above table PH's error score on the static lip-mouthed speech sounds falls outside the normal subject's range.

A Binomial test was used to calculate the probability of PH making the number of errors he did by chance, (as extrapolated from the normal subject's performance). PH's error score was significantly different from that expected by chance ($z = 7.74$, $p < .001$). Thus, it was concluded that PH shows a significant impairment in the recognition of static lip-mouthed speech sounds.

PH's result could be considered to be an artifact of the unnaturalness of the task demands, as very rarely under normal circumstances is one asked to analyse lip-mouthed speech from a static photograph. However, if this were a significant factor then one would have expected the normal subjects to have made more errors on the task than they did. It is believed therefore, that PH's impaired performance represents an underlying problem which PH has in the analysis of any static facial information, whether it involves the analysis of lip-mouthed speech information or the analysis of facial expressions.

6.3.2 Dynamic lip-reading task.

This task required the recognition of the three lip-mouthed sounds ee, oo and ah from both static and dynamic clips. By comparing static and dynamic lip-mouthed sounds one is able to determine the extent to which dynamic information facilitates the recognition of such speech sounds.

Stimuli and procedure

Two actors and two actresses, all members of Durham University Psychology Department produced the lip-mouthed sounds. The clips were of head and shoulders only and recorded the actor/actress moving from a neutral face into each lip-mouthed sound. They were asked to actually produce the lip-mouthed sounds (for authenticity) although the sound was not recorded. Each clip was six seconds long and was interspersed by a blank clip of equal duration. Each actor/actress provided 12 clips of each of the lip-mouthed sounds ee, oo and ah, including two static and two dynamic examples of each (the static clips were recorded from the apex of the moving clips held on pause). There were six practice trial clips randomly assigned to a combination of actors providing one example of each lip-mouthed sound ee, oo and ah in both static and dynamic mode of presentation. The test clips were arranged in four blocks of 12 (two blocks of static lip-mouthed sounds and two blocks of dynamic lip-mouthed sounds) each actor posing one example of each lip-mouthed sound in each block. The practice and test clip presentation order was randomised (within blocks), with the only constraint that clips of the same lip-mouthed sound and by the same actor/actress did not occur in more than two consecutive trials. The blocks were arranged in an ABBA design with static lip-mouthed sounds presented first. The practice trial clips were also blocked, with static lip-mouthed sounds representing the first presentation.

Subjects were required to judge whether the lip-mouthed sound they saw was either "ee," "oo" and "ah."

Normal subjects

The same normal subjects who completed the forced-choice lip-reading task (see task 6.3.1) also completed this task.

Results and discussion

Perhaps the first point to note from Table 22 is the fact that the normal subjects' performance is close to ceiling level. Therefore, for the reasons discussed in chapter three (see task 3.4.1) the range of the normal subjects' performance is included for comparison with PH's performance. As one can see from Table 22 PH's error score on both the static and dynamic lip-mouthed sounds falls outside the respective ranges of the normal subjects' performance.

Table 22: PH and the normal subjects' error scores on the dynamic lip-reading task.

	Lip-mouthed Sound Static clips	 Moving clips
PH		
Error score	5/24 ($p < .001$)	2/24 ($p < .001$)
Normal subjects		
Mean error score	0.3	0
SD	0.7	0
Range	0-2	0

A Binomial test was used to calculate the probability of PH making the number of errors on the static and dynamic clips respectively by chance, (as extrapolated from the normal subjects' performance). PH's error scores for both static and dynamic clips respectively were significantly different from that expected by chance, (static clips, $z = 8.70$, $p < .001$ and dynamic clips, $z = \infty$, $p < .001$). Thus, it was concluded that PH is significantly impaired at recognising both static and dynamic lip-mouthed sounds.

The normal subjects' performance falls in line with that predicted in the hypothesis, where they experience a facilitation in their recognition of lip-mouthed sound with the introduction of movement. PH's performance, although significantly impaired, does go some way to falling in line with the predicted pattern of performance. He makes less errors when analysing dynamic lip-mouthed sounds than static sounds, suggesting that he too does gain some advantage from the inclusion of dynamic information.

In summary, it seems that when PH is asked to lip-read speech sounds he is impaired regardless of whether the sounds seen are dynamic or static. However, he makes less errors when judging dynamic lip-mouthed sounds than static lip-mouthed sounds, suggesting that dynamic information does aid to some extent his recognition of lip-mouthed sounds.

6.3.3 "McGurk" illusion task.

This short task demonstrates the importance of vision upon the perception of speech.

Stimuli and procedure

This video task consisted of a male actor mouthing a sentence which had been dubbed with the soundtrack of an incongruent auditory sentence. Subjects are asked to report what they hear whilst watching the video. If they are able to lip-read speech information they become susceptible to the McGurk illusion, combining what they hear with what see, resulting in reporting the sentence they believed to have heard as "my dad taught me to drive."

In this task there are 21 presentations of the sentence where the auditory and visual information are incongruent. Each is separated by a small pause. These are followed by three presentations of the visual version of the sentence with no auditory input and a single presentation of the auditory version of the sentence with no visual input.

PH viewed each sentence in the above order and was asked for each presentation to report what he heard.

Results and discussion

PH was susceptible to the McGurk illusion reporting a blend of what he heard and saw "my dad taught me to drive." This demonstrated that PH was able to analyse dynamic lip-mouthed speech information, which influenced what he heard.

6.3.4 Speech perception fusion illusion task.

This task was concerned with the influence of vision upon the perception of speech. Its design was based upon the McGurk and MacDonald (1976) fusion illusion effect described in the introduction of this chapter.

Stimuli and procedure

This task consisted of two parts; A and B. Part A compared an equal number of clips of the consonant-vowel utterances "ba-ba," "ga-ga" and "da-da" (where each auditory utterance was superimposed onto the same lip movements) and the fusion illusion "da-da" (where the auditory utterance ba-ba was superimposed onto the lip movements ga-ga, resulting in hearing a fusion of the two, da-da). Part B compared an equal number of clips of the consonant-vowel utterances "pa-pa," "ka-ka" and "ta-

ta" (where each auditory utterance was superimposed onto the same lip movements) and the fusion illusion "ta-ta" (where the auditory utterance pa-pa was superimposed onto the lip movements ka-ka resulting in hearing a fusion of the two ta-ta). Parts A and B were exactly the same in design. They consisted of 12 practice trial clips and 80 test clips, including equal numbers of each of the four categories of consonant-vowel utterances. The clips were produced by myself and were of head and shoulders only. Each utterance was repeated once per second and was interspersed by a six second blank clip. The clips were recorded without sound but the sound track was later dubbed onto the visual recording ensuring auditory-visual coincidence of the release of the consonant of the first syllable of each utterance. The presentation order throughout the practice and test clips was randomised with the only constraint that the same category of consonant-vowel utterance (including the fusion utterances) did not occur in more than three consecutive trials.

A pilot study was conducted to measure the “accuracy” of the 40 fusion illusion clips (20 ba-ga-da and 20 pa-ka-ta), in terms of the auditory-visual coincidence in the release of the consonant of the first syllable of each utterance. The clips were arranged in a randomised presentation order, each clip interspersed by a blank clip. Three judges (all male, aged between 23 and 31 years) were required for each clip to report what they heard whilst simultaneously viewing the television. They were informed that they would be viewing some consonant-vowel utterances but were not given any indication as to which utterances, therefore, they had a free response choice. They recorded their own responses on the task response sheet. From their responses, percentage frequency scores were obtained for the number of occasions which they reported the auditory component of the clip (reporting either ba or pa), or the visual component of the clip (reporting either ga or ka). The number of occasions they fused what they heard and saw (reporting either da or ta), and the number of occasions on which they reported neither the visual, the auditory or a fusion, this category was classified as “other.” For the following purposes the performance of the normal subjects on the fusion illusion clips ba-ga-da and pa-ka-ta has been combined. From these, a mean percentage frequency score was calculated for the number of occasions the judges reported the visual, auditory, fusion or other category. See Table 23 below.

Table 23: Mean percentage frequency scores for the fusion illusion clips ba-ga-da and pa-ka-ta as given by the three judges.

	Aspect of Consonant-Vowel Utterance Reported			
	Auditory (ba or pa)	Visual (ga or ka)	Fusion (da or ta)	Other
Mean % frequency score	3.33%	39.17%	41.67%	15.83%

From the mean percentage frequency scores presented in Table 23 we can see that the auditory-visual coincidence of the release of the consonant in the first syllable of each utterance was fairly accurate, as the judges fused what they heard and saw for 41% of the clips. Further illustration of the fusion clips accuracy is shown by the fact that the judges only report the auditory component of the clip on 3% of occasions. Bearing in mind the fact that the judges were primarily asked to report what they heard, this result demonstrates auditory-visual coincidence in the release of the consonants, making what is heard different to what is seen. One would otherwise expect the judges to report the auditory component of the fusion clip on more occasions.

Once the two fusion illusion tasks A and B were produced in their final format they were then piloted on a group of six normal subjects (all were postgraduate students at the University of Durham), in order to check whether the task demands were reasonable. Subjects were required to watch the television screen and for each clip report what they heard the person saying. Their possible response alternatives were for part A either ba-ba, ga-ga or da-da, and for part B either pa-pa, ka-ka or ta-ta. When the auditory and visual component of the clip were congruous the normal subjects were 100% accurate at reporting what they heard. Their performance on the incongruous fusion illusion clips was somewhat different. For the following purposes, the performance of the normal subjects on the fusion illusion clips from parts A and B have now been combined. A mean percentage frequency score was calculated for the number of occasions which the auditory component of the fusion clip was reported, the number of occasions which the visual component of the fusion clip was reported and the number of occasions on which a fusion of the visual and auditory component of the clip was reported. These means are presented in Table 24.

Table 24: Mean percentage frequency scores of the "pilot study" normal subjects on the fusion illusion clips of tasks A and B.

	Aspect of Consonant-Vowel Utterance Reported		
	Auditory	Visual	Fusion
Mean % frequency score	1.67%	57.08%	41.25%

Before the results are discussed, it is important to emphasise exactly why the two fusion illusion tasks were piloted again. It was felt that providing subjects with only three response alternatives may create problems when the subjects had to categorise what they heard during the fusion illusion clips. During the fusion illusion clips the subject, if able to lip-read, finds they fuse what they hear and see, resulting in hearing either the consonant-vowel utterance da or ta. However, these da and ta sounds are very different to the da and ta sounds, which are heard when the auditory and visual information was congruous. The results presented in Table 24 demonstrate that although having only three response alternatives does create some problems, indicated by the high mean percentage frequency with which the normal subjects report the visual component of the clip, they nevertheless only report the auditory component of the clip on 2% of occasions, and they report fusions of what they have heard and seen, on a relatively high 41% of occasions. Therefore, although the resulting sound often heard (either da or ta) during the incongruous fusion clips does not maybe sound as close, to the sound heard when the auditory and visual components are the same, it nevertheless sounds more like da or ta, than either ba or pa, which is the sound that is actually heard. Therefore, it was decided to administer the fusion illusion tasks A and B, using their respective three way response alternatives provided in this pilot study.

Exactly the same procedure as used in the pilot study above, was used to present the tasks to PH and the normal subjects. Parts A and part B were also replayed only this time the subjects had only the auditory channel of information to listen to. They were again asked to report what they heard me saying, choosing from the same possible response alternatives as above. Finally parts A and B were replayed only this time the subjects had only the visual channel of information to watch. They were asked to report what I was saying by using lip-read speech information, again choosing from the same possible response alternatives as above. A careful watch was kept on all subjects to ensure that they viewed the television screen throughout the whole presentation of each clip.

Normal subjects

A population of five normal subjects matched to PH on gender, age at date of testing and years in full-time education were paid to complete this task. They were selected from the population of normal subjects who also completed the forced-choice lip-reading task. Their mean age at date of testing was 32.2 years and their mean age on leaving full-time education was 16 years.

PH was 28 years at date of testing and left full-time education at 16 years.

Results and discussion

Table 25: PH and the normal subjects' frequency scores combined for the two fusion illusion tasks.

	Nature of the Consonant-Vowel Utterance seen			
	SAME	FUSION		
	Auditory & Visual	Auditory	Visual	Fused
PH				
Frequency score	120/120	18 ***	9 *	13
Normal subjects				
Mean frequency score	119.8	1.6	31.6	6.8
SD	0.4	2.2	10	9.9

(SAME = the same auditory consonant-vowel utterance superimposed onto the same visual consonant-vowel utterance. FUSION = the auditory consonant-vowel utterance ba-ba or pa-pa superimposed onto the visual consonant-vowel utterance ga-ga or ka-ka respectively, producing a fused consonant-vowel utterance da-da or ta-ta. Auditory = where the auditory component of the fusion clip is reported, Visual = where the visual component of the fusion clip is reported, Fused = where the auditory/visual components are fused.

*** $z > 3.10$, $p < .001$
** $z > 2.33$, $p < .01$
* $z > 1.65$, $p < .05$

We can see from Table 25 that PH is able to accurately report the consonant-vowel utterances when the auditory and visual components of the utterance are congruous. However, when the auditory and visual information are incongruous PH performs quite differently to the normal subjects, showing a significantly greater tendency to report the auditory channel ($z = 7.45$, $p < .001$) than the visual channel ($z = 2.26$, $p < .05$). Although it appears that PH is influenced less by visual information than the normal subjects, he is still susceptible to the McGurk and MacDonald (1976) fusion illusion effect. Thus, although PH is obviously poorer at lip-reading than the normal subjects he does show some evidence of being able to lip-read. PH actually shows a greater tendency than the normal subjects to fuse what he hears with what he sees, producing the fused consonant-vowel utterances.

In summary then, it appears that when given incongruous auditory and visual information PH shows a greater tendency than the normal subjects to report the auditory channel and is more likely than normal subjects to fuse what he hears with what he sees. Normal subjects on the other hand show a greater tendency to report the visual channel (possible because they are able to accurately lip-read speech information). It is possible that because the normal subjects are able to accurately lip-read speech they find themselves more influenced by the visual than the auditory channel and in their failure to analyse the auditory channel, are less likely to report fusions of auditory and visual information.

It is concluded, that PH is able to use dynamic information in his recognition of lip-mouthed speech. However, his ability is not perfect and there will be occasions when he will not be influenced by the incongruity between what is said and what is heard. Therefore, when he is asked to report what he hears, he will be able to do just that, as his auditory perception will not be distorted by the visual perception of a different consonant-vowel utterance.

Campbell, Landis and Regard (1986) found that one of their patients 'D' who was able to lip-read and was also susceptible to their fusion illusion task, occasionally reported a visual ba synchronised with an auditory da or ta, as ba. Campbell et al claimed that D was thus, not only able to fuse auditory and visual information but she also showed dominance for seen over heard inputs. Campbell et al also observed this visual dominance in the performance of their normal subjects. PH does not show this visual dominance, unlike the group of matched normal subjects reported in this task, whose performance does fall in line with Campbell et al's normal subjects.

PH's perception of consonant-vowel utterances when listening to the auditory channel only, was normal (see Table 26). Therefore, PH was clearly able to hear the auditory components of the fusion illusion clips. When PH was asked to lip-read the consonant-vowel utterances using the visual channel of information only, he made many errors but his performance was still nevertheless normal (see Table 26). The fact that PH's performance when judging the consonant-vowel utterances from the visual channel only was only 0.5 SD below the normal subjects' mean, suggests two things. Firstly, that PH is able to use dynamic information in his recognition of lip-mouthed speech and secondly, that these consonant-vowel utterances are very difficult to recognise from the visual channel only. This is reflected by the performance of the normal subjects, who are normally able to lip-read speech sounds very accurately (the normal subjects who completed this task also completed tasks 6.3.1 and 6.3.2 and their mean number of lip-reading errors on these tasks was very small), but on this task they make a significant number of errors.

Table 26: PH and the normal subjects' accuracy score on the fusion illusion tasks when using auditory information only and visual information only.

	Consonant-vowel Utterances	
	Auditory information only	Visual information only
PH		
Accuracy score	159/160	115/160
Normal subjects		
Mean accuracy score	155	121.2
SD	8.5	13.2

The scores represent combined scores from the two fusion illusion tasks (ba-ga-da and pa-ka-ta.)

This difference between the normal subjects' performance on tasks 6.3.1 and 6.3.2 and this task, suggests there are qualitative differences between the lip-mouthed sounds ee, oo and ah and the consonant-vowel utterances ba, ga, da and pa, ka, ta. These differences obviously have significant effects upon their recognition, making it much easier to distinguish between the former than the latter.

6.3.5 White noise interference speech perception task.

This task was concerned with the extent to which PH was able to use lip-read information to aid his perception of speech masked by white noise. Its design was based upon Dodd's (1977) study, which was based upon the original work of Miller and Nicely (1955).

Stimuli and procedure

This task consisted of three experimental conditions; a pre-test, administered to set the level of white noise necessary for PH to reproduce only three out of ten words correctly when he both heard the words through the headphones and saw the same word simultaneously mouthed by myself on video, a speech perception task, consisting of 120 words, 60 presented simultaneously in both visual and auditory mode and 60 presented in auditory mode only, and a lip-reading speech perception task, consisting of 60 words presented in visual mode only. In each word list the words were presented at a rate of one word every five seconds.

The different word lists used in the three experimental conditions were matched on the following; word length, each list consisted of words ranging between three and eight characters in length (the most frequently occurring character length was four {n = 17}, the least frequently occurring character length was eight {n = 1}). Word frequency (Kucera and Francis, 1967), all words had a rank score of 15 or more (it was aimed in using high frequency words to improve the chances of the words ultimately being lip-read). Number of syllables, (each word list consisting of 36 one syllable words, 23 two syllable words and one three syllable word). Word class, all words were nouns and imageability, all words were rated by five independent judges (four males and one female, whose age ranged between 21 and 47 years) for imageability on a five point scale, only words with an overall imageability score of 20 or more out of 25 were used (the average imageability score was 21.98 for each of the three lists of words). (See appendix three - 10.2, for a full list of the words used). The 129 words available in the pre test condition were also selected from Kucera and Francis, all having a rank score of one, two or three (see appendix three - 10.1, for a full list of words). There were no other constraints laid upon their selection, except that none of the words used in the pre test were used in the experimental task word list, or the lip-reading task word list. The presentation order of the words in each word list was randomised. In the speech perception task, the visual and auditory and the auditory alone word lists were divided into three blocks of 20 each and presented in an ABBA design, with the visual and auditory words presented first. The word length in each of the six blocks was matched as closely as possible.

In the pre test condition PH was presented with three words masked by 55 decibels (dBs.) of white noise and the number of correctly repeated words was recorded. The level of white noise was increased in steps of five dBs. until a level of masking was reached where PH reported on average three out of ten words correctly (equivalent to 75 dBs.) Using this predetermined level of white noise masking (75 dBs.) PH was given the speech perception task word lists. It was explained to PH that sometimes he would be able to listen and simultaneously view the words and at other times he would only be able to hear the words through the headphones. This was achieved by asking PH to face away from the television screen so that the experimenter could still see which words were being correctly recalled. PH was finally given the lip-reading task word list and was instructed that he was going to view a video of me saying some words and that for each presentation he should try to lip-read what I was saying.

For each of the three experimental conditions PH was required to repeat the words I said (which he either heard through the headphones whilst simultaneously viewing them on television or heard only through the headphones or viewed only on the television screen.) His verbal responses were recorded on the task response sheet by the experimenter. He was asked to say "don't know" for every word he was unable to repeat and instructed that if at any time the white noise became too loud that he should take the headphones off.

Apparatus

I filmed myself (head and shoulders only) saying the three lists of words. The noise level of the video sound track was set using a sound pressure level metre so that the average noise level of each word spoken was 60 dBs (+ or - 2 dBs.) A white noise generator created white noise which was passed through a step attenuator into a Shure audio level controller, output from the video player also entered the Shure audio level controller. Dynamic headphones were plugged into the Shure audio level controller and received the sound track of the video tape (set to 60 dBs + or - 2 dBs) and the white noise (adjusted accordingly) using the step attenuator.

Results and discussion

From Table 27 we can clearly see that PH shows evidence of being able to use lip-read speech information to aid his perception of auditory speech masked by white noise. However, when PH was asked to lip-read or use pure auditory information only (masked by white noise) his speech perception was adversely affected.

Table 27: PH's total number of words accurately reported in the white noise speech perception task and the lip-reading task.

	Speech Perception Task		Lip-reading Task
	vision & speech	speech only	
PH Number of words accurately reported	18/60	0/60	1/60

PH appears to be able to analyse the dynamic mouth, lip and tongue movements seen during the production of some words and use these to complement what he hears, thus facilitating his perception of auditory speech. This clearly suggests that PH is able to use dynamic lip-read information to facilitate his auditory perception of speech.

In summary, it appears that PH is able to use movement information in his processing of lip-mouthed speech. He is clearly not able to lip-read as accurately as normal subjects, showing a significant impairment in the processing of the highly identifiable lip-mouthed sounds ee, oo and ah, when presented in the static mode of presentation. However, when given the same lip-mouthed sounds in dynamic mode of presentation he makes less recognition errors, although he is still significantly impaired.

PH appears to be able to process dynamic lip-mouthed speech. He is susceptible to the fusion illusion effect reported by McGurk and MacDonald (1976), and actually shows a greater tendency than the normal subjects to fuse what he hears with what he sees. However, this task clearly demonstrated that although PH is able to lip-read to a degree, his performance is by no means the same as that shown by normal subjects.

There is evidence presented in the literature (Campbell, Landis and Regard, 1986) that normal subjects show a greater tendency when given incongruous auditory and visual information, to report the visual channel over and above the auditory channel, evidence which is supported by the performance of the normal subjects in the speech perception fusion illusion task (see task 6.3.5) reported in this chapter. PH however, shows the reverse pattern, where he is actually biased towards reporting the auditory channel of information. This observation clearly demonstrates the limitations of PH's lip-reading abilities.

PH is also able to lip-read these same consonant-vowel utterances from the visual channel only in the absence of any auditory input. However, the performance of the normal subjects on this task (see task 6.3.5) and the lip-reading task requiring the recognition of both static and dynamic lip-mouthed sounds (see tasks 6.3.1 and 6.3.2), clearly demonstrates how the nature of the lip-mouthed stimuli, can significantly affect its recognition. The sounds ee and oo for example, are much easier to recognise than the consonant-vowel utterances pa or ba. It is important to point out therefore, that although PH performs normally when recognising consonant-vowel utterances from the visual channel of information only, the normal subjects actually make a significant number of errors on this task.

PH is also able to use lip-read speech information to aid his auditory perception of speech masked by white noise. He is not however, able to lip-read words from the visual channel of information only. This evidence supports the claims of Campbell (1989) who stated that lip-reading alone cannot support the comprehension of speech, (except without special training). She said that we really need to have some idea of the nature of the lip-mouthed gesture to be recognised, eg. whether it is a digit between one and ten, before we can successfully use pure visual information in the recognition of speech.

Collectively, this evidence supports the notion that lip-reading is essentially a dynamic process although, lip-mouthed sounds can be successfully identified by normal subjects from stationary clips. PH although experiencing problems in the processing of stationary lip-mouthed sounds, clearly demonstrated that his facial speech analysis channel (Bruce and Young, 1986) remains, to an extent, intact and is highly dependent upon input from the movement processing channel.

Chapter Seven

Discussion and Conclusions

7.1 Overview of study.

This thesis has examined the ability of patients with brain-injury to process various sources of facial information, specifically questioning the role which dynamic information plays in such processing.

Bruce and Young's (1986) proposals for the existence of distinct channels for the processing of identity, facial expressions and unfamiliar face matching was examined in a group of brain-injured patients. This study led to questioning the nature of the task demands used in the majority of the face processing tasks reported in the current literature and how these task demands differ from those encompassed in our everyday processing of facial information. In particular the question was raised as to the role of dynamic information in the processing of various sources of facial information including identity, facial expressions and lip-read speech. A group of agnosic patients' ability to process movement was measured and the role which movement played in their processing of facial expressions was also considered. One agnosic patient was able to process movement and showed a facilitation in his impaired recognition of static facial expressions with the introduction of dynamic information. The remaining part of the thesis examined in detail the role of movement in this agnosic patient's ability to process identity, facial expressions and lip-read speech. The main findings from each of these separate investigations are presented below.

7.2 Synopsis of main findings.

There was already a wealth of evidence presented in the literature which provided support for the distinct processing channels for identity, facial expressions and unfamiliar face matching proposed, by Bruce and Young (1986) in their functional model of face recognition. However, these studies were severely limited by the fact that their task demands varied extensively and the tasks were rarely administered in the same investigation. In particular, there was no evidence of a patient who was impaired on facial expressions, but not impaired on familiar face identity and unfamiliar face matching, or of a patient who was impaired on unfamiliar face matching but not impaired on facial expressions and familiar face identity. Neither were there any reports of a patient impaired on familiar face identity, but not impaired on facial expressions and unfamiliar face matching. Aiming to correct this, three forced-choice recognition tasks examining identity, expression and unfamiliar face matching, were administered at a single test session to a group of brain-injured patients and a matched group of normal subjects. A significant difference was hypothesised between the performance of the patients and the normal subjects. It was also hoped that individual differences would be observed between the patients' performance on the different tasks.

As predicted, the brain-injured patients made significantly more errors than the normal subjects and four patients were observed with specific dissociable impairments on the three face processing tasks; one patient was impaired on the facial expression task, but not on the identity or unfamiliar face matching tasks, another two patients were impaired on the identity task, but not on the facial expression or the unfamiliar face matching tasks, whilst the fourth patient was impaired on the unfamiliar face matching, but not on the facial expression or identity tasks. However, similar differences were observed in the performance of the normal subjects. Therefore, it was argued that if specific dissociable impairments are to provide support for the independence of each processing route as proposed by Bruce and Young (1986), much larger impairments are needed in the patient group.

In conducting this examination particular reference was paid to the nature of the face processing tasks cited in the literature to date. It was noted that primarily these tasks consisted of static, black and white photographs or slides, yet as we are all aware in our normal processing of facial information we perceive dynamic, sometimes articulating faces, usually seen in colour. It appeared that a dichotomy existed between the nature of the stimuli we perceive when making everyday judgements of face identity, facial expressions and to a lesser extent lip-read speech (another source of facial information), and the nature of the stimuli provided in cognitive tasks attempting to assess one's ability to process these different sources of facial information. Bearing in mind the above and the claim that form and movement are processed by independent processing channels (Livingstone, 1988, Livingstone and Hubel, 1988), it was considered important to examine the role of movement in the processing of facial information. In particular the question arose as to whether patients with known face processing impairments, but who are nevertheless able to process movement, are able to use dynamic information to facilitate their processing of facial information.

A significant role for movement in the processing of facial expressions was hypothesised, as facial expressions, by their very nature, rely heavily upon dynamic information for the unfurling of their successive facial muscle actions involved in their production. We do not suddenly look happy, but move from a neutral facial expression through a sequence of facial movements to happiness. This facial expression may be held for some time, or alternatively may fluctuate between varying degrees of happiness or indeed other expressions and then eventually return to a neutral facial expression again. Therefore, recognition judgements based upon dynamic presentations, where one is able to see the unfurling of the successive facial muscle actions involved in the production of each facial expression, should be easier than judgements from static presentations.

Three agnosic patients with severe longstanding prosopagnosia were examined using two tests of movement perception and one test of emotion recognition (which especially considered the role of dynamic information in the processing of this source of facial information). One of the prosopagnosic patients, PH, was able to recognise movement and demonstrated that movement facilitated his otherwise significantly impaired processing of static facial expressions.

We already knew from previous work (De Haan, Young and Newcombe, 1987b), that PH experienced a mild facial expression recognition impairment when given tasks involving static, black and white photographs. This effect was confirmed in the agnosic patient group study mentioned above, where PH was significantly impaired at recognising static facial expressions. It appears that PH's facial expression recognition performance is influenced by the nature of the task stimuli given. Dynamic and in a sense more natural clips of facial expressions, are more useful to PH above and beyond static photographic like presentations. This observed facilitation in PH's recognition of facial expressions with the introduction of dynamic information led to questioning the extent to which dynamic information may play a facilitative role (if any) in his processing of other sources of facial information, including face identity and lip-read speech.

PH was given a large battery of identity, expression and lip-read speech recognition tasks, which were designed to assess the role of dynamic information (if any) in the processing of these sources of facial information. Each of these shall be discussed in turn below.

A significant role for dynamic information in the processing of identity was not hypothesised. The identity of a person is not dependent upon movement in the same way as facial expressions are. Normal subjects are also able to recognise identity from static photographic displays extremely accurately, much more so than they can recognise facial expressions from static displays. PH was given two identity recognition tasks comparing both static and dynamic clips. Dynamic information did not facilitate PH's recognition of familiar face identity. PH was at chance level at deciding if a seen face was familiar or not and there was no difference in his performance for static and dynamic faces. Even when PH's face recognition judgements were raised off chance, using a forced-choice procedure, PH still did not experience any facilitation in his recognition judgements with the introduction of dynamic information. It was concluded that movement is not able to feed into the familiar face identity processing channel with facilitative consequences upon the recognition of familiar persons identity, in the same way that it is able to feed into the facial expression analysis module.

It was concluded that PH's familiar face identity processing channel, directed through the face recognition unit (Bruce and Young, 1986), is clearly damaged.

PH had already demonstrated that he was able to use dynamic information to facilitate his otherwise impaired processing of static facial expressions. However, this finding was investigated further, considering not only the role which dynamic information plays in conjunction with structural/configural information, but also the role which pure movement information as found in PLDs (where pure movement information is provided in the absence of any structural/configural information), may play. Consideration was also given to the role which other variables, like the degree of affect seen and the region in which the facial expression is displayed, have upon the recognition of facial expressions.

PH again showed a facilitation in his recognition of facial expressions with the introduction of dynamic information; showing a significant impairment in the recognition of static facial expressions whilst being able to recognise dynamic facial expressions normally. PH also demonstrated that he was able to use pure movement information (PLD clips) absent of any structural/configural information in his recognition of facial expressions.

These facilitative effects of dynamic information upon PH's recognition of facial expressions, lead to the conclusion that facial expressions are stored both in terms of their structural/configural information and also in terms of their specific pattern of facial movements involved in their production. It is possible that some facial expressions are more efficiently recognised from a static image (for example, happiness), whilst others (whose content is rather more ambiguous, for example, surprise) may actually require dynamic information to enable a more successful recognition judgement, as a static image simply cannot provide "enough" information. It also suggests that dynamic information not only feeds into facial expression analysis as a supplementary source of information to the underlying structural/configural information, but that dynamic information alone can provide pure movement information specific to each expression, from which recognition can occur. Dynamic information is obviously not essential for facial expression analysis, as normal subjects are clearly able to process static facial expressions with reasonable accuracy. It appears that for PH however, dynamic information is not only able to supplement his processing of the underlying structural/configural information, but also provide a pure dynamic source of information from which he is able to make successful expression recognition judgements. This finding has important consequences in terms of possible remediation techniques for patients with facial emotion processing problems, which shall be discussed later.

It was hypothesised that the accuracy with which a facial expression will be recognised is dependent upon the degree of affect displayed, where recognition accuracy for strong displays of affect should be higher than that for moderate displays, which in turn should be higher than that for weak displays. PH's facial expression recognition performance was influenced by the degree of affect seen. He was significantly impaired at recognising weak displays of affect, whilst showing normal recognition of both moderate and strong displays of affect.

Again these findings have important implications for the remediation of patients with deficits affecting their ability to process facial emotion, a discussion of which can be found later in this chapter.

It was also hypothesised that if PH experiences a visual configural processing deficit which extends to his processing of facial expressions, then when given a facial expression recognition task requiring the recognition of expressions from the upper, lower and whole region of the face, PH should make less recognition errors for the upper and lower region of the face displays, than for the whole face presentations. There is evidence presented in the literature however, which claims that normal subjects actually make less expression recognition errors from whole face presentations, than they do on lower face presentations, which in turn are lower than those they make on upper face presentations (Bassili, 1979). PH's performance did not seem to reflect a visual configural processing deficit, as he did not make significantly less errors on the upper and lower face presentations than the whole face presentations. However, in considering the role which each specific region of the face played in the recognition of each facial expression, it was evident that PH never actually made less errors on the whole face presentations than on the lower half face presentations. Therefore, one could argue that when PH makes expression recognition judgements from whole face presentations he may actually only attend to the information in the lower region of the face, basing his judgement upon this and not the whole of the facial information. Thus, although PH did not show the predicted pattern of performance, where it was hoped he would make less errors on the upper/lower face presentation clips than on the whole face presentation clips it is still possible that PH may experience a deficit in the processing of configural information.

These results also have implications for the design of remediation tasks, especially for patients with emotion processing deficits, a discussion of which can be found later in this chapter.

If one considers PH's performance on all the expression recognition tasks as a whole, they clearly seem to demonstrate that PH's expression analysis channel (Bruce and Young, 1986) remains intact, but it is highly dependent upon input from the movement processing channel for its successful operation.

Finally PH's ability to process lip-read speech was considered. Speech by its very nature is a dynamic process requiring the articulation of the mouth, lips and tongue in its production. The notion of recognising/analysing a static lip-mouthed speech sound is very unnatural and it is impossible to comprehend lip-reading a static lip-mouthed word, thus making it extremely difficult to get a meaningful baseline measurement from a population of normal subjects. Therefore, movement was seen to play a fundamental role in the processing of this source of facial information.

It was considered important to measure PH's ability to process lip-read speech, specifically examining whether he could use the dynamic information available during the processing of this source of information. PH was given lip-reading tasks requiring the recognition of lip-mouthed sounds from both static and dynamic presentations. Lip-reading tasks testing his susceptibility to the McGurk and MacDonald (1976) fusion illusion and another lip-reading task assessing his ability to use lip-read speech information, in his auditory perception of speech masked by white noise. PH clearly demonstrated that he was able to use the dynamic information available during the production of speech. He was significantly impaired at recognising static lip-mouthed speech sounds, but made less errors (although he was still significantly impaired compared to the normal subjects) when recognising the same lip-mouthed sounds seen in dynamic mode of presentation. PH was also susceptible to the fusion illusion and actually showed a greater tendency than the normal subjects to fuse what he saw with what he heard. PH also demonstrated that he was able to use lip-read speech information to aid his perception of auditory speech masked by white noise. PH thus, is able to use the dynamic information available in the processing of lip-read speech information. However, his lip-reading skills are not normal.

Clearly PH's facial speech analysis channel (Bruce and Young, 1986) remains to an extent intact and is highly dependent upon input from the movement processing channel.

From this summary, one is able to see that the majority of the experimental hypotheses posed and tested in this thesis have been accepted. Perhaps the most important of which, in terms of its consequences upon the direction of future research, was the experimental hypothesis stating that dynamic information should play a facilitative role in the processing of facial expressions.

It is maybe worth emphasising that although a facilitation in the recognition of facial expressions with the introduction of dynamic information has been observed in this thesis, it does not mean that all other patients with static facial expression recognition impairments will also experience such a facilitation. Movement is an important and valuable source of information which has been shown to selectively feed in various face processing channels, with facilitative consequences. However, it is not essential in the recognition of facial expressions. Normal subjects are able to very accurately recognise facial expressions from static photographic images. Also, although it has been argued throughout this thesis that facial expressions have their own pattern of facial movements involved in their production and that dynamic information plays an integral role, allowing the unfurling of these successive facial movements, some facial expressions do maintain static poses for varying lengths of time during their production. For example, an individual can maintain a static pose of a smile for several seconds during the production of the expression happiness. Therefore, although movement is obviously a very useful source of information in the posing and recognition of facial expressions, static information is also useful and sufficient for many normal subjects to accurately recognise many facial expressions.

It is also important to clarify the role which dynamic information plays in the processing of facial identity. Although no significant role was hypothesised for movement in the processing of face identity it does not mean that movement is redundant in the processing of this source of information. It has already been mentioned (see chapter four) that movement could be useful in the recognition of a specific facial mannerisms, possibly enabling the identification of the individual with whom we have learnt to associate this mannerism.

7.3 Implications of the findings.

There are several implications of these findings. Firstly, one needs to seriously consider the "movement variable" in the future design of tasks, specifically addressing the question of how one can best measure the role of dynamic information in the processing of any source of facial information. Secondly, the current models of face recognition need to be amended, so that they can account for the role of movement in the processing of facial information. Thirdly, these results pose certain questions which could be addressed in future research, while finally careful consideration needs to be given to this facilitative role of dynamic information experienced in PH's processing of facial information, in terms of how it may be applied to the remediation of face processing impairments experienced by brain-injured patients in the future. Each of these implications shall be discussed in turn below.

7.3.1 Design of future face processing task.

These results strongly suggest that the current approach towards measuring facial expression recognition needs to be seriously reconsidered, especially in light of the facilitative role which dynamic information has been shown to play in PH's recognition of facial expressions. It is possible that some of the milder face processing impairments reported in the literature to date, actually reflect the unnatural nature of the test stimuli used (namely static images, often photographs), rather than the existence of an underlying expression analysis deficit. In light of the evidence presented in this thesis it may be worthwhile re-examining some of these milder expression recognition impairments reported in the literature, this time using tasks which compare static and dynamic clips of facial expressions.

It is also particularly important to give careful consideration to the design of future face processing tasks. In particular one should be aware in designing facial expression recognition tasks of the importance of the movement variable in the processing of facial expressions. Ideally a comparison should be made between moving and static clips (where the static clip is recorded from the apex of the moving clip held on pause), or at the minimum, a comparison should be made between a patients performance on the more traditional expression recognition tasks using the Ekman and Friesen (1976), or similar photographs of facial expressions, with tasks composed of dynamic sequences of facial expressions.

7.3.2 "Modelling" the role of movement in facial information processing.

These findings raise questions concerning current models of face recognition, in terms of their ability to account for the role of movement in the respective face processing channels. Because this thesis has been concerned with brain-injured patients' ability to process facial information and specifically with their ability to use dynamic information, it was considered important and relevant to extrapolate and discuss these findings in the modelling of the role of movement in the processing of facial information. For comparison some consideration will also be given to normal subjects proposed use of movement in the processing of facial information.

Bruce and Young's (1986) functional model of face recognition has been referred to throughout this thesis, therefore specific consideration will only be given to the way in which their model could be amended in order to account for the role of dynamic information in the processing of facial information.

Before doing this however, it is important to stress that movement is not a single source of information. It can be subdivided into two components; movement which is seen in conjunction with the underlying structural/configural information and pure movement information as seen in PLDs. In general it is considered (Bassili, 1979 and evidence presented in this thesis) that movement seen in conjunction with the underlying structural/configural information is more informative, allowing the successful recognition of many sources of facial information, than pure movement information seen in PLDs, although both are very valuable sources of information. This thesis has given some consideration to the role of pure dynamic information in the processing of facial information. However, the majority of tasks examining the role of dynamic information in the processing of facial information, were composed of video clips, providing the perceiver with dynamic information seen in conjunction with the underlying structural/configural information. There is no evidence to suggest that the information available in a video clip (where dynamic information is seen in conjunction with the underlying structural/configural information) is not actually, the sum of the information seen in a static image (for example, a photograph; where only structural/configural information is available) and the information available in a PLD clip (where pure dynamic information is provided). Therefore, in an attempt to simplify the modelling of the use made of dynamic information in the processing of facial information, this information deemed to be available in video and PLD clips, shall be combined and collectively referred to in the model as "dynamic information." This label, dynamic information, therefore encompasses dynamic information seen in conjunction with the underlying structural/configural information and pure dynamic information. However, it is important to stress that the majority of the evidence available concerning PH's ability to use dynamic information is based on video rather than PLD tasks. The reader is referred to this definition of dynamic information, wherever this label in used throughout the remainder of the thesis. This dynamic information shall be compared to the information available in static images (for example, photographs, slides and pictures etc.), namely structural/configural information. This source of information shall be referred to in the model as "static information."

It is important to emphasise that the following attempt at modelling the utilisation of movement in the processing of facial information has been based upon the premise that brain-injured patients (who do not have a movement perception deficit) and normal subjects are able to utilise the static and dynamic sources of information, although there may be considerable variation in the degree to which these different sources are utilised. The amendments made to the Bruce and Young model therefore, are an attempt at mapping out the uses made of these two respective sources of information in the processing of the three sources of facial information, by on the one hand, the severely prosopagnosic patient PH and on the other, normal subjects as a whole.

In order to present a clear proposed outline of the use made of movement in the processing of facial information, various changes have been made to the Bruce and Young model. Firstly, the directed visual processing module has been ignored, as PH's ability to process unfamiliar faces was not assessed in this thesis and there is no evidence available in the literature which considers the role of movement in the matching of unfamiliar faces. Secondly, the familiar face processing channel has been simplified to one processing module, which shall be referred to as the familiar face identity analysis module. The facial speech analysis module, is considered capable of analysing both lip-read sounds (for example, ee and oo and the consonant-vowel utterances ba, ga, da, etc.) and words. However, it is important to point out that in modelling the use made of static information in the processing of speech, one is referring exclusively to the processing of lip-read sounds, as the notion of lip-reading a static lip-mouthed word is incomprehensible, primarily because it would be extremely difficult to get a meaningful baseline measurement from a population of normal subjects.

In an attempt to try and present a diagrammatical overview of the specific use made of static and dynamic information in each face processing capacity, parallel "channels" have been drawn for each source of information, which vary in width. The wider the channel is drawn, the more useful this source of information is deemed to be in the processing of that source of facial information.

It is proposed that the two distinct sources of information; static (structural/configural only) and dynamic (structural/configural with movement and pure dynamic information), are both capable of providing information suitable for structural encoding, which can then be directed to the three distinct analysis modules, (speech, expression and identity). Because PH's performance on the speech, expression and identity (forced-choice task only) tasks administered in this thesis was above chance, it was concluded that he is able to utilise (to an extent) input from these two distinct information sources. What follows is a discussion of the degree to which PH is able to use these distinct sources of information in the processing of the respective sources of facial information, based upon his performance on the tasks given in this thesis.

Figure 4 represents PH's ability to use the different sources of information in the processing of facial speech, facial expressions and facial identity. PH demonstrated that he was able to use static information to a degree, in the processing of speech (namely lip-mouthed speech sounds) as his performance was above chance. However, he was significantly impaired compared to the normal subjects. PH clearly demonstrated that he was able to use dynamic information in the processing of lip-read speech, although his performance did differ quite considerably on occasions, from the normal subjects. One can see from the channels drawn between the facial speech analysis module and the cognitive system that movement in conjunction with the underlying structural/configural information plays a fundamental role in PH's processing of facial speech information. Static structural/configural information alone has a relatively minor role to play in PH's processing of facial speech.

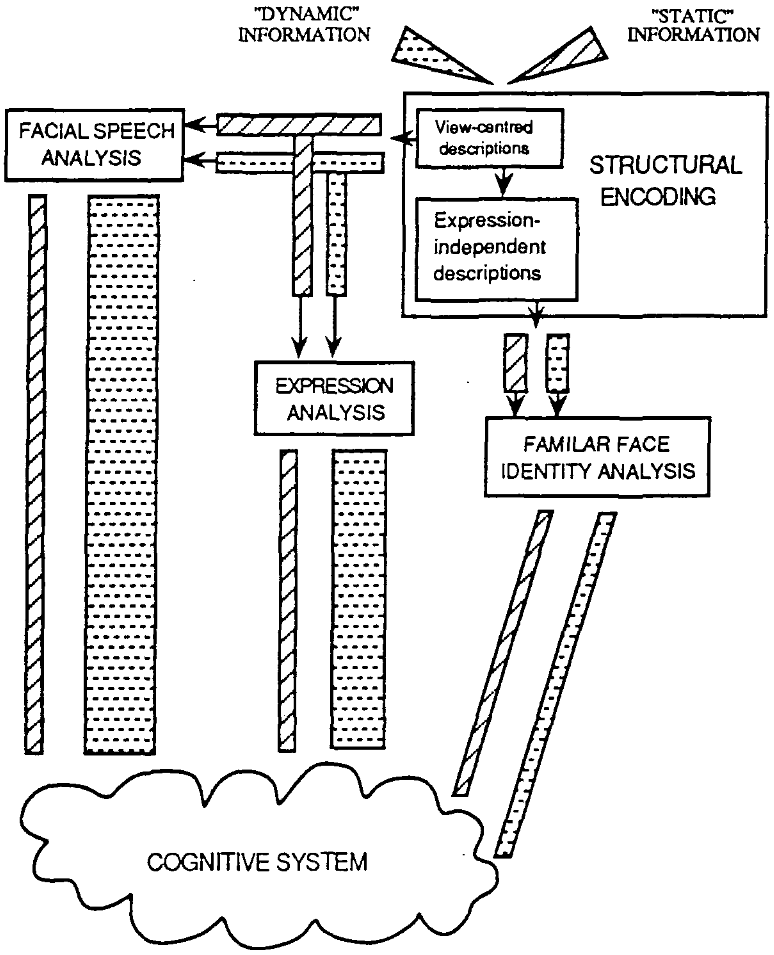

Figure 4: Revision of Bruce and Young's (1986) functional model of face recognition mapping out the proposed role of movement in PH's processing of familiar face identity, facial expressions, and lip-read speech.

(The wider the column, the more important this source of information is deemed to be in the processing of each particular source of facial information.)

Although being significantly impaired at recognising facial expressions from structural/configural information only, PH was able to use this source of information to above chance levels. In comparison PH found dynamic information to be a most informative source of information in his recognition of facial expression. The parallel processing channels drawn between the expression analysis module and the cognitive system, illustrate the importance of movement in PH's processing of facial expressions. PH demonstrated that he was able to use movement information in conjunction with structural/configural information and to a lesser extent, pure movement information, to facilitate his otherwise impaired processing of facial expressions from static information alone.

In the recognition of familiar faces, PH demonstrated that he was able to use both static and dynamic (using a forced-choice procedure) information to a degree, as his performance was just above chance. However, he was significantly impaired compared to the normal subjects. The channels drawn between the familiar face identity analysis module and the cognitive system, illustrate the extent of PH's severe impairment in the processing of face identity, which is independent of the nature of the information available during the processing of a face.

We can see from Figure 5 outlining the proposed use of the different sources of information made by normal subjects, that they are generally better at recognising facial speech, facial expressions and facial identity than PH and that they are able to use both sources of information to a much greater extent in their processing of these sources of facial information. The most obvious difference between the proposed performance of the normal subjects and PH, is that the normal subjects are shown to make a much greater use of static than dynamic information in the processing of familiar face identity.

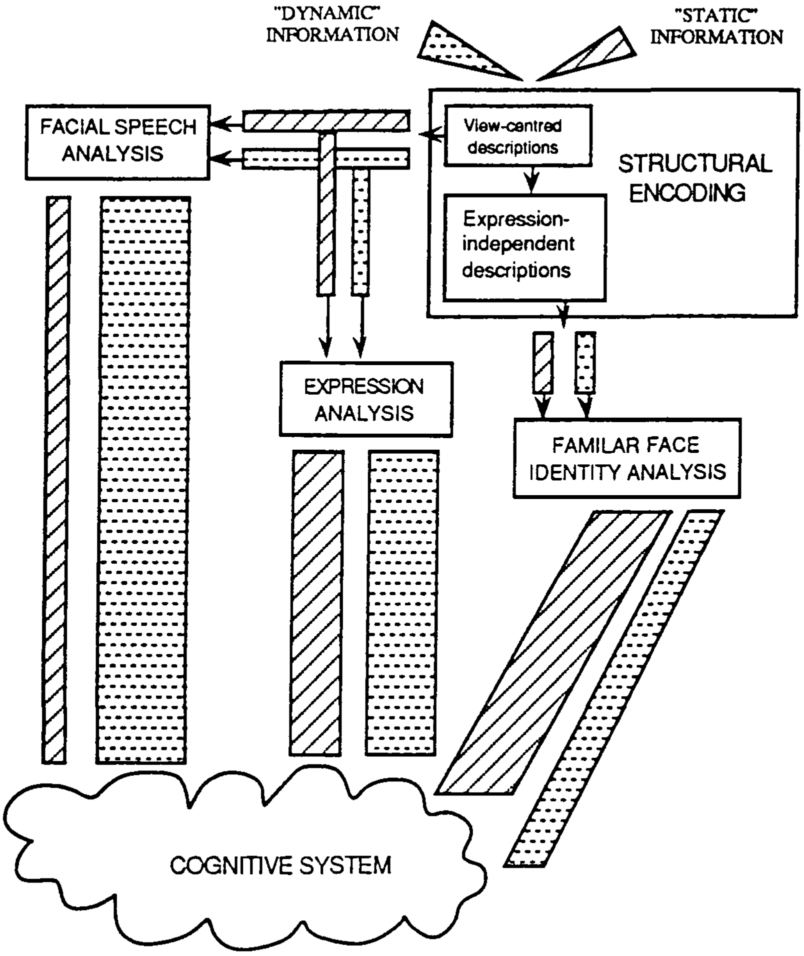

Figure 5: Revision of Bruce and Young's (1986) functional model of face recognition mapping out the proposed role of movement in normals' processing of familiar face identity, facial expressions, and lip-read speech.

(The wider the column, the more important this source of information is deemed to be in the processing of each particular source of facial information.)

Figures 4 and 5 have been specifically laid out so that they can provide a schematical overview of the use made of static and dynamic information in the processing of facial information. These models illustrate a gradient in the use made of static and dynamic information in the processing of the different sources of information. This can best be seen by looking at Figure 5, which outlines the proposed role of dynamic information in normal subjects' processing of facial information. Reading from left to right across the model one can see a gradient illustrating the use made of static and dynamic information in the processing of speech, expressions and identity. A steady increase is shown for the use of static information and a steady decrease is shown for the use of dynamic information.

For example, dynamic information is shown to play a very important role in the processing of facial speech whilst static information is seen to play a relatively minor role. Static and dynamic information are seen to play a relatively similar role in the processing of facial expressions, whilst static information is seen to play a significant role in the processing of facial identity and dynamic information in comparison, is seen to play a relatively minor role. Figure 6 should illustrate this gradient more clearly, see below.

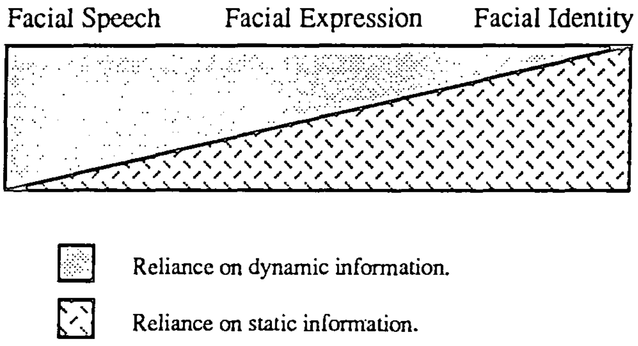

Figure 6: Schematic overview of the role of movement in the processing of facial information, specifcally illustrating the "gradient."

The proposed role for movement in the processing of facial information outlined in Figure 6 is what one might intuitively have predicted, when considering the ecology of face processing. Facial speech analysis is a highly dynamic process involving the articulation of the mouth, lips and tongue in its production. Movement is necessary to produce the mouth articulations seen during the production of words and sounds. The notion of analysing static lip-mouthed sounds seems very unnatural and the idea of lip-reading static lip-mouthed words is incomprehensible, primarily because it would be extremely difficult to get a meaningful baseline measurement from a population of normal subjects. Therefore, movement intuitively could be seen to play a fundamental role in the recognition of speech. However, that is not say that static information is redundant in the processing of speech. Static information may be useful in the processing of lip-mouthed sounds. This intuitive explanation of the role of static and dynamic information in facial speech analysis is clearly supported by the schematic overview illustrated above (see Figure 6). This shows that facial speech analysis is primarily dependent upon dynamic information, with static information playing a relatively minor role.

Facial expressions are also highly dependent upon dynamic information. Movement is necessary for the unfurling of the successive facial muscle actions involved in the production of a facial expression. Therefore, intuitively dynamic information could be seen to play a significant role in the recognition of facial expressions. However, that is not to say that facial expressions cannot be recognised from photographs. Although facial expressions are essentially dynamic, a particular expressive pose can be maintained for quite some time during the production of a given facial expression. For example, a static smile is often held for several seconds during the production of happiness. There is a substantial amount of evidence to suggest that normal subjects are very accurate at recognising static facial expressions. The schematic overview (see Figure 6) supports this intuitive role outlined for static and dynamic information in the processing of facial expressions. It illustrates how facial expressions are clearly able to utilise both dynamic and static information, to roughly equal extents.

Facial identity on the other hand is not dependent upon dynamic information. When we see a person we need to know immediately who they are. The identity recognition system cannot therefore be dependent upon the processing of dynamic information in order to achieve a successful identity recognition judgement. It needs to make an instantaneous judgement; which does not then need to be modified during an encounter. However, that is not to say that dynamic information is redundant. There maybe some instances when dynamic information actually facilitates the recognition of an individual's identity, eg. the movements involved in the production of a facial mannerism may actually lead to the successful recognition of a person's identity. Therefore, intuitively facial identity could be seen to be more dependent upon static information than dynamic information. This intuition is clearly supported by the schematic overview (see Figure 6). Facial identity is able to use static information more efficiently than dynamic information.

This schematic overview clearly provides a neat description of the role of static and dynamic information in the processing of facial information. Essentially it describes how a normal face processing system would function. However, it could also possibly be used to account for PH's performance (whose face processing system is obviously damaged), reported in this thesis. PH's face processing deficits could be explained in terms of PH experiencing an underlying deficit in the processing of static facial information. Briefly, PH was able to use dynamic information in the processing of facial speech and expressions, but not identity, while showing varying degrees of impairment on static speech, expression and identity recognition tasks. The schematic overview (see Figure 6) could account for his performance. It shows that despite having a static impairment, PH was able to use movement in the processing of speech and expression, two sources of information which are highly dependent upon dynamic information. The fact that he was not able to use movement in identity, was because the identity processing system is normally heavily biased towards using static information. Dynamic information thus plays a relatively minor role in the processing of identity. A static information processing deficit, could therefore, be used to explain PHs across the board (eg. static and dynamic) facial identity recognition impairment.

It is hoped that these revisions made to the Bruce and Young model of face recognition clarify the importance of the role of dynamic information in the processing of facial information.

7.3.3 Future research directions.

There seem to be two directions which future research should follow. Probably the most important direction is to administer this battery of face processing tasks to a larger sample of patients. Obviously one would not only be looking to possibly replicate the findings reported here regarding PH's performance, but also to consider the extent to which the role argued here, for dynamic information in the processing of facial information, is in fact correct.

The other direction would be to consider the role of colour in the processing of facial information. This thesis has examined the role of dynamic information in the processing of facial information and based upon the knowledge that form and movement are handled by independent processing channels (Livingstone, 1988 and Livingstone and Hubel, 1988), it was argued that dynamic information should have a significant role to play in the processing of facial information, particularly facial expressions. However, Livingstone and Livingstone and Hubel, have also claimed that colour is another source of information, whose processing is handled by a channel independent to those involved in the processing of form and movement. (For specific psychological evidence supporting the functional dissociation of colour, movement and form see Heywood, Wilson and Cowey, 1987 and Meadows, 1974.)

It has been shown that movement is able to feed into various form processing channels (specific to facial information) with facilitative consequences upon recognition judgements. The next most obvious question therefore, is to ask whether colour is able to feed into form, with the same kind of facilitative consequences ? Colour along with movement, is available when we process facial information under everyday normal circumstances and colour like movement has been given very little consideration in the majority of the face processing tasks reported in the current literature. Although the role for dynamic information in the processing of facial information seems to be more integral than colour, in that dynamic images by their very nature provide both a qualitatively and quantitatively different kind of information to that found in static photographic displays, colour too could be seen to play an important role. Whilst colour information is likely to be less critical, subtle colour discriminations of skin tone etc. might play an important role in the recognition of highly familiar people (Bruce, Hanna and Burton, 1991). Colour has obvious semantic associations with specific emotions, like red and anger, white with fear. Also colour may have possible associations with the identity of a person, where we may have semantic information associated with a specific person, stating that that person is known for their rosy red cheeks, or very pale complexion.

However, although movement and colour are very important sources of information in our perception, successful recognition is not dependent upon either of them. The mere fact that black and white photographs can be recognised without difficulty is sufficient to demonstrate this. We are so expert at processing facial information that we are able to adapt to varying circumstances, basing our recognition judgement on static as well as dynamic images, and achromatic as well as chromatic images. This thesis however, has provided evidence suggesting that dynamic information is a useful source of information in the processing of facial information. It is possible therefore, that colour too may play an important role in the processing of various sources of information.

If one were to consider the role of colour in the processing of facial information one would probably do so under the basic assumption that although colour may feed into the selective face processing channels at a semantic level. It would be very surprising however, to find a patient impaired on a specific face processing task when given achromatic stimuli, to show a significant improvement in his/her ability when given chromatic stimuli. In general, the evidence presented to date suggests that colour may be a useful source of information, but it is not essential for successful recognition. Other evidence in support of this claim can be seen by the fact that we are unable to recognise either identity or expressions from "pure" colour information, in the same way that we can from pure (PLD) movement information.

It would be necessary to assess a patient's perception of colour using standard procedures and also to consider their processing of brightness and texture. Then the role of colour could be assessed in the processing of various sources of facial information by comparing chromatic and achromatic images.

7.3.4 Remedial application of findings.

The final and most important implication of these findings is the obvious application they have upon the remediation of patients with longstanding, face processing deficits. Before these remedial applications are discussed it might be useful to describe some of the consequences of brain-injury.

Brain-injury can have significant consequences upon an individuals normal functioning. Not only do their cognitive deficits cause them immense problems, but so do the behavioural problems often associated with brain-injury. Patients find their emotions change, often they become very irritable and aggressive. Their emotions become more labile and they find they are no longer able to judge other peoples' feelings as well as they use to. The patient often fails to notice when their comments are upsetting someone's feelings or when they are annoying someone else. Carers of the brain-injured patient become frustrated, they feel the patient is uncooperative and antagonistic. These "emotion" related problems cause the patients and carers great concern and although these behavioural problems are often short lived (often only seen in their extreme form in the 12-24 month period following the injury), at the time their effects are immense. Therefore, the existence of a constructive emotion rehabilitation programme would be very valuable.

Careful consideration needs to be given therefore, to how this valuable source of information (movement), can be used in the remediation of face processing impairments. In particular, movement could play a valuable role in the remediation of facial expression recognition impairments. Patients could be taught the importance of movement as a source of information and the importance of the specific regions of the face in each of the different facial expressions. They could learn to recognise facial expressions in terms of the specific facial movements associated with each. Ekman and Friesen (1975) claimed that each facial expression has its own specific pattern of facial movements involved in its production. It could be possible therefore, to teach a patient the importance of the specific facial movements involved in the production of each facial expression. Video could be used as a training medium, where patients could be provided with multiple choice expression recognition tasks. Computers could also be used to help patients recognise facial expressions. Ekman and Friesen (1975) in describing the facial muscle actions involved in the production of each facial expression, divided the face into three regions the brow, eyes and mouth. They claimed that each facial expression incorporates these regions to different extents in its production. Several computer packages are now available which are able to present high quality images of static faces, which can be manipulated for example, shading out certain regions of the face. Patients could be trained to recognise the specific facial actions involved in the different regions of the face (by shading out certain areas), during the production of the different facial expressions. It would be possible to design a forced-choice expression recognition task where patients have to recognise different facial expressions from the different regions of the face. Patients could also be taught the importance of other variables in the recognition of facial expressions. For example, the degree of affect seen and what this tells us about the nature of the individual's emotions.

It is important to point out that these remediation techniques may not actually facilitate performance, but it is hoped that they may make the patient more aware of the different sources of information available when analysing a facial expression.

7.4 Conclusion.

This thesis examined Bruce and Young's (1986) claims for the existence of distinct channels for the processing of familiar face identity, facial expressions and unfamiliar faces. Although the patients showed specific dissociable impairments on the tasks, similar differences were also observed in the performance of the normal subjects. Its argued that if specific dissociable impairments are to provide support for the independence of each processing route, much larger impairments are needed in the patient group. It has also presented evidence suggesting that movement is a very important source of information, which is able to selectively feed into various face processing channels with facilitative consequences upon recognition. This evidence raises the question of whether some of the milder face processing impairments reported in the literature to date (measured using tasks consisting of static stimuli), are actually an artifact of the unnatural nature of the task demands. It is important that consideration is given to the role of the movement variable, in the design of future face processing tasks. This facilitative role of dynamic information in the processing of facial expressions has obvious implications for the remediation of patients with emotion processing deficits.

Appendix One

8.1 Additional face processing tasks.

8.1.1 Introduction.

There were several tasks that were designed and produced during the investigation of PH's ability to process facial information, which for one reason or another were not successful. Some were found to be too easy, creating ceiling effects in both PH and the normal subjects' performance. Others failed because of conceptual problems where both PH and to a lesser extent the normal subjects, were unable to comprehend the task demands. Others, were in retrospect considered to have design faults, whilst others simply failed to add anything to the overall picture being developed, regarding PH's ability to process the various sources of facial information. However, it was considered important to at least present a synopsis of these tasks and their results, as they may prove to be of interest to individuals conducting research in a similar field.

These tasks have been broken down into four groups; those tasks that measure movement perception, those tasks that broadly consider the role of speech in the processing of facial expressions, a task which considers facial expression recognition from PLD and normally illuminated face displays, and a task which measures the ability to differentiate between facial expressions and lip-mouthed speech gestures. Details of these tasks, including their results and discussions, shall be presented shortly, in the above order.

8.1.2 Test Methodology.

Unless stated otherwise each task consisted of 48 unique test clips, each clip was six seconds long and was interspersed by a blank clip of equal length, during which the experimenter recorded the subject's verbal response on the task response sheet. All the video tasks were recorded without sound.

The clips were filmed using a colour video camera. Tapes initially recorded and edited using Betamax video recorders were later copied to VHS tape. PH viewed the video tasks on a colour receiver/monitor (screen size 20 cm * 25 cm), the normal subjects viewed the video tasks on a colour receiver/monitor (screen size of 19 cm * 24 cm), all tasks were played in VHS video cassette recorders.

Again, unless stated otherwise the procedure was the same as used in the expression recognition tasks (see test methodology 5.2).

8.2 Movement perception task.

Two further movement recognition tasks were designed and produced; a replication of the spontaneous internal facial movement task described in chapter three (see task 3.4.1), using posed clips of movement and an internal object movement task. The results shall be analysed and discussed collectively. A brief stimuli and procedure section for each task follows.

8.2.1 Posed internal facial movement task.

This task required the detection of posed internal facial movements, eg. muscle twitches.

Stimuli and procedure

This task compared an equal number of clips of "head static, internal features static" with clips of "head static, internal features moving." The clips were edited from a large collection of posed internal facial movements produced by four professional actors; two actors and two actresses. The clips were of head and shoulders only, with no hand or body movement. Because of the "unnaturalness" caused by recording a clip held on pause in the spontaneous version of this task (see task 3.4.1), the static clips were produced by the actor/actress maintaining their head and facial features in one position for the duration of the clip. For the test clips each actor provided six clips of head static internal features static and six clips of head static internal features moving. There were six practice trial clips (which were randomly assigned to a combination of actors) including three static and three moving conditions respectively. The presentation order was randomised throughout the practice and test clips with the only constraint that the same experimental condition (internal features static/moving) did not occur in more than three consecutive trials and the same actor/actress did not occur in more than two consecutive trials. Subjects were required to decide whether the internal features were "static" or "moving."

Normal subjects

A matched population of 10 normal subjects were paid for completing this task. These subjects were matched to PH on gender, age at date of testing and age on leaving full time education. They were all members of Durham University technical and maintenance staff. Their mean age at date of testing was 35.1 years. Their mean age on leaving full-time education was 15.9 years. PH was 26 years of age at date of testing and left full time education at 16 years of age.

8.2.2 Internal object movement task.

This task required the detection of internal object movements eg. the second hand ticking on a clock.

Stimuli and procedure

This task compared an equal number of clips of "stationary objects, with internal object movement" with clips of "stationary objects, with no internal object movement." Eight different objects each providing examples for both the moving and static experimental conditions were used. These included a video recorder, with a video tape being ejected during the moving condition. An air conditioning fan, with the fan blade rotating during the moving condition. A stop clock, with the second hand rotating during the moving condition. A record player, with a record spinning during the moving condition. A tape to tape recorder, with the tapes rotating during the moving condition. A computer printer, with paper automatically being fed through the printer during the moving condition. A volt meter, with the volt needle deflecting during the moving condition and a signal generator, with a sine wave moving across the screen during the moving condition. Each object was chosen for its capacity to display movement without having to be manually operated, or the ability to be manually operated in such a way that its operation would not be seen during the recording of each clip. There were a total of 16 practice trial clips providing an example of each object during both static and moving mode of presentation. The practice and test clip presentation order was randomised with the only constraint that the same mode of presentation (internal object static/moving) did not occur in more than three consecutive trials. Subjects were required to make an internal object movement detection judgement, their possible response alternatives being either internal object "static" or "moving."

Normal subjects

A matched population of ten normal subjects were paid to complete this task. These subjects were matched to PH on gender, age at date of testing and age on leaving full-time education. They were all members of Durham University technical and maintenance staff. Their mean age at date of testing was 32.9 years. Their mean age on leaving full time education was 15.7 years. PH was 27 years of age at date of testing, and left full time education at 16 years of age.

Results and discussion

Perhaps the first point to note from Table 28 is the fact that the normal subjects' performance is close to ceiling level. Therefore, for the reasons already discussed in chapter three (see task 3.4.1) the range of the normal subjects' performance is included for comparison with PH's performance, where we can see that PH's performance falls outside the normal range. However, a Binomial test was also used to calculate the probability of PH making two errors by chance, (as extrapolated from the normal subjects' performance). z = 1.48 which was not found to be significant, thus, although PH's performance fell outside the normal range, it did not differ significantly from the normal subjects.

Table 28: PH and the normal subjects' error scores on the posed internal facial movement task.

	Internal Facial Movement
PH	
Error score	2/48
Normal subjects	
Mean error score	0.6
SD	0.5
Range	0-1

Neither PH or the normal subjects made a single error on the internal object movement task. This ceiling effect suggests the task was too easy.

In summary, PH's perception of posed internal facial movement was normal and he was also able to detect internal object movement accurately. He was also able to make accurate judgments of form from motion (see task 5.3.3), detect spontaneous internal facial feature movement (see task 3.4.1) and judge the speed of facial feature articulation (see task 3.4.2) accurately. These results taken as a whole provide clear evidence that PH is able to successfully process movement.

8.3 Examination of the role of speech in the processing of facial expressions.

The following three tasks were designed and produced to examine the role of speech in the recognition of facial expressions. Their results however, did not add to the overall picture developed in chapter five, where PH's ability to process facial expressions was examined. The results shall be analysed and discussed collectively. A brief stimuli and procedure section for each task follows.

8.3.1 Talking with/without emotion task.

This task required a decision regarding whether someone was talking whilst expressing an emotion or talking in a non expressive, neutral manner.

Stimuli and procedure

Two actors and two actresses provided six clips of talking with emotion, including two of talking whilst being happy, angry and sad respectively and six clips of talking without emotion. There were six practice trial clips randomly assigned to a combination of actors, providing three examples of talking without emotion and three examples of talking with emotion, including one example of happiness, angriness and sadness. The practice and test clip presentation order was randomised with the only constraint that the same experimental condition (talking with/without emotion) did not occur in more than three consecutive trials, (when there were three consecutive trials in the talking with emotion category they included an example of talking whilst being happy, angry and sad) and the same actor/actress did not occur in more than two consecutive trials. Subjects were required to decide whether the clip they saw was of someone talking "with" or "without" emotion.

8.3.2 Dynamic expression (with/without talking) task.

This task required a facial expression recognition judgement from clips of faces that are expressing an emotion whilst talking and clips of faces that are expressing an emotion without talking. By comparing clips of expressions both with and without talking, one is possibly able to determine whether articulation of the mouth is important in the recognition of facial expressions.

Stimuli and procedure

This task compared an equal number of clips of "dynamic displays of the facial expressions happiness, angriness and sadness with talking," with clips of "dynamic displays of the expressions happiness, angriness and sadness without talking."

In this task all the clips produced by the two actors and two actresses, were rated for accuracy by the same judges as used in the degree of affect task (see task 5.3.5). All the clips produced by each actor/actress were edited into a randomised presentation order, with the without talking clips presented first. The only constraint laid upon their presentation order was that each category of facial expression either happiness, angriness or sadness did not occur in more than three consecutive trials. Each clip was separated by a blank clip a few seconds long. This procedure was carried out separately for each actor/actress. The same procedure as used in the degree of affect task (see task 5.3.5) was used except this time, the judges had to indicate whether the facial expression they had seen was happiness, angriness or sadness. They were also asked to indicate the degree to which they felt each clip was an accurate portrayal of that given facial affect, using the same rating scale as used in the degree of affect recognition task (task 5.3.5).

These ratings were later analysed calculating firstly, the number of judges who correctly identified each clip and secondly the total rating score for each clip. From these ratings only those clips that were correctly identified by all five judges and which obtained the highest rating score were used in the production of the final version of this task. Table 29 provides the mean rating score of each of the with/without talking clips used in the final version of this task.

Table 29: Mean rating score for each clip used in the final version of the talking with/without emotion task.

	Facial Expression		
	Happiness	Anger	Sadness
Without talking	3.49	3.01	3.26
With talking	3.60	3.32	3.16

The maximum rating score in any condition is seven, therefore we can see from Table 29 that the accuracy with which each clip represents the facial expression it was supposed to represent, as indicated by the judges, is reasonably high.

In the final version of this task each actor/actress provided four clips of each of the facial expressions happiness, angriness and sadness, two displayed with talking and two displayed without talking. The test clips were arranged in four blocks of 12 (two expression with talking and two expression without talking blocks). The blocks were arranged in an ABBA design with the talking without emotion category presented first. There were six practice trials randomly assigned to a combination of actors, three with and without talking respectively, including one example of each expression. The practice and test clip presentation order was randomised (within blocks) with the only constraint that the same category of emotion and the same actor/actress did not occur in more than two consecutive trials. The practice trial clips were also blocked, with the without talking clips presented first. Subjects were required to decide whether the facial expression they had seen was either "happy," "anger" or "sad."

8.3.3 Static expression task.

This task required the recognition of static facial expressions, which were recorded from the apex of the moving clips used in the dynamic expression (with/without talking) task (see task 8.3.2).

Stimuli and procedure

This task compared an equal number of static displays of the facial expressions happiness, angriness and sadness. These clips were recorded (using the same randomised presentation order) from the apex of the clips in task 8.3.2. PH was required to say whether the facial expression he had seen was either "happy," "angry" or "sad."

Normal subjects

The same normal subjects who completed the posed facial expression recognition task (a) (see task 5.3.1) also completed the talking with/without posed emotion and the dynamic expression with/without talking tasks.

Results and discussion

Table 30: Summary table of PH and the normal subjects' error scores on the talking with/without emotion task, the dynamic expression (with/without)talking task and the static facial expression task.

	Talking with/without emotion	Expression recognition with/without talking	Static facial expression
PH			
Error score	11/48 ***	1/48	1/48
Normal subjects			
Mean error score	2.2	0.3	
SD	0.9	0.7	

Firstly, Table 30 shows that PH's error score on the talking with/without emotion task is significantly above the normal mean ($z = 9.78$, $p < .001$). He appears to have the most difficulty deciding when someone is talking without expressing an emotion, showing a tendency to say people are talking with emotion when in fact they are not. It is believed that PH's significantly impaired performance is a result of a conceptual misunderstanding of the nature of the task demands and cannot therefore, provide any useful reflections upon the nature of his expression recognition impairment. Table 30 also shows that PH's error score on the expression recognition with/without talking task is normal, suggesting that he is able to recognise these dynamic clips of facial expression accurately, regardless of whether the clip seen was with or without talking. This suggests that articulation of the mouth is not important in the recognition of facial expressions. However, PH's performance on this task is somewhat puzzling, as he only makes one error. This is a significant improvement upon his performance on the other expression recognition tasks listed so far. Bearing in mind the similarity of this task to the other tasks, in that it demands a facial expression judgement from three possible alternatives, two possible explanations for PH's performance come to mind. Firstly, PH may have been aided by the fact that all the clips in this task are dynamic. This could be easily checked by giving PH the same task only this time getting him to base his expression judgements upon static clips recorded from the apex of the moving clips. If this manipulation of dynamic information does not significantly affect PH's performance, then it suggests that maybe these dynamic clips are qualitatively different from the clips in the other facial expression recognition tasks and that in essence, these clips are easier to recognise than the other clips of facial expression which PH has seen to date.

Table 30 shows that PH still only makes one error when he is given this expression recognition task again, only this time comparing static clips. Therefore, the fact that all the clips were dynamic in task 8.3.2 cannot account for the drastic improvement in PH's performance. Instead it seems to suggest that the clips found in task 8.3.2 are qualitatively different from the clips found in the other spontaneous and posed facial expression recognition tasks, which PH has been given to date.

8.4 Other expression recognition tasks.

8.4.1 Introduction.

Facial expressions by their very nature are dependent upon dynamic information for the unfurling of their successive facial muscle actions involved in their production. Therefore, it was safe to assume that dynamic information would play a facilitative role in the recognition of facial expressions. However, it also appears that the information pertaining to each facial expression can be stored in the form of a pure movement pattern. It is possible therefore, that dynamic facial expressions are essentially processed and stored in terms of their dynamic pattern of facial movements and that structural/configural information could be thought of as supplementary source of information to the pure movement pattern and therefore, not essential for successful expression recognition. One way of measuring the role of both pure movement information and structural/configural information in conjunction with movement, in the recognition of dynamic facial expressions, is to compare the accuracy of the facial expression recognition judgements made from PLDs with judgements made from normally illuminated face displays in the same test.

A task was designed which attempted to measure the extent to which (if any) pure movement information is used in preference to dynamic information seen in conjunction with the underlying structural/configural information, in the processing of facial expressions. This task compared the recognition of the facial expressions smiling, frowning and surprise from both PLD clips and normally illuminated face display clips.

Unfortunately this task suffered from a design flaw. Ideally if one wants to make a comparison in expression recognition accuracy between two different sources of facial information, one really needs to ensure that at the minimum, the clips from the two different sources of information are provided by the same actor/actress and ideally that the compared sources of information are obtained from the same clip. That is to say, a particular facial expression seen once under normal illumination will also be seen under the PLD conditions. Unfortunately, for technical reasons this could not be achieved and it was felt because of this that the results of this task are somewhat limited in terms of what they can add to our understanding of PH's ability to process facial expressions.

8.4.2 Point light/normally illuminated face display expression task.

Stimuli and procedure

The PLD clips were edited from Bruce and Valentine's (1988) PLD task (a) (see task 5.3.4). For the normal illuminated face displays two actors and two actresses (all members of Durham University Psychology Department) provided six clips of each facial expression, including three static and three dynamic versions. Due to technical editing problems with the PLD clips of facial expression, it was impossible to use the same actor/actress in the display of each category of facial expression. Instead a total of three actors and three actresses provided clips for the static and dynamic categories, of each facial expression. Some provided clips exclusively for one category of facial expression, whilst others provided clips for all three categories of facial expression (in both static and dynamic mode). However, for each category of facial expression there was an equal number of actors and actresses providing the clips. There were 12 practice trial clips randomly assigned to a combination of actors, providing six PLDs and six normal illumination displays of the facial expressions; two for each category of facial expression, including one static and one dynamic version. There were 144 test clips. The practice and test clip presentation order was randomised with the only constraint that the same mode of presentation (static/dynamic) and the same type of display (PLD/normal illumination) and the same category of facial expression (smiling/frowning/surprise) and the same actor/actress, did not occur in more than two consecutive trials. PH was required to decide whether he had seen the facial expression "smiling," "frowning" or "surprise."

Results and discussion

PH's performance on this task was compared to chance.

Table 31: PH's accuracy score on the point light/normally illuminated facial expression task.

	Facial Expression			
	Normally illuminated face displays		Point light face displays	
	static	moving	static	moving
PH				
Accuracy score	36/36	32/36	13/36	19/36

Table 31 shows that PH is able to recognise facial expressions from normal illumination face displays and PLDs at above chance levels (chance = 48, PH's accuracy = 100). PH was highly accurate at recognising facial expressions from normally illuminated face displays and showed little difference between the recognition of static (100% accuracy) and moving faces (89% accuracy). When given PLD clips of facial expressions however, PH performed quite differently. Firstly, his recognition of static PLD clips was very poor. He was only 36% accurate at recognising facial expressions from static PLDs. However, this is what one would expect as the static clips were recorded from the apex of the dynamic clips and the dynamic clips were expected to contain no structural/configural information, only pure movement information. His recognition of dynamic PLD clips although slightly better, is still poor (53% accuracy) in comparison to recognition from normally illuminated face displays. Thus, it appears that PH is better able to recognise facial expressions from normally illuminated face displays than from PLD.

It also appears that PH's performance at recognising facial expressions from PLD clips is significantly reduced when he is given a task which compares facial expression recognition judgements from both normally illuminated face displays and PLD clips. As it has already been pointed out PH obtains an accuracy score of 53% when recognising facial expressions from the PLD clips in this task. However, he obtains an accuracy score of 69% when recognising the same PLD clips in the "point light display task" (see task 5.3.4). Thus, it appears that although PH is able to use pure dynamic information in the recognition of facial expressions, he is far superior at recognising facial expressions from clips which provide him with the dynamic information in conjunction with the structural/configural information.

It is important to remember however, that the conclusions drawn from these results are severely limited by the design fault which was discussed earlier.

8.4.3 Facial expression/lip-reading differentiation task.

This task measured PH's ability to differentiate between the facial actions involved in the production of the facial expressions smiling and surprise and the lip-mouthed speech sounds ee and ah, comparing them in both static and dynamic mode of presentation. The lip-mouthed speech sounds and facial expressions were specifically chosen for their resemblance in terms of the type of facial action involved in the production of each. The production of the lip-mouthed sound ee and the facial expression smiling are very similar to look at, as is the production of the lip-mouthed sound ah and the facial expression surprise. The results of this task did not really add anything to the overall story regarding PH's ability to process facial expressions and lip-read speech.

Stimulus and procedure

This task compared an equal number of static and dynamic clips of two lip-mouthed speech sounds ah and ee and the two facial expressions, smiling and surprise. The static clips were recorded from the apex of the dynamic clips held on pause. All the dynamic expression clips were of facial movement without talking. Two actors and two actresses (all members of Durham University Psychology Department) provided three clips of each lip-mouthed speech sound and each facial expression. The task is arranged in four blocks of 12, each block included three examples of each lip-mouthed speech sound and each facial expression, provided by a random combination of actors and actresses. The blocks were arranged in an ABBA design with static lip-mouthed speech sounds/facial expressions representing the first presentation. The eight practice trial clips, providing one example of each lip-mouthed speech sound/facial expression in both static and moving mode of presentation, were randomly assigned to a combination of actors/actresses, with each providing one clip for both the static and moving mode of presentation. The practice trial clips were blocked with static clips representing the first presentation. The practice and test clip presentation order was randomised (within blocks) with the only constraint that the same category of lip-mouthed speech sound/facial expression and the actor/actress did not occur in more than two consecutive trials. PH was required to make a lip-reading/facial expression discrimination judgement. His possible response alternatives being either "ee," "ah," "smiling" or "surprised."

Results and discussion

PH's performance was compared to chance.

Table 32: PH's accuracy score on the facial expression/lip-reading discrimination task.

	Lip-mouthed Sounds		Facial Expressions	
	Static	Moving	Static	Moving
PH				
Accuracy score	9/12	11/12	9/12	8/12

Table 32 shows that PH is reasonably accurate at determining whether some one is producing a lip-mouthed speech sound or posing a facial expression, which is regardless of whether the clip seen was static or dynamic. His performance at discriminating facial expressions and lip-mouthed speech sounds was well above chance (chance = 12, PH's accuracy score = 37). PH shows no difference between his recognition of static and dynamic facial expressions, but he is slightly more accurate at recognising the dynamic lip-mouthed speech sounds than the static speech sounds, which supports the experimental hypothesis stated in the introduction of chapter six. Overall, this result seems to suggest that PH can differentiate accurately between the facial actions involved in the production of lip-mouthed speech sounds and facial expressions.

Appendix Two

9.1 List of the matched pairs of familiar persons' names used in the forced-choice identity recognition task (see task 4.2.2).

Practice trial clips;
Peter Cook/Eric Sykes.
Maureen Lipman/Prunella Scales.
David Puttnam/Richard Attenborough.
Robert Morely/Peter Ustinov.
Richard Baker/David Frost.
Tom King/John Gummer.

Test clips;
Tom Jones/Engelburt Humperdink.
Nicholas Parsons/Magnus Magnusson.
Michael Heseltine/Jeffrey Archer.
Robby Coltraine/Billy Connolly.
Dionne Warwick/Shirley Bassey.
Arthur Scargill/Roy Hattersley.
Mike Smith/Keith Chegwin.
Bob Hope/George Burns.
Dennis Norden/Barry Norman.
Patrick Moore/David Bellamy.
Robert De Niro/Harrison Ford.
Barbara Woodhouse/Mary Whitehouse.
Dennis Healey/Cyril Smith.
Claire Rayner/Miriam Stoppard.
Richard Beckinsale/Michael Crawford.
Leslie Grantham/Dennis Waterman.
Harry Enfield/Ben Elton.
Tommy Cannon/Russ Abbot.
Clive James/Clive Anderson.
Margaret Thatcher/Barbara Castle.
Michael Caine/Roger Moore.
Mel Smith/Stephen Fry.
Esther Rantzen/Lyn Faulds-Wood.
Ken Dodd/Jimmy Tarbuck.
Bob Monkhouse/Michael Barrymore.
David Attenborough/Johnny Morris.
Bella Emberg/Hatti Jacques.
Griff Rhys-Jones/Rowan Atkinson.
President Mubarek/Sadam Hussein.
Leslie Crowther/Ted Rogers.
Geoffrey Howe/Douglas Hurd.
Elizabeth Taylor/Joan Collins.
Les Dawson/Bernard Manning.
Norman Tebbit/Norman Fowler.
Jeremy Beadle/Noel Edmonds.
Dennis Taylor/Eddie Edwards.
Meryl Streep/Barbara Streisand.
Paul Gascoigne/Gary Lineker.
Sue Lawley/Angela Rippon.
Terry Wogan/Michael Aspel.
Ernie Wise/Ronnie Corbett.
Graham Gooch/Ian Botham.
Brain Clough/Bobby Robson.
Melvin Bragg/David Dimbleby.
Henry Cooper/Joe Bugner.
Richard Mays/Jonathan Ross.
Sarah Kennedy/Anneka Rice.
Anthony Hopkins/Dennis Hopper.
Rod Stewert/Davis Essex.
Cliff Michelmore/Robin Day.
Kenny Dalglish/Kevin Keegan.
Billy Hardy/Terry Marsh.
Bruce Forsyth/Larry Grayson.
Cilla Black/Lulu.
Andy Crane/Phillip Schofield.
Terry Jones/Dudley Moore.
Dave McCorley/Barry McGuigan.
Neil Kinnock/Tony Benn.
Julie Walters/Victoria Wood.
Sarah Greene/Selina Scott.

Appendix Three

10.1 Words used in the pre test condition of the the white noise interference speech perception task (see task 6.3.5), selected from Kucera and Francis, (1967).

Moth
Carrot
Bus
Torch
Coupon
Wizard
Jewellry
Canal
Grape
Pizza
Cakes
Haystack
Parrot
Sausage
Violin
Owl
Puppy
Nun
Crow
Swan
Autograph
Greenhouse
Pigeon
Omelet
Frog
Donkey
Flute
Parcel
Magpie
Booklet
Mushroom
Peach
Magnet
Shrub
Raisin
Jumper
Pram
Seahorse
Waitress
Cider
Dragon
Campfire
Diamond
Kite
Robot
Curry
Cinema
Toothpaste
Sword
Peacock
Spaghetti
Chalk
Glacier
Wasp
Cauliflower
Mailbox
Funnel
Beehive
Napkin
Keyhole
Handbag
Doorbell
Salmon
Bracelet
Squirrel
Windmill
Volcano
Sweatshirt
Snail
Catalogue
Torn
Chestnuts
Seaweed
Bookcase
Tomatoes
Clown
Biscuit
Locomotive
Dustbin
Tramp
Kettle
Haddock
Caterpillar
Briefcase
Taxis
Spider
Pumpkin
Sandpiper
Claw
Fungus
Waistcoat
Liquor
Freezer
Cockatoo
Handcuffs
Dolphin
Bungalow
Mammal
Groceries
Tandem
Scrapbook
Orchestra
Kneecap
Guerrilla
Camel
Burger
Apricot
Coconuts
Crate
Nostril
Volleyball
Gymnast
Lemonade
Bagpipes
Broccoli
Archery
Curl
Canoes
Antiques
Chess
Steamboat
Cigars
Scissors
Turban
Canteen
Shrimp
Pensioner
Harp
Tablet

10.2 List of words used in the white noise interference task (see task 6.3.5) including their mean imageability ratings from the five independent judges. (Maximum imageability score for each word = 25).

Vision and Speech condition.

Home 20
Boat 21
Kitchen 22
Nest 25
Wall 20
Horse 21
Bridge 24
Plug 21
Square 23
Belt 23
Sand 23
Cup 23
Glass 20
Bed 23
Ears 20
String 21
Fish 24
Beard 22
Money 23
Clock 23
Record 24
Cottage 23
Picture 21
Bullet 22
Cat 25
Face 22
Mouth 23
Football 23
War 21
Cash 22
Woman 22
Fruit 21
Children 21
Knife 23
Window 21
Hair 20
Forest 21
Garden 20
Lawn 22
Rifle 21
Weapons 21
Coal 21
Dog 23
House 24
Guitar 23
Collar 20
Village 20
Ball 23
Building 20
Uniform 22
People 22
Vein 22
Wheel 22
Disk 22
Tea 21
Needle 22
Van 20
Pencil 23
Bottle 24
Santa 24

Speech only condition.

Tent 24
Shop 20
Package 21
Wedding 21
Mother 22
Moon 24
Neck 21
Anchor 23
Skirt 22
Sea 25
Bird 20
Barn 22
Church 24
Cross 20
Bowl 20
Road 23
Desk 23
Stairs 23
Snake 23
Hen 23
Candle 24
Letter 22
Peas 21
Doctor 22
Key 23
Table 23
Razor 24
Child 24
Soldiers 20
Hat 21
Barrel 20
Blood 21
Rope 23
Fountain 21
Devil 21
Skin 21
Cowboy 24
Fist 22
Gun 23
Saddle 23
Girl 22
Student 22
Rain 22
Stream 20
Vehicle 20
Beer 21
Nut 20
Hills 23
Suitcase 23
Garage 21
Bread 22
Sky 21
Funeral 22
River 22
Queen 21
Bath 22
Fingers 24
Jacket 21
Shower 20
Chair 23

Vision only condition.

Sun 23
Snow 24
Feet 20
Soap 21
Paper 23
Ladder 24
Boy 22
Ship 22
Tray 20
Night 21
Head 22
Bus 24
Tongue 24
Brick 22
Flower 23
Pin 21
Pot 20
Island 23
Pistol 22
Hay 23
Jungle 22
Blanket 21
Cattle 22
Grass 22
Tooth 24
Bathroom 20
Pilot 22
Chicken 23
Butter 21
Aircraft 22
Dishes 20
Eggs 24
Plates 23
Door 22
Smile 23
Factory 22
Lemon 23
Mirror 21
Tractor 22
Bones 20
Gold 20
Pond 21
Giant 21
Cloud 23
Jet 23
Roof 22
Nurse 23
Street 20
Lake 23
Circle 24
Lamp 22
Book 23
Glasses 22
Hand 23
Airport 20
Mountain 23
Graph 21
Meadow 20
Palm 21
Gate 21

For each list the following applies;

Frequency of word length:

	Number of Letters in Word					
	3	4	5	6	7	8
Frequency	7	17	13	14	6	3

Number of syllables:

One syllable word = 36
Two syllable words = 23
Three syllable words = 1

Mean imageability rating = 21.98

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