FACE PROCESSING: THE ROLE OF DYNAMIC INFORMATION

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Abstract

This thesis explores the effects of movement on various face processing tasks. In Experiments One to Four, unfamiliar face recognition was investigated using identical numbers of frames in the learning phase; these were viewed as a series of static images, or in moving sequences (using computer animation). There was no additional benefit from studying the moving sequences, but signal detection measurements showed an advantage for using dynamic sequences at test.

In Experiments Five and Six, moving and static images of unfamiliar faces were matched for expression or identity. Without prior study, movement only helped in matching the expression. It was proposed that motion provided more effective access to a stored representation of an emotional expression. Brief familiarisation with the faces led to an advantage for dynamic presentations in referring to a stored representation of identity as well as expression.

Experiments Seven to Nine explored the suggestion that motion is beneficial when accessing a pre-existing description. Significantly more famous faces were recognised in inverted and negated formats when shown in dynamic clips, compared with recognition using static images. This benefit may be through detecting idiosyncratic gesture patterns at test, or extracting spatial and temporal relationships which overlapped the stored kinematic details.

Finally, unfamiliar faces were studied as moving or static images; recognition was tested under dynamic or fixed conditions using inverted or

negated formats. As there was no difference between moving and static study phases, it was unlikely that idiosyncratic gesture patterns were being detected, so the significant advantage for motion at test seemed due to an overlap with the stored description.

However, complex interactions were found, and participants demonstrated bias when viewing motion at test. Future work utilising dynamic image-manipulated displays needs to be undertaken before we fully understand the processing of facial movement.

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Experiments One to Four provided the basis for the following presentations and publications:

Bruce, V., Christie, F., Hill, H., Akamatsu, S. (1996). Missing Dimensions in Facial Appearance. Paper presented at XXVI International Congress of Psychology, Montreal, August 1996. Abstract to appear in *International Journal of Psychology* later.

Christie, F, Bruce, V. (in press). The Role of Dynamic Information in the Recognition of Unfamiliar Faces. *Memory and Cognition.*

Christie, F., Bruce, V. (1996). The Role of Movement in Unfamiliar Face Recognition. Paper presented at the EPS Bristol meeting, March 1996.

Experiments One to Four and Seven to Nine are discussed in:

Lander, K, Christie, F. and Bruce, V. (Submitted). The Role of Dynamic Information in the Recognition of Famous Faces. *Memory and Cognition.*

" In solving one mystery, we never fail to get an imperfect knowledge of others, of which we had no idea before, so we cannot solve one doubt without creating several new ones".

J. Priestley,

Experiments and observations on different kinds of air

(1775-1786)

Chapter One

Introduction: The Role of Movement in Face Processing

This thesis examines the role of movement in establishing and accessing representations of faces, in order to identify people and their expressions. This introductory chapter reviews previous research and theories in face processing; it also outlines the reasoning behind the studies conducted, by illustrating that dynamic aspects of faces have largely been overlooked until now.

Background

Faces determine our individual identities: they are also involved in transmitting other types of information, such as our affective (emotional) state, and a variety of additional, non-verbal signals which are made during the course of communication. Face processing therefore refers to the variety of analyses that information from a face is subjected to, not only the identification of a particular person (recognition), but also the analysis of emotional expression and lip-read speech (movements of the mouth made whilst talking). This is one way in which face processing may be different, and more complex, in comparison with other types of visual processing, such as object recognition. Another difference is that face processing requires within-category distinctions to be made, rather than between-category decisions. All faces share the same basic layout, so in that respect, faces are very similar; yet, at the same time, each face is unique. As an example, the same basic set of Identikit features can be manipulated to 'create' a range of seemingly different people, merely by changing the spatial arrangement of the features (e.g. Sergent, 1984). Successful within-category discrimination will determine and facilitate our impending social interactions with that person; for example, we might react differently to seeing one of our parents approaching from how we might react if it was the bank manager.

Much of the early research into specific aspects of face processing in the 1960's and 1970's was carried out by social psychologists, interested in how faces regulated inter-personal communication. In the late 1970's, more interest was shown within cognitive psychology, and the investigations concerned the manipulation of variables (such as viewing time, or the interval between learning and test) on the subsequent recognition memory for previously unfamiliar faces. The impetus behind this came from a need to understand the practical limitations of face memory in the study of eye-witness testimony. Despite this sort of interest, these studies did not really guide research, or attempt to determine possible mechanisms underlying the processing of facial stimuli. There was an eclectic body of facts, that lacked a simple, coherent framework or theory to attach this knowledge to.

Models of face processing

As interest in face processing gained momentum within the discipline of cognitive psychology, theoretical models were developed that tried to accommodate the complex variety of findings that were being made. These models attempted to account for converging evidence from neuropsychological data, gathered from studies of brain damaged patients, and experimental data, which used the results of cognitive studies of 'normal' participants.

The neuropsychological data will be discussed in more detail later, but it basically considered what sort of mechanisms could allow for some aspects of face processing to be impaired, whilst others seemed unaffected after brain injury or disease. For example, some patients were unable to recognise the face of a familiar person (a syndrome termed 'prosopagnosia'), yet they were still able to tell if that person was smiling, or frowning (e.g. Hécaen and Angelergues, 1962; Bruyer, Laterre, Seron et al, 1983). The opposite dissociations were reported by Bornstein (1963), who found some prosopagnosics recovered some ability to recognise familiar faces, but they were unable to interpret facial expressions. Such evidence gave strong support for the proposals that there were distinct routes used to process a variety of types of facial information, which could be differentially affected by injury, brain-disease, etc. Other neuropsychological evidence supported the claim that within these routes, there was a series of stages in the processing of facial information.

This thesis concentrates on one of the models proposed, that of Bruce and Young (1986). This is a framework which illustrates the functional independence of different aspects of face processing, and also the sequential nature of identification. There now follows a short discussion of evidence from several sources (psychological, neuropsychological and physiological) which points to the dissociation, or the independence of these different types of face processing. This aspect of independence may become important when considering the possible role of dynamic information, where it may be the case that motion is useful for some, but not all, types of face processing.

Evidence for the independence of processing expression from identity

It seems that we do not need to know the identity of someone in order to judge their emotional facial expression (although in cases of a complex or an ambiguous expression, such as a smile of embarrassment, familiarity with that person may clarify the meaning). Experiments have found no difference between the time it takes to recognise a particular expression on either an unfamiliar face, or a familiar face (e.g. Bruce, 1986). A familiar, or famous face can be recognised as such, irrespective of the expressive gesture being posed, so we would be able to recognise Prince Charles whether we are shown a picture of him smiling, or one of him frowning, etc. (e.g. Ellis, Young, Flude, and Hay, 1987).

Neuropsychological evidence of such a dissociation between processing identity and facial expressions comes from Bruyer (1983), when he reported the case of Mr W, a 54 year old who had suffered a stroke. He was able to identify the gender of a face (even when the hair was hidden by a hood, preventing him from using hairstyle as a cue), and he was able to judge the facial expression being posed in photographs; yet, he was unable to recognise familiar faces. So, although Mr W could detect some of the differences between faces (as shown in his ability to judge facial expressions), he could not use knowledge of the same areas of the face in order to determine the identity of the person. Kurucz, Feldmar and Werner (1979) reported a group of patients who were impaired at recognising facial expressions, yet were able to recognise familiar faces (American presidents).

Patient HJA (Humphreys and Riddoch, 1987; Humphreys, Donnelly and Riddoch, 1993) had impaired object and face recognition after suffering a stroke. He could correctly judge what emotional expression was being displayed on a moving face, but he could not identify previously familiar faces (famous people, family or friends). Patterns of the opposite dissociations were shown by GK, who could recognise familiar faces; however, unlike HJA, he could not judge facial expressions from moving and static displays accurately (Humphreys et al, 1993). These case studies show that impairments in analysing facial expressions are dissociable from disorders affecting familiar face recognition.

Evidence for the independence between lip-reading and other types of face processing

We do not need to know who a person is in order to lip-read; we can still integrate the audio and visual speech-based information which can cause a lip-reading illusion, even in cases where the voice and face belong to different genders (Green, Kuhl, Meltzoff, and Stevens, 1991). Lip-reading is not only carried out by hearing-impaired people, but it is also used by unimpaired listeners in order to assist comprehension. For example, a spoken message when delivered against background noise is more easily understood if the listeners can see the speakers' lips moving (e.g. Sumby and Pollock, 1954). As this area of the face is also used in the analysis of identity and emotional expression, any evidence of differential abilities in patients would support the proposal that the processes underlying these tasks are functionally independent.

Campbell, Landis and Regard (1986) described the abilities of two patients, illustrating a dissociation of lip-reading abilities from those of recognition, and expression analysis. Mrs D, the first patient, had a right hemisphere lesion, and was unable to recognise previously familiar faces. She could not judge facial expressions accurately when looking at photographs of posed facial expressions, but she could detect facial emotional expressions from a moving display that used a series of reflective dots placed on the surface of the face; however, her performance was at lower levels than normal participants (this 'point-light' technique is detailed later).

Mrs D was able to use some information derived from faces, as she was able to lip-read, using both moving and static displays. She could correctly judge which phoneme was being articulated from a static picture; she also responded to the McGurk illusion in the same way as control subjects. This is a lip-reading phenomenon, where the speaker's lips modify what the listener 'hears'; it is discussed in more detail later, but it shows that the area of the face used in lip-reading can alter the perception of a synchronised audio-visual speech act. Campbell et al concluded that Mrs D must be using a different type of analysis of the structural details involved in lip-reading and dynamic expression analysis than she used in the processing of identity.

The other patient discussed in the 1986 paper, Mrs T, showed a different pattern of processing deficits after a lesion to the opposite hemisphere (the left). She was unable to read, but she was able to recognise faces. Some investigators in face recognition would argue that facial identification uses ‘part-to-whole processing’, which is analogous to the processes underlying the visual processing of written words (e.g. Farah, 1991), and so Mrs T’s patterns of impairments are of interest. It is argued that word recognition depends on identification of individual features (letters), as well as an appreciation of the global appearance of the word; in a similar way, the same sorts of individual basic features combine globally to make an individual face.

Mrs T was able to judge basic emotional facial expressions from a photograph, though she was worse than Mrs D at the movement-only displays. However, Mrs T was unable to lip-read using either type of task: she could not judge phonemes from the static pictures, and she was not susceptible to the McGurk illusion. She seemed almost to ignore the visual aspects (or was unable to process them effectively), and merely reported the sound she heard, i.e. the auditory input dominated her responses.

There are complications to the discussion of evidence of the dissociations between lip-reading and other types of face processing. In Campbell’s discussion of HJA (1992), she found that like Mrs D, he could accurately report silent lip-read speech. However, when this was combined with conflicting auditory stimuli in the McGurk Illusion, like Mrs T, he only reported the auditory channel.

Saffran (1982) raises a note of caution, by pointing out that nature is inherently opportunistic, and that we may adopt unusual solutions to problems as a result of neuropsychological damage. Therefore, we must be wary when making inferences from such evidence about which aspects of processing are missing, and which are left intact, and are presumably supporting these 'spared' abilities; these strategies may not be a true reflection of otherwise 'normal' functioning. What such cases do illustrate is that double dissociations can be found between different aspects of face processing as a result of brain injury. This neuropsychological evidence showing different spared and impaired abilities can only suggest there is some segmentation or differentiation which may exist in people capable of 'normal' processing (Caramazza, 1984).

Such distinctions may be found in the non-patient population, as there is physiological evidence of a more general distinction between these proposed types of face processing. Sergent and Signoret (1992) investigated human brain activity of non-impaired participants, using regional blood-flow patterns, MRI and PET scans. The measurements were taken whilst a variety of face processing tasks were carried out. It was discovered that there were different levels of activity in the same areas of the brain according to the type of decision being made (such as age, gender, or emotional expression). Ojemann,

Ojemann, and Lettich (1992) monitored the brain activity in non-impaired humans under different types of processing task. Using magnoencephalography, they found there were different populations of cells that responded separately to facial identity and emotional expression analysis.

Familiar and unfamiliar face processing.

There is evidence from studies carried out on both 'normal' and neuropsychological populations that the property of familiarity can affect how faces are processed. For example, using students as participants, Ellis, Shepherd and Davies (1979) found there were differences in identification rates for unfamiliar and familiar faces according to the features used at test, which could be either internal or external (eyes, or nose, vs. chin or hair). Familiar faces were recognised more successfully using internal, rather than external features. At a more fundamental level, studies of brain activation have demonstrated that there are differences in patterns of spared and impaired abilities in neuropsychological cases, and in patterns of processing of non-impaired 'controls', according to the type of task and the level of familiarity with the faces being used. Where patients can carry out some types of face-processing successfully (such as matching, or expression analysis), they must have retained some access to the necessary mechanism. However, if they cannot <u>recognise</u> faces, this suggests they have lost the ability to access or activate other aspects of that mechanism. Perhaps the important difference between these types of processing abilities lies in the requirement to refer to a stored memory trace specific to each known face in order to complete the task.

Unfamiliar and familiar face processing could therefore be distinguished on the basis of some pre-existing representation in memory; we can complete some tasks (e.g. matching) without needing to activate this previously formed exemplar.

There is a further, physiological distinction which can be made between familiar and unfamiliar face processing. Whilst it is known that there are cells in the macaque cortex whose highest levels of activity are in response to static pictures of human faces, there is further differentiation within that population, e.g. some are activated by familiar faces (such as their keepers), as opposed to unfamiliar faces (e.g. Perrett, Heitenan, Oram and Benson, 1992); some are even sensitive to the viewpoint they are shown in (e.g. Perrett, Smith, Mistlin, Heal, Milner, and Jeeves, 1985).

Results of neuropsychological investigations have shown differences between tasks which require access to a stored representation (familiar face recognition) and tasks which do not (e.g. matching pictures of novel faces), which likewise suggests there is a dissociation between familiar and unfamiliar face processing abilities. Malone, Morris, Kay and Levin (1982) describe two case studies which illustrate this. Soon after his illness was reported, one patient was unable to recognise familiar faces for a period of ten weeks, but he regained his ability to identify famous and familiar faces after about twenty weeks. However, he remained impaired in tasks involving matching pictures of unfamiliar faces throughout, and even after, this period. The second patient had the opposite pattern of deficits; as with the first patient, he was unable to recognise familiar faces, or match unfamiliar ones immediately after the onset of his symptoms. After a similar period, he regained only his ability to match unfamiliar faces; he never recovered his ability to recognise familiar, famous faces correctly.

Young, Newcombe, de Haan, Small and Hay (1993) discussed their findings from a group of brain injured ex-servicemen. They found that selective impairments and patterns of deficits existed between the accuracies of familiar face recognition, and unfamiliar face-matching. However, the evidence does not necessarily point to a simple dissociation of the two tasks; despite the clear dissociation between tasks in terms of accuracy measures, the patterns of latencies to make decisions did not show such a clear distinction.

Thus, there is evidence which supports the suggestion of the independence of the route leading to person identification from those leading to other types of face processing (lip-reading and expression analysis). In addition to this, there is the suggestion that familiar and unfamiliar faces are processed differently, according to the type of task being undertaken. Within the route involved in identification, there are some stages which can be successfully resolved for both familiar and unfamiliar faces, but there are some face processing tasks which rely on the presence of a pre-existing representation in memory (such as those requiring recognition or retrieval of the person's name).

Evidence for stages within the identification route

The framework discussed within this thesis is based on the Bruce and Young (1986) model; its primary use is in illustrating aspects of face recognition, which, according to this model, occur in sequence. In common with similar cognitive approaches (e.g. Hay and Young, 1982), the basic premise is that there is a principle processing route, or pathway, whose final goal is the identification of a specific person. There are 'satellite' modules which process other kinds of information about faces independently, and in parallel, such as the analysis of facial expression, lip-reading, and the detection of age, race or gender. Due to the sequential nature of the processing pathway for recognition, some stages (according to the model) are dependent on completing earlier stages successfully; for example, in order for a person to be recognised, what is presented must correspond with some sort of representation in memory; the visual processing must arrive at a description which matches something that is stored (aspects of which will be discussed in later sections).

As Galton pointed out in 1883, merely recognising a facial stimulus as a face does not in itself help to mediate subsequent behaviours, we need to know the particular and unique identity of the person we are looking at. In order to do this, information undergoes a series of stages along this 'identification pathway' (Carlesimo and Caltagirone, 1995). An initial analysis of the stimulus is carried out in terms of its 'structural encoding'.

The next stage, 'face recognition', compares the current face with the representations that are stored in memory of faces that have been seen before. Each face held in memory has its own 'face recognition unit' or FRU. If the present perceptual item matches the stored representation, or FRU, then the face is familiar: this will allow for information unique to that person to be available. As with the concept of a separate FRU for every face, each individual known will have a unique 'person identity node', or PIN, that contains (or allows for access to) a wide variety of semantic information about that individual (Burton, Bruce and Johnston, 1990). Both FRU's and PIN's require constant update of information, to accommodate transformations in visual appearance (such as seeing that person when they are older, or with glasses) (e.g. Hay, Young and Ellis, 1991), and new semantic details (such as their recent marriage).

The final stage in this sequence is that of 'name generation', which leads to the retrieval of the specific name. It can only be achieved if the other stages in the sequence are successfully completed. Sometimes, we can experience a 'tip-of-the-tongue' (TOT) phenomenon, where we 'feel' or 'know' the person is familiar, and can remember something about them (job, associates) but not their name. As we never seem to remember a person's name without any other details, it appears that in reaching this final stage, there is evidence of successfully achieving earlier stages within the route.

The cognitive stage model of person recognition continued to be developed successfully (e.g. Burton, Bruce and Johnston, 1990; Young and

Bruce, 1991), but there was increasing concern that there was little initial discussion about the exact nature of the visual representations that are involved in any of the processing routes. There was even less consideration of the possibility that differences might exist within these processing routes as a result of using either moving or static stimuli.

Several alternatives regarding the nature of the representation have been suggested and are discussed at several points in the thesis. In summary, the issues involve the differences between processing features and processing the configuration (or more holistic aspects); also, the explanation of how this representation can accommodate changes in expression or viewpoint which occur naturally. With regards to this second issue, there are three broad categories of explanations offered. The first of these suggests that recognition is facilitated by having many different instances in memory (which could explain some of the differences between familiar and unfamiliar face processing). The second theory suggests that recognition is mediated by a stored 3D representation, which can accommodate differences in viewpoint. This might involve a description of the configuration, or of invariants which define that person's facial appearance, or even one of shape-from-shading. The final explanation is discussed in terms of a prototype, where variations in expression (for example) can still be recognised as they are processed with reference to a prototypical expression, i.e. an 'average' of each exemplar we have seen. Each of these proposals is supported by findings based on static image studies. The implications of these different proposals are discussed in more depth at relevant stages of the thesis, but a brief resumé of the main issues follows.

It has been suggested that recognition is more than a direct correspondence between the description of the face as seen at test and a stored description of a single viewpoint, or a single expression, as we seem able to generalise from specific examples of particular faces to novel aspects of the same people (e.g. a new hairstyle). It may be the case that this processing involves the use of a more structurally-based description (such as the configuration, or invariants). The description of such an ability holds a potentially beneficial role for motion, as it is more likely that a dynamic display (rather than static images) would provide cues to the underlying structure via a description of likely transformations that are acceptable. If movement is used at either study or test, there may provide an overlap of cues to likely transformations. For example, if the face was studied rotating in the horizontal plane, so it was seen from in front (zero degrees) and turning to some point on the right (say, 30 degrees), we might expect some recognition (via extrapolation) if the test phase showed more than 40 degrees to the right, because the trajectories of the features were towards that direction.

Any benefits for motion may be because dynamic image sequences provide more instances (i.e. higher information content), or perhaps they illustrate a more fundamental aspect of that person, such as a sample of the typical trajectories of those particular features (which may be the way in which that particular person's face moves, or the amounts by which the features move). A dynamic sequence might prove more beneficial than a static image if it re-instated any cues (e.g. invariant properties) which might be missing, or difficult to extract in certain circumstances (such as seeing the face at a distance), or if the images shown were blurred.

Further, this potential ability for motion to re-instate cues about the structure, or even give cues about individual 'dynamics' could become more relevant if the representation in memory is defined in terms of shape-from-shading details. The 3D organisation of a particular face might rely on the correct interpretation of shading and brightness details, e.g. the nose and eyebrows protrude, so there is an area of shadow around the eyes. Such elements can also be described using low-spatial frequency information, showing varying patterns of light and shadow, i.e. with little 'form' information. If low-spatial frequency images are viewed (which can be achieved e.g. by using a filter, or a small number of pixels), the facial image is blurred, so individual features are hard to distinguish, but the overall configuration, or spatial layout is retained. The face can still be identified, and other decisions (e.g. gender) can also be made successfully using this description (e.g. Harmon, 1973; Sergent, 1986); therefore low-spatial frequency may be considered to be important in many aspects of face processing.

Low spatial frequency information has also been implicated in transmitting information about movement (e.g. Livingstone and Hübel, 1987). If facial images are 'degraded' (perhaps by being in negative, or filtered so that they contain only low-spatial frequency information), and are then shown in motion, then the dynamics themselves might provide additional cues, perhaps about the underlying shape, which could be achieved using a 'form-from-motion' algorithm (Ullman, 1979). This would allow for specific sequences of transformations of light and dark areas across the face to be reliably interpreted as being caused by a specific configuration (Gibson, 1979).

However, previous definitions concerning the possible nature of the representation had not critically included the consideration that motion might be an integral part of that description, or that it might assist in the processing of information during various tasks. There may be advantages for movement for some or all of the stages involved in processing, starting from learning the face initially, to the circumstances under which its recognition was tested.

The Present Research

These proposals regarding the nature of facial representations in memory were primarily based on findings from studies using static images; however, that is not how we normally experience faces. This thesis was therefore undertaken to redress this imbalance, by comparing several aspects of face processing using dynamic image sequences with the results obtained using static instances. In particular, the role of dynamic information was examined in relation to the recognition and matching of unfamiliar faces, familiar face identification, and also some aspects of expression analysis. The studies carried out questioned whether previous findings from research into face processing may be constrained due to utilising only static materials, and whether any further insights into the essential qualities of the representation (e.g. how it was constructed, or how it might be accessed) could be gained from using dynamic stimuli.

It may be the case that movement is not a fundamental element of the representation. For example, if 'recognition' relies on the storage and retrieval of a discrete image or an instance, then the representation need only comprise static cues. One would not expect moving stimuli to effect more successful processing than static stimuli, because the description of features could be captured in a photograph. If, however, the properties underlying face recognition depended on a more abstract description, then under some circumstances, moving sequences may be more appropriate, for example in providing additional information about the 3D shape of the face (via form-from-motion: Ullman, 1979).

As the face itself is a dynamic entity, there are several possibilities with regards to how this movement might be used in processing. Firstly, it may be that movement itself simply provides more 'instances', or has more sources of information to sample and match against the stored representation. Secondly, presenting the faces in motion may help in the extraction of some type of '3D information'; such form-from-motion details may give cues to the underlying structure itself, or the description derived may be more abstract, comprising a representation based on the spatial arrangement of features (e.g. a 'typical' example of the relative position of the features in the sample seen), or it might comprise 'invariants'. The invariant description might be a distribution of information which would accommodate some process of generalisation, where the invariants are aspects of the face which remain unchanged (e.g. the length of the nose, or the distance between the eyes and tip of the nose). This description can tolerate differences across a variety of viewing conditions, e.g. the size of the image, viewpoint, etc. Thirdly, moving sequences may help by providing individualistic 'time-varying cues', by displaying a pattern of the rhythm and timing of changes (e.g. Rosenblum and Saldaña, in press). The dynamic acts may themselves portray idiosyncratic movements, such as the manner of speech or expressive gesturing, which may be part of the representation, or description of that person stored in memory.

The first suggestion of how dynamic cues might be useful in face processing refers to the actual information content embedded in moving sequences, i.e. more frames are required to show something is moving compared with only one frame which is needed to portray something as static. The second suggestion concerns the spatial and structural layout of the face which might be interpreted using form-from-motion cues. These could provide a description of the underlying configuration, or they may help in the extraction of invariants. The final suggestion involves aspects of the mobile properties of the faces themselves: movement might be beneficial in the processing of identity for example, as it matches the type of description stored in memory, i.e. where the stored representation also comprises dynamic information of the rates of change (rhythm and timing of speech and/or expressive gesturing), or perhaps the amounts by which these changes occur (trajectories of features) within each particular known face.

We rarely encounter people in a situation that only allows us to sample single, static instances, particularly those whose faces we become highly familiar with. This may lead to a more robust representation which is more tolerant of changes across viewing conditions; indeed, it has been shown that familiar face recognition is less affected by changes in viewpoint, expression, context, etc. than unfamiliar faces (e.g. Davies and Milne, 1982; Bruce and Valentine, 1985). This leads to the suggestion that there may be more to familiar face identification than simply instance-based representations in memory. The implication is that advantages to familiar face recognition tested in novel circumstances may arise because we have seen them moving at some stage. As a result of this type of viewing, we have a representation in memory which either comprises more static instances (the storage of discrete exemplars), or which comprises a more generalised description, such as an abstract representation (invariants, or the dynamic patterns of change themselves).

The role of movement in unfamiliar face recognition seems to be more restricted, as results suggest we rely more on instance-based strategies, which may be due to the rather limited exposure we have had to them. However, it seems unreasonable, in principle, to assume that we collect and keep every single instance, as this would make huge demands on storage and retrieval capacities. To some extent, unfamiliar face recognition may be restricted within specific sets of circumstances, which are influenced by aspects of the occasion in which the face was first encountered, such as context or background. This may be because we are less able to rely on a more abstract representation in memory for them (such as an established 3D, or invariant code). As an example, Bruce, Valentine and Baddeley (1987) and Logie, Baddeley and Woodhead (1987) both showed that changes in viewpoint between study and test caused decrements in the recognition of unfamiliar faces.

Movement and face processing: general

Having outlined some of the distinctions that seem to exist between the processing of familiar and unfamiliar faces, and having suggested that there might be some dynamic aspect to the description or representation stored, the discussion now turns to consider whether there is any other evidence that movement is beneficial in other face processing tasks, and where the nature of this benefit might lie.

The developmental and neuropsychological literature both support the idea that moving displays of faces are in some way processed differently from static displays of faces, which might be due to reliance on motion-carried information. Kaufmann and Kaufmann (1980) found that 36 hour-old infants habituate to (i.e. do not show any interest in) facial images portraying a fixed expression; they dishabituate (show renewed interest) when the expression changes. Kaufmann-Hayoz and Jäger (1983) and Stucki, Kaufmann-Hayoz and Kaufmann (1987) demonstrated that infants aged three and a half months old react as if they are seeing a normal moving face when they are in fact watching a face that is made up of a series of moving dots (similar to point-light display techniques), or a rubber mask moved by hand. As with adults, the infants seem to achieve some form of structural coherence from the motion-only displays. The presentation of such stimuli as static or inverted images interrupts their interest, as do random-dot patterns; by inference, this disrupts their processing (as is found to be the case when adults are shown the same displays).

Patients HJA and GK (Humphreys et al, 1993) show differential abilities in being able to process moving information to resolve aspects of identification and emotional expression analysis. HJA's processing was sensitive to facial movements, using these patterns of change to judge emotion and gender, and his performance was close to that of normal participants. GK's performance was comparable with 'normal' participants when judging other types of facial movement that were not connected to the analysis of emotional expression.

With the exception of research into lip-reading, the emphasis on face processing in general has tended to concentrate on information based on static images, again ignoring the fact that our faces are mobile. As a reminder, this thesis is attempting to examine whether information about the dynamic aspects of the face are used for processing faces in different ways from that derived from static images. In addition to this, there is a consideration of whether any benefits for motion are due to the large amounts of information embedded in such stimuli, or whether there is a fundamental benefit for the use of motion that goes beyond the information content, i.e. over and above the number of instances shown.

Movement and face processing: lip-reading

A more thorough investigation into the role of movement has occurred recently for the analysis of lip-read speech rather than other aspects of face processing, partly because speech is, by nature, a dynamic act, a combination of audition and vision that occurs over a period of time. However, it has been shown that we can judge a limited set of phonemes (CV, or consonant vowel sounds, such as 'ga') by looking at a static image of the 'point of plosion' or apex of this act (e.g. Campbell, Landis and Regard, 1986; Campbell, 1992). As an example, in the speech sound 'ba', the point of plosion is where the lips change from pursing in sounding the 'b' to opening slightly to sound the 'a'. Indeed, many studies which analyse visual speech still use descriptions of static instances, such as the degree of lip opening, tongue height, etc. (e.g. Summerfield and McGrath, 1984).

By dynamic articulation, we can produce a variety of sounds using the tongue, lips, larynx, etc. which have to be presented within the correct time-course, i.e. the movements have to match the sounds. Dodd (1979) showed that infants pay less attention to speech that is out of synchrony than where the lip movements match the auditory signal. Adult listeners can tolerate asynchronies up to 80 m/sec without it interfering with their comprehension of the message (McGrath and Summerfield, 1985).

Under normal circumstances, we do not seem to rely on the lip movements of the speaker when the auditory channel is clear, but they can be useful in integrating the visual speech information. We may attend to the articulatory motion of the lips and face more in recovering the message when we are listening to someone with a heavy foreign accent, for example. An experimental demonstration of the importance of the visual aspects of speech production comes from the McGurk illusion (McGurk and McDonald, 1976). This is a lip-reading illusion, a perceptual blend of the cues from visual speech, and the cues from auditory speech; what the listeners report 'hearing' is neither what was articulated, nor what was actually said; the speakers' lip movements modify the perception of what the listener heard.

In a further investigation into the role of motion in this effect, my undergraduate Honours project (Christie, 1993) compared moving and static presentations of lip-read phoneme sounds in a McGurk-type test. The static speech sounds which were being compared with the dynamic presentations were represented by a freeze-frame of the point of plosion of phonemes known to contribute to the illusory blend; the articulatory movements were represented using a series of pixelated images, i.e. the face seemed to be a series of moving squares (which are interpreted by the 'form-from-motion' algorithm; Ullman, 1979).

The illusion was only experienced in trials where the moving pixelated images were combined with the conflicting auditory stimuli; it was not experienced when a static picture was shown. This was not due to difficulties in processing the pixelated images; as both types of display supported normal phoneme perception. When the pixelated moving images were seen without sound, participants could judge which phoneme was being articulated by lip-reading these sequences as accurately as they could judge the static 'normal' pictures. As only the moving pixelated sequences produced the McGurk fusions usually experienced with moving 'normally' presented stimuli, this suggested that form and form-from-motion information have differential inputs into lip-reading, and that integration with the auditory stimulus can occur equally with either type.

In addition, Rosenblum and Saldaña (1996) demonstrated that lip-reading is possible when viewing faces shown as point-light stimuli (where reflective dots are placed on the lips, tongue, teeth, etc. of a talking face which is filmed under high luminance conditions). When stationary, these dots are reported as a random series of spots, but the 'kinematic form', i.e. the moving face, can be used in experiencing the McGurk lip-reading illusion. It is proposed that this is achieved by using the information provided by the displacement of these dots over time. This is articulatory visual information is then integrated with the auditory speech elements to produce the illusion. Rosenblum and Saldaña (in press) conclude that these dynamic aspects of the face which change over time provide more 'robust' information to the perceiver than 'time-independent' (i.e. static) cues.

Movement and face processing: expression analysis

Ekman and Friesen (1971) illustrated there were several human facial expressions that were recognised as accurately by remote tribes-people in New Guinea, as they were by people in America. Ekman used static images (i.e. photographs), which showed the apex of several expressions; these were later described as the six 'basic' emotions: fear, anger, sadness, disgust, surprise, and happiness.

Other investigations in the analysis of emotional expressions have similarly used static images. Kearney (1991) devised a system called JANUS, which was a machine-based interpretation of facial expressions, used in human-computer interactions. JANUS was designed to evaluate and learn a description of a face in terms of a labelled emotional expression. Kearney and McKenzie (1993) based their descriptions of facial expressions on the same rules as JANUS, and physically measured out co-ordinates of various landmark features (brows, eye-size) to input into the system. They used a series of verbal descriptions (e.g. nose flared, jaw dropped), as well as the co-ordinate measurements. From this, a set of parameters was derived analysing facial/featural positions associated with different basic emotions.

However, these are descriptions of stages within dynamic events, yet they are input as a series of static instances; the descriptions are of the end-point or apex of the gesture. There are no details of the transitional stages or the movements produced between, for example, exhibiting a neutral face and its transformation into the full-blown expression.

It could be argued because we can accurately judge the emotion by seeing the static end-point of an expression, transitions and movements themselves leading up to this point are not important. As Campbell (1992) points out, processing facial expressions using photographs involves analysing only the static endpoint of the gesture, ignoring intermediate stages in their production. Nevertheless, when we watch a moving sequence of the emotional expression unfolding, this may reveal particular differences in their production; when seen in isolation (i.e. as static images). Such individual stages may not give sufficient specific clues as to the eventual gesture. Static pictures do not inform of the timings or size of the movement, the latency, speed of onset, duration etc. These aspects might be important in making decisions concerning the spontaneity of the gesture, rather than it being posed, etc. Therefore dynamic information, or rather information about the dynamics, is important.

Yamada (1993) attempted to account for aspects of transitional movement in emotional expression analysis, by adding quantitative vectors, or trajectories to static faces, to describe the direction that specific features moved in the course of producing such expressive gestures. Participants manipulated stationary schematic faces (which were produced by a computer) to produce representations of the six basic emotions. For example, they were given the shape of an eyebrow (or eyelid) and asked to arrange it within the context of a full face to depict anger. They had to select the direction in which the feature would move, and to state an amount by which these parts would be required to move. Other groups of participants later verified the positions and the descriptions of the trajectories as accurately depicting the way that specific expressions were produced.

The successful inclusion of these vectors shows that movement is considered to be important in expression analysis, but the majority of the work still concentrates on static images. This is despite the fact that as far back as 1862, the role of movement in expression analysis was thought to be important, when Duchenne considered particular dynamic changes in facial musculature when smiling. He was able to distinguish two types of smile (spontaneous or posed) on the basis of the movements of areas of the face: one set of movements giving rise to this expression was said to 'obey the sweet emotions of the soul....the other obeys the will, and reveals a false friend' (in Ekman, Friesen and Davidson, 1990).

Ekman himself devised a systematic way of analysing the time-course of facial expressions in his FACS (Facial Action Coding System), to accommodate the potential importance of movement in emotional expression analysis (Ekman and Friesen, 1978). FACS was used to illustrate differences in emotional expressions in terms of which areas of the face ('action units') moved at which point during the production of emotional expressions. These visually distinct areas can be easily measured to provide frequency and duration data on each type of facial action, which is related to the intensity of the stimulus. Therefore each face can be objectively and unambiguously described, with particular gestures being reliably recognised on the basis of that code. For example, Ekman, Friesen and Simons (1985) used FACS to analyse 'startle' expressions, on hearing a gunshot. If the actors were merely posing the expression, the onset (at what point the expression unfolds) of the expression was 100 m/sec later than a spontaneous expression as a result of the sudden noise.

Therefore, movement is important for expression analysis as it portrays articulatory changes in facial musculature which give rise tot he emotional expression itself; more importantly, these changes necessarily occur over time. FACS can help in discriminating between the production of posed (regulated, deliberate) emotional expressions, as opposed to genuine (spontaneous) expressions. The rate of change (caused by movement) at which an expression occurs can modify its meaning. For example, disgust and fear are often confused by participants judging static displays, but FACS shows that the two can be distinguished on the basis of their onset times.

As a large part of expression analysis seems to be connected with the dynamics of production, we must ask to what extent we are able to make use of this moving information, if it differs from the cues we extract from the static information. Evidence of such a contrast comes from neuropsychological investigations, where patterns of differential abilities can be found between recognising expressions from moving displays compared with static images. Patient HJA (e.g. Humphreys at al, 1993; Campbell, 1992) can identify facial expression and gender from a sequence showing a moving face, but not from static pictures. GK (in Humphreys et al, 1993) can recognise emotional expressions from static pictures, but not from moving displays.

Having illustrated how more effective processing of lip-read speech and emotional expression analysis can be achieved from moving rather than static presentations, the discussion now turns to the role of movement in face recognition, where previous research has been dominated by static stimuli presentations.

Movement and face processing: the identification of unfamiliar faces

In considering the processes leading to the identification of faces, there are two issues which need to be considered: the initial encoding of the face, and the act of recognition itself. The first concern is the establishment of a description in memory, and there was a discussion earlier of what this representation might comprise; the second involves the issue of how this stored item is accessed.

Many authors have questioned the paradigm normally found when testing unfamiliar face recognition, where participants study and are tested with static pictures (e.g. Bruce, 1982; Hay and Young, 1982; Bartlett and Leslie, 1986; Vokey and Read, 1992). Klatzky and Forrest (1984) stated that using a single photograph or pose at study would actually encourage pictorial encoding, or view-specific information. This would provide the basis for the recognition process, not the 'person', i.e. such a paradigm is a test of photo recognition, and not face recognition per se. Klatzky et al also pointed out that we assume the strength of facial episodes is shown in higher recognition rates when the viewpoint is the same between study and test. Such results may be due to over-confidence, consistently saying 'Yes' if the view-specific details are the same, but this would not only result in higher recognition rates, it would also result in higher False Positive rates. If we err on the side of caution, and say 'Yes' less often when the viewpoint changes between study and test, then there may be less hits (correct identifications) but there will also be fewer false alarms. Thus, it is important to consider signal detection measurements of face processing performance (discrimination and bias), and not simply accuracy data.

Previously in this chapter, there was a consideration that motion might be important in face processing, because these sequences provide more instances. There were other suggestions that motion during study or test might provide a more abstract description, which might be cues allowing for access to the underlying 3D structure. Instead, motion might encourage a representation which is based on previously experienced dynamic patterns that were specific to individual faces. These sorts of issues now lead us to question how unfamiliar faces are initially learned, if the original description formed contains dynamic information, or if these details are added later, as a result of several different viewing occasions.

Pike (1994) investigated whether viewing rotations of an unfamiliar person's head in depth could assist face recognition in a way similar to the results for object recognition found by Lawson, Humphreys and Watson (1994). In Lawson et al's experiment, it seemed that participants extracted structure-from-motion invariants from a coherent structured series of views (not dynamic), which led to accurate recognition of objects tested in novel viewpoints; such generalisation was not possible after studying a random sequence of those same views. If such generalisation was possible after studying a structured series of static images, perhaps analogous extrapolation could be found where the structured series was shown in a moving sequence.

In Pike's experiment, unfamiliar target faces were filmed under uni-directional lighting conditions (one light source) and from a fixed point, whilst the chair was rotated horizontally through 360 degrees. The faces were presented in one of three types of learning phase, each lasting ten seconds: a full-face single static shot; five static images of the head as the chair turned through 60 degree steps (multiple-static); or a dynamic sweep through the full 360 degree rotation. The test was of a single, static, full-face picture (but not identical to the one shown at test). He found a significant advantage for the recognition of faces learned from the coherent moving sequences, followed by those faces learned from multiple static views.

Bruce and Valentine (1988) compared recognition memory of novel faces shown using video footage (i.e. dynamic sequences) with recognition memory for faces presented as a sequence of stills, or as a single static picture; participants were aware that recognition would be tested later. When the test phase was of the target seen from a 3/4 viewpoint, there was no significant difference between the performance of participants in either the dynamic or static learning conditions, although there was a trend towards greater accuracy for participants initially viewing the dynamic sequences.

Further studies of the effects of a dynamic learning phase can be found more specifically within the eye-witness literature, which is a practical application of the findings from face processing research. Shepherd, Ellis and Davies (1982) compared recognition rates for participants shown a variety of formats. In the 'learning' phase, participants either saw the 'event', a film of the event, or they saw a (static) picture taken from the event. In each case, during this study phase they were asked to make decisions about the truthfulness, or honesty of the person being seen. When tested for recognition of the target, there was an overall advantage for the use of motion. The recognition performances of those groups seeing either the dynamic 'live' or the dynamic 'filmed' presentations were significantly better in each condition when compared with the performance of the group viewing the single picture. However, participants who actually saw the 'perpetrator' "live" in the event were more accurate than those shown either the film, or the single picture. This suggests that the advantages for motion are more complex than the simple dynamics of the method of presentation.

The methodology used to investigate eye-witness situations can involve the use of movement at both learning and test phases, and it is here that slightly more encouraging data to support the benefits of motion can be found. Schiff, Banka and de Bordes Galai (1987) demonstrated there was an advantage for the use of motion at test in an eye-witness situation. Participants (the 'witnesses') saw either a video of a hold-up, a series of freeze-frames from the event, or slides of the 'criminals' in the presentation/learning phase. Recognition was tested under three conditions: using a moving sequence, or using one of two types of multiple static images. The moving test phase consisted of a horizontal 180 degree sweep of the face; the camera was fixed, and films were taken of targets and distractors as their chair rotated through 180 degrees. One of the static test conditions used three slides i.e. multiple viewpoints; the other used freeze-frames of the event. In this last condition, there would be a reinstatement of a variety of cues at test from the incident itself, such as clothing, hairstyle, context; these would not be present in the other two test conditions.

It was predicted that the slide-at-learning/slide-at-test condition would result in most accurate performance, but Schiff et al (1987) found that the recognition of a 'criminal' was more successful in the event/dynamic condition than in any of the static image presentations. Highest Hit rates were found in conditions where the participants saw the crime take place, and where their ability to recognise the 'criminal' was probed using a dynamic sequence of a horizontal rotation of the face; poorest performance was found when a static 'mug-shot' was seen at test.

These types of inconsistencies in findings about the benefits of motion may be more to do with methodology, rather than a genuine lack of an effect. For example, it may be that the use of photographs encourages indirect perception, leading to different types of processing strategy, such as episodic, or pictorial, learning. When we observe a moving face, we may be processing with reference to 'real' stimuli, and that might involve aspects of direct perception. Bruce and Valentine (1988) suggest that the differences in patterns of results may be due to participants using different strategies in the 'live' presentation, rather than the moving film, or static version of events. Further analysis by Schiff and colleagues (1987) revealed that both individual and event characteristics affected participants' ability to recognise the 'criminals'. Indeed, participants themselves reported having used non-facial aspects, such as clothing, body, or movement properties to help identify the target. This led Schiff et al (1987) to conclude that the face is a 'dynamic event', and that ecological considerations, such as the provision of moving test sequences, should be made in further research into face processing, an appeal which is fundamental to this thesis.

Eye-witness paradigms may provide a more accurate model of what happens in our everyday experiences with unfamiliar faces, compared with previous laboratory-based studies, as the 'learning phase' involves the provision of movement. Eye-witness testimony studies also serve to illustrate the complexity of identification, where not only the face, but other characteristics of the person may be encoded in conjunction with the events themselves. It may be these which act as cues to recognition at test, not just the face. Perhaps there is indeed an ecological advantage for learning an unfamiliar face from moving sequences, but that this advantage is masked by other aspects of the learning process, such as context, or encoding strategy; this may also be true for laboratory-induced recognition.

Movement and face processing: the identification of familiar faces

In everyday circumstances, faces are normally seen as being constantly in motion, either as a result of internal changes (producing speech, or making expressive gestures), or of global changes, where the whole head moves through space (such as tilting the head when listening attentively, or shaking it in disagreement). Faces become familiar to us by virtue of repeated exposure to them, and learning and recognition events usually involve motion. This may lead to us not only extracting and storing spatial aspects of their 3D facial structure, or their configuration, but viewing these dynamic transformations might also lead to us encoding aspects of that person's idiosyncratic facial gesturing (which might be the amounts by which these features are displaced/change, or the way that face changes).

Knight and Johnston (in press) have provided evidence that there are significant advantages to be found in testing the recognition of famous faces with moving sequences, rather than static images. They showed images of famous people, i.e. familiar faces, in photographic negative; these faces were seen either as a single picture, or in short moving film clips. There were significantly more faces recognised as a result of viewing the films than the single pictures. Bruce and Valentine (1988) also found significant advantages in using moving stimuli to recognise familiar faces, when lecturers and tutors of a certain institution (i.e. who would be familiar faces) were presented as dynamic point-light displays to students of that same University; when viewed as static instances, recognition performance was not significantly above chance. These experiments suggest that motion can help identify familiar faces when the testing situation is made difficult (by format manipulation, or requiring retrieval of form-from-motion). Whilst Bruce and Valentine account for the advantage of viewing moving sequences in terms of deriving cues to the underlying 3D structure from the dynamic displays, Knight and Johnston propose further that the advantage is due to the extraction of characteristic gesture patterns. Under either explanation, this information is not present in single instances, and the benefits for motion are due to a more fundamental property of this type of presentation.

Overview

Having outlined some of the differences to be found between the use of static and moving information in face processing, the thesis aimed to clarify under what circumstances these processing tasks were helped by motion, and why. Fundamental problems about the use of motion have been raised at several points throughout this Introduction, perhaps advantages could simply be due to the number of instances required to portray a stimulus as moving; alternatively, they may instead be due to some essential quality of movement per se.

The first of these alternatives is addressed in Chapter Two, which describes the first set of experiments. Unfamiliar faces were learned in moving and static training periods which comprised identical amounts of information. In both types of sequence, the same frames were shown either as a random series of static images, or were animated in their correct order using a computer programme to portray moving sequences. Recognition rates were tested using combinations of changes in viewpoint, expression. Experiments also varied in the use of moving and static test phases. Across all four experiments, there was a consistently detrimental effect of changing viewpoint between learning and test, but there was no additional advantage in having learned the faces in moving, as opposed to static, sequences. However, there was a suggestion that movement was beneficial in testing the recognition of those faces; there was a significant advantage in the non-parametric signal detection measurement of discrimination (A') when dynamic sequences were used at test.

In the next set of experiments which are described in Chapter Three, rather than recognition, the task involved matching unfamiliar faces on the basis of expression or identity. The faces to be matched were split horizontally, and either moving or static halves were presented. It was expected that there would be better results achieved when moving trials were seen by those in the expression-matching groups, compared to performances of those viewing static pictures. The reason proposed was that there would be more useful cues during the dynamic production of an expression seen in separate halves of the face which would help to access the (full-face) representation in memory for that type of gesture. In contrast, the cues to expression-matches given in the static trials would be potentially ambiguous. There was no expected benefit for motion in those matching on the basis of identity, as there would be no pre-existing description of that person's full-face to access in memory.

A main effect of the type of task being undertaken was found, with significantly more correct matching decisions made on the basis of expression; there was no significant difference between moving and static presentation types. However, performance in the identity-matching groups was almost at floor, and in an attempt to improve the performance in these conditions, there was a brief familiarisation phase before the matching trials for participants of the following experiment. In Experiment Six, there was an overall increase in the numbers of correct decisions made, and there was no longer a significant difference between the task groups. There was now a significant overall advantage for the use of moving trials across both types of task; it was suggested that the dynamic sequences were providing cues to access a representation in memory for both the category of expression, and a description of identity more successfully than did the static cues.

As it seemed that movement was advantageous when carrying out matching tasks, which might have been achieved by accessing descriptions in memory (for expressions as well as newly-learned faces), the question was posed if similar advantages could be found when recognising faces that were highly familiar, i.e. where the representation was well-established (due to exposure to many different viewing episodes). Chapter Four describes the investigation of the role of movement in tapping representations of faces of famous people. This was carried out as an extension to the work of Knight and Johnston (in press). In addition to testing famous faces using a negative format as they had done, the technique of inversion was introduced in Experiments

Seven to Nine; this manipulation is also known to affect the recognition of such faces. As earlier aspects of the thesis had questioned whether any benefits found as a result of using moving sequences may simply be due to additional numbers of instances, recognition rates from dynamic presentations were compared with recognition rates from multiple static conditions (with more individual frames).

There was a significant advantage for the use of dynamic test sequences, and it was found consistently across both types of image manipulation. Even when participants in the static presentation conditions had more instances to view, there were significantly more faces recognised from the moving film clips, compared with multi-static conditions. It was concluded that benefits were not solely due to information content, but rather some attribute of motion itself. One of the proposals was that this may be due to some integral property of the individual dynamics of each person's face, i.e. something characteristic in their way of gesturing or talking which helped to identify them, even in these difficult format presentations.

Chapter Five describes the final investigation, which considers the effects of movement in familiarisation (this time using extended viewing times during the learning phase), and the use of video footage. The computer animation technique used in the first four experiments had allowed for equivalent amounts of information to be shown as both moving and static image sequences, but it had produced a limited set of results, and indeterminate conclusions. Therefore, the computer animation technique was no longer considered a necessary tool for these further studies.

Unfamiliar faces were studied in either long or short durations, using either moving or static image types; recognition was tested using either dynamic or fixed (static) images which were in either inverted or negated format. A significant advantage for the use of dynamic sequences at test was found, and there was also a significant interaction which showed beneficial effects arising from a dynamic test phase when this followed a long training period, irrespective of the type of sequences (moving or static) shown during the learning phase. It was suggested that movement at test may give more cues about possible overlaps with the stored representation (by somehow allowing the test sequence to be reconciled with the stored description), but it does not discriminate how the face was learned. However, this pattern of results could not be interpreted as being analogous to the finding from the familiar face recognition experiments, as the recognition rates reflected a significant shift in bias between responses made to dynamic and fixed test stimuli, rather than a genuine advantage for motion.

Conclusion

The final appraisal is that movement may be beneficial in accessing representations of faces with whom we are relatively or highly familiar, in order to identify them or analyse their facial expression. The advantage in these cases seems to be for movement per se, and not simply a product of the amounts of information they contain. One of the explanations offered earlier concerned the extraction and detection of characteristic motion patterns, particularly in the case of highly familiar faces. These dynamic descriptions may be stored alongside other description/s in memory, e.g. the configuration, shape-from-shading details, or the invariant properties. Motion at test may be beneficial as it provides something extra, such as an ability to overlap with (not categorically 'match') the stored representation, or via 3D configural or shape-from-shading details, or via characteristic gesture patterns; a further possible explanation is that it might simply reflect aspects of the learning phase.

However, the picture is less than clear in the case of relatively unfamiliar faces; the overall hit rate was quite low, and there was a bias in performance. It seems from Experiment Ten, and Experiments One to Four, that structure-from-motion cues do not appear to be useful in constructing the representation in memory for a new, previously unfamiliar face. Yet, there is a significant advantage for its use during the test of recognition of unfamiliar faces, as well as famous faces. This benefit for motion was also found in terms of discrimination performance (A') in the first four experiments, and in the accuracy of decisions made on unfamiliar faces shown in inverted and negated formats in Experiment Ten. There is a potential paradox, in that moving test sequences seem to be beneficial in the recognition of previously unfamiliar faces that were learned from either dynamic or static image sequences. However, we cannot appeal to the proposed explanation of idiosyncratic gesturing here, as it is hard to determine how this description could be extracted from simply viewing static instances, or sequences of only ten seconds (in the case of Experiment Ten), or less (in Experiments One to Four).

It may be that we have to resort to another explanation, which is based on the premise that motion at test provides an opportunity to compare the test description with the stored description by means of an 'overlap', not a precise correspondence with the existing representation in memory. Such an overlap may provide cues to what likely changes can be produced, or tolerated within a particular configuration, e.g. trajectories of parts of the face. The acceptable level of overlap might be determined by the amounts by which the features move, or the ways in which the facial configuration changes as it moves during speech, etc.

Overall, the thesis provides several reasonable lines of evidence to suggest that the role of motion in face processing is to facilitate the successful access of a pre-existing representation for the purposes of recognition and the analysis of emotional expression. However, there are some questions that remain unresolved, and some new issues that have been raised as a result of this investigation.

Chapter Two

Unfamiliar Face Recognition: Equating Moving and Static Sources of Information

Introduction

When we look at a face, with little apparent effort we are able to extract a wide variety of information from it, such as gender, emotional expression, and, for familiar faces, identity. Several models have been proposed which attempt to break down the processing of such information into discrete functions (e.g. Bruce and Young, 1986), and this experimental chapter sets out to assess the role of movement in one of those aspects, that of recognition. In the case of familiar faces, according to these types of models, recognition occurs when what we see successfully 'matches' (or is judged to be a legitimate variation of) what we have 'stored'. Identity therefore can be seen to depend upon the formation of a structural representation. In the case of unfamiliar face recognition, an accurate response depends on there being an adequate description in memory in the first instance, which seems to be primarily structural, and then successful activation of that representation at test. The aim of this chapter is to ascertain the role of movement in building up, and/or accessing such a representation of a previously unfamiliar face.

The typical research paradigm which has been used to investigate the recognition of unfamiliar faces would present participants with single pictures of previously novel faces and examine how well these faces can be recognised when later shown as the same or in a different picture from that studied (see

Shapiro and Penrod, 1986, for an overview and meta-analysis of many such studies). The results of these typically favour a situation where the test picture matches what was originally seen, and poorer performance when memory is tested with a different picture of the individual studied (e.g. Bruce, 1982). Such investigations lead to the suggestion that, for unfamiliar face recognition, people tend to rely on a picture-specific memory, or a picture-matching strategy, with poor extrapolation to a novel viewpoint or expression.

Although experiments would tend to suggest otherwise, in everyday life we do not seem to experience such limitations, as we can tolerate variations in viewpoint, lighting, expression, etc. when recognising faces we are *highly* familiar with. In order to explain this, the representation in memory must either comprise enough instances which allows us to generalise and recognise them under this new set of circumstances, or we must store faces in some way that *facilitates* such generalisation. One possibility is that this might involve the extraction and storage of information that is invariant across different views and expressions.

Earlier studies of object recognition emphasised the storage of *viewpoint-invariant* information in the form of 3D models which would explain our abilities to extrapolate to novel aspects (e.g. Marr and Nishihara, 1978; Biederman, 1987). More recently, research has suggested that *viewpoint-specific* information is stored (at least for certain types of objects) (Tarr and Bülthoff, 1995). Thus approaches to object recognition include both 3D model-based and exemplar-based representational theories, with the inference that the same might apply to face recognition. However, such explanations are fairly restricted in application to face processing, as few objects undergo the sorts of continuous, non-rigid changes that are fundamental attributes of human faces, for example, when talking, or conveying emotional feelings. There has been little consideration of how this sort of variation may be stored, or processed in face recognition.

The instance-based approach was discussed in the Introduction, along with the suggestion that techniques showing such an effect confounded picture recognition with recognition of the person (e.g. Bruce, 1982; Bartlett and Leslie, 1986; Vokey and Read, 1992). Therefore, we need to study situations more similar to those of everyday life, in order to assess if movement is used in the encoding and retrieval of the required information, and if so, then how.

Movement and the study phase

There are several possible ways in which studying a dynamic sequence might be expected to build a more robust representation of the face. When we see a moving sequence, we sample different aspects of expression, view (both by the movement of the 'target', and the observer), etc. This would provide more 'instances', or exemplars to be held in memory for a particular face. If moving sequences provide a better 3D representation of that face, which Ullman suggests in his algorithm for inferring form-from-motion (1979), then our ability to recognise that person in a previously unseen view should be better than recognition based on static instances (as we have more cues to the underlying structure). Finally, studying moving sequences should inform us of aspects which remain constant over changes in viewpoint and expression, i.e. a better range of permissible variations of other kinds of invariant characteristics of faces (such as the spatial layout, or configuration of the features).

Movement and the test phase

In addition, there may be benefits in using movement to test the recognition of those faces, irrespective of learning them from dynamic sequences or static instances. For example, if memory for the face is tested in a pose different from that originally studied, a dynamic sequence should provide a greater range of exemplars to judge from at that time, and allow for more successful generalisation from that originally studied, in comparison with static test images. This benefit might arise because of a process of normalising, where there is a greater overlap between what is seen during a moving sequence and what is seen in a single test image, or dynamic sequences may facilitate the extraction of invariants, or a 3D description to tap the representation, which itself might comprise invariants, or a 3D description.

The Introduction outlined some studies which show advantages for the use of movement in either the study or test of recognition of unfamiliar faces (e.g. Pike, 1994; see also Pike and Kemp, 1995; Bruce and Valentine, 1988). Pike (1994) found advantages for using moving study phases involving unfamiliar faces; Schiff et al (1986) found an advantage for testing (unfamiliar) face recognition using a moving sequence, rather than a static mug-shot.

Information content

However, a fundamental problem is that we only need to see one frame to perceive a static image; in order to portray movement, more than one frame is necessary; therefore moving stimuli are bound to have more information embedded in them than static stimuli. As an example, one second of a moving video sequence contains between 25 and 50 frames. If the comparison is made between recognition based on a single, static picture viewed for five seconds, with a five second moving sequence, there are over one hundred additional instances shown in the moving condition. Therefore, it may be the case that movement in either phase of an experiment is advantageous purely because it contains more information than a static presentation, and that coherent movement per se adds little to perceptual processing. In order to distinguish between the possible sources of this benefit, displays need to be constructed which somehow equate the amount of information shown in each type of presentation.

The Present Studies

The series of four experiments presented in this chapter aimed to compare recognition of faces that were studied using moving or static sequences, with equal amounts of information contained in each, by showing identical numbers of frames. The results of this investigation should help in the understanding of the nature of the representations which mediate the recognition of previously unfamiliar faces. If faces are represented as collections of instances, then, when the information content of the two conditions is equated, there should be no benefit for studying dynamic sequences. However, if movement facilitates extraction of a more abstract description, such as one based on 3D information, or invariants, then the recognition of faces from novel viewpoints or with different expressions should be better for those shown in dynamic conditions.

The hypothesis was that the use of movement in the learning and/or test of unfamiliar faces might result in higher recognition rates, when compared to the recognition of faces learned and/or tested using static images, due to the extraction of 3D structure from motion. In all four experiments, there was a comparison between participants' memory for faces studied in static and dynamic sequences. At test, Experiments One and Three used static images, and Experiments Two and Four used dynamic sequences. In all experiments, there was a comparison between recognition memory for faces tested in different viewpoints from those originally studied, with that shown for faces tested in the same viewpoint. If movement did assist in building up a representation, comprising a 3D model-based description, then there should be less decrements in recognition performance when the test involves a change in viewpoint (such as that found by Logie, Baddeley and Woodhead, 1987; Bruce, Valentine and Baddeley, 1987), compared with poorer performance found when static images were studied.

Types of movement

The internal features of faces move when speaking and expressing emotions (which can be described as non-rigid movements); the whole head also moves, or rotates in depth, such as in nodding, or tilting (which can be described as rigid movements). It may be that there are different mechanisms involved in processing these two types of change: the construction of a representation based on internal movements should allow for generalisation across expression, but it may not accommodate changes in plane/viewpoint. The Bruce and Young (1986) model has been used to argue that structural representations for face recognition might be viewpoint-dependent, but expression-independent. Support of this viewpoint-specificity came from studies on the visual processing of monkeys, where cells have been found that were maximally responsive to faces shown in a certain orientation (e.g. Perrett, Smith et al, 1985). In addition, the evidence of our ability to extract 'stability from variation' (Bruce, 1994) illustrates how, within the same viewpoint, variations in appearance which arise when expressive gestures are produced, seem to be processed and stored in memory in a way which favours the average of the exemplars viewed; between-view variations do not give rise to such prototype or 'averaging' effects. Cabeza, Bruce, Kato and Oda (1996) provide further evidence for this position.

In contrast, Wallis and colleagues (Wallis, 1996; Wallis and Rolls, 1997; Wallis and Baddeley, 1997) and Lawson et al (1994) have used alternative (e.g. non-human) methodologies which demonstrate that studying a series of images which present an object or a face within certain spatial and temporal boundaries facilitated the extraction of invariants, and recognition of the exemplar in a new viewing situation. In Wallis et al's studies, object and face recognition was tested using neural network paradigms, and the visual system of the macaque. In both techniques, it was demonstrated that invariant properties of objects and faces can be extracted, as long as different examples of the same item are shown within specific temporal and spatial parameters. Both the neural network and the activity in the temporal cortical visual areas show learning and classification based on invariant properties which are only derived when different views are shown in the correct order (rotation, viewpoint) and where the stimulus occupies the same relative space (size, retinal position); this is analogous to the findings discussed in Lawson et al's paper (1994). Although both Lawson and Wallis et al's studies used a series of static images, the implication is that dynamic sequences maintain the same sort of legitimate pattern of presentation, because coherent movement requires each instant to be spatially and temporally related to the next instant, as well as the previous one. A series of images shown in motion should therefore facilitate the same types of advantages in generalisation.

However, the majority of evidence seems to suggest that viewpoint-invariance mediates some aspects of face processing; it may therefore be the case that variations in viewpoint are treated as discrete instances, while variations within those same internal features are not (e.g. brought about by expressive changes). If dynamic sequences are used to portray these changes, this may result in different effects on the recognition of faces tested from new viewpoints, compared to the recognition of faces shown with different expressions. This was tested in Experiments One and Two, where participants initially studied faces in expressive sequences (i.e. in non-rigid movements);

recognition was tested with the expression either maintained or changed. Some participants were also tested with changes in viewpoint. In Experiments Three and Four, the faces were initially studied carrying out rigid (head-turning) gestures; recognition rates were assessed when the gesture was the same or different at test.

As there are many methodological similarities within the series of four experiments, with regards to the means of constructing the learning and test sequences (as well as design, and procedure), there now follows a general description of the Methods. Any deviations from this general pattern are discussed before individual experiments.

General Methods

Materials: Target and distractor actors were filmed against a black background, wearing a bathing cap, and with a towel wrapped around their shoulders. This was to eliminate any subsequent cues to recognition being derived from clothing or hair-style, and to focus attention on the internal features, and shape of the face.

The actors were filmed simultaneously from two perspectives: face-on shots (now denoted by FF), and 3/4 profile-views (now called TQ). In the TQ view, the right side of the face was filmed at an angle such that there was a clear view of the right side of the face; the left eye was visible up to the mid-point of the eye-brow; the right half of the left eye was also visible, as was the bow of the lips. The two cameras used were Sony Super-8's, and the actor was seated approximately 45 cm. away from each camera. There was lighting from above, and from both the front and the side (i.e. behind each camera).

The actors carried out a variety of facial gestures and head movements, including the changes in configuration associated with a continuum from a smile to a sad gesture (where the person had to raise, and then lower the corners of their mouth); the mouth movements performed whilst pronouncing the speech sounds "eeh", followed immediately by the "ooh" sound. They were also filmed nodding and shaking their head.

In order to construct the learning and test sequences, frames were grabbed from the Super-8 films using the 'Quick Image' package (Shareware), which allowed for the selection of specific frames from each of the required gestures. The TQ frames were chosen to show the same points of articulation (or rotation) as each of the FF frames.

As the purpose of the experiments was to ascertain the benefits of movement per se, over and above the amount of information embedded in the sequences, it was essential to have an economical set of frames that could run together, encapsulating a moving face. It was also important to have a small number of frames, in order that the animation package (Xrastool; see Appendix One for a description) could show all target learning phases in one entire film. Several attempts were made to find the least number, and shortest duration, of frames to be viewed that would allow for the perception of coherent 'natural' movement of the face, or head. It was found that when the frames were played at 150 m/sec per item (using the 'Xrastool' application) that the movement seemed smooth and natural. For Experiments One and Two, five independent sources judged that five frames were adequate in portraying the internal expression changes; for Experiments Three and Four, three were sufficient to display the changes in angle/rotational displacements (see Method section of Experiments Three and Four for further details).

Each sequence of frames was stored as 8-bit grey scale images, sized 156 X 156 pixels. Using Xrastool on a Sun Workstation, the physical size of each frame (on the screen) was 7.5cm X 7.5cm for each experiment's presentation phase, and also for the moving test phases in Experiments Two and Four. Experiments One and Three had a static test phase, which showed a 9cm X 9.5cm image on a Macintosh Centris 650 using Superlab.

Moving vs Static presentation: The same principles applied to the manufacture of each type of stimulus for all four experimental study and test phases, but individual experiments have further details.

In Experiments One and Two, the faces were to be shown depicting the 'smile-sad' gesture. Both the moving and static study phases used five FF frames. In order to construct the moving sequences, these frames were played in the correct running order through Xrastool, at a rate of 150 m/sec per frame on the Sun Workstation. Each target was randomly allocated to a position in the learning 'film'. Each actor's sequence was shown four times (with the effect of that person making a smooth facial gesture), giving a total of 20 frames per gesture. There were two blank, black frames shown at the beginning and end of each of these blocks of 20 frames (the reason for these blank frames becomes important for the static sequences, described below). The running order for the 'moving' presentation of each target was therefore: blank, blank, 12345, 12345, 12345, 12345, 12345, blank, blank. Frame 1 refers only to the numerical start of the sequence, but the actual start of the articulation was randomised, to eliminate any effects of initial exposure and learning. The screen was then blank (grey) for two seconds between each stimulus' sequence, (achieved by inserting a grey frame for two seconds in the Xrastool film 'script'): this was for participants to make a description of the face aloud to the experimenter (see below).

For faces to be shown in the static presentation format, the same set of five frames used above was shown in a pre-determined random sequence, to eliminate any perception of apparent motion between each set, i.e. it was not a coherently-ordered presentation. Each separate frame was repeated four times in succession, so that the sequence (when animated using Xrastool at 150 m/sec per frame) would be experienced as a cycle of five different static pictures. One of the blank, black frames used at the beginning of the moving sequences was used to separate each static 'block' of four. This ensured that participants were exposed to the same amount of information (identical number of frames) as they were in the moving presentation format, and also that each one would be seen for the same duration. The starting point of each target learning sequence was (again)randomised. The running order of frames for the static study phase could be, for example: 2222, blank, 5555, blank, 3333, blank, 1111, blank, 4444.

Presentation Counterbalancing: In all four experiments, there were five male and five female target faces: of these, five were learned by half the participants in each condition in an animated (moving) sequence, and five were learned in a static sequence. All faces changed their moving/static status for the remaining sub-groups of participants. Of the five males shown to one sub-group, two were moving, and three were static: of the five females shown to the same sub-group, three were moving, and two were static. The order that the faces appeared in the 'film' was randomly selected, but maintained for sub-groups of participants.

General Design: The experiments are described in pairs (One and Two, Three and Four). The first experiment in each pair used a static test (a single frame); the second in each pair used a dynamic test. Although the combined description of the experiments might suggest otherwise, all four experiments were carried out as distinct studies, and experiments within a pair are analysed and discussed individually. This is due to there being differences in both the size and nature of the participant populations, as well as variations in the way that responses were noted. In each experiment, participants were randomly assigned to one of four between-subjects conditions.

The design in each experiment was a 2x2x2 factorial. The within-subjects factor in all experiments was Presentation format - static or dynamic. All participants initially studied half the faces in dynamic and half in static formats. Each experiment had two further between-subjects factors. One of these varied the Viewpoint/Plane in which the face was tested, either the same or different plane from that studied; the other factor varied was the Expression/Gesture. In Experiments One and Two, the learning gesture was always a smile-sad expressive sequence, and the test gesture was either the same, or it showed a facial speech movement. In Experiments Three and Four, the gestures involved whole-head transitions, nodding and shaking gestures which were shown to different groups of participants in the learning and test phases.

General Procedure - Study Phases: The experimental paradigm throughout this series was an incidental learning task. In all presentation phases, participants were required to judge whether each of the faces shown on the Sun Workstation was an 'arts' or a 'science' student. Participants were told that some faces would be seen in animated sequences, some as a series of stills, for about three seconds each. There would be a blank screen for two seconds between each of the faces, during which time they had to give their ‘arts’ or ‘science’ decision aloud, for the experimenter to write down. They then carried out a series of unrelated filler tasks for approximately 30 minutes, before completing the test of recognition.

General Procedure - Test Phases: The test phases of Experiments One and Three required participants to make their recognition decisions based on single static frames: these depicted the apex of the relevant facial, or rotational, gesture (see individual experiments). In both cases, Superlab was used to measure the accuracy and latencies for recognition decisions for the ten targets. The faces of the targets were randomly interleaved with a series of faces including ten distractors, and these were presented in a different random order for each participant.

The test phases of Experiments Two and Four involved participants making recognition decisions verbally to moving sequences, tested on the same Sun Workstation as used for presentation; it was not possible to measure response latencies for these experiments. To create these test sequences, two Xrastool movies were made for each experimental condition, using the same procedure as that employed in the learning phase. These films showed the ten targets and ten distractor faces in a previously assigned, but random order. They were shown performing the moving facial gesture appropriate to the relevant condition (internal gestures for Two, whole-head rotations for Four). The first film made for each experimental condition had six target faces randomly interleaved with four distractors; in the second of the films, there were four targets interleaved with six distractors. Participants were informed that each target was only represented once in either of the two test films. There was a two second blank screen between each item presented at test, in order for participants to make their recognition decisions aloud, for the experimenter to note.

Treatment of Results: The analyses of accuracy are presented for all four experiments. Although RT's were collected for Experiments One and Three, the data is not discussed, but the details are shown in the Appendix section. This is because the latencies data are highly variable (mean RT's > 2 seconds, SD's > 850m/sec), and the overall performance was highly error-prone. Thus, any analysis of latencies would be less informative than analysis by hit and false positive (FP) rates. The RT's data generally reflected the results found in the Hits and FP's, therefore, only the accuracy data is discussed in the body of this thesis.

Participants' performance was examined using separate analysis of hits and FP's, and their combination using the non-parametric signal detection measurements A' and B". This analysis was undertaken to determine whether observed effects arose from shifts in bias or sensitivity due to some of variables.

A' is the non-parametric discrimination index (the participant's sensitivity to the signal), where chance is when A' = 0.5. B" is the non-parametric bias index (criterion bias), between -1 and +1: when B" = 0, this shows a neutral criterion; B" > 0 is liberal criterion, where there is a bias to noise; B" < 0 shows a conservative (cautious) criterion being utilised, where there is a bias to signal (see Snodgrass and Corwin, 1988). There were no significant effects in any of the individual experimental analyses using B"; therefore, they are not discussed further.

There was an additional post-hoc analysis, combining the results from all four experiments, to examine (amongst other things) the overall effects of the changes in Viewpoint and Presentation type using a 2x2x2x2 factor ANOVA; again, only significant A' effects are discussed.

Hit rates were entered into 2x2x2 factor ANOVAs. FP's were entered into 2x2 factor ANOVAs, corresponding to the between-subjects factors which were varied. As the distractors were only seen at test, the FP rate could only be measured for the specific test format used (i.e. static images in Experiments One and Three; dynamic sequences in Experiments Two and Four). In order to calculate the A' measures, FP rates are required for both moving and static cells. However, as distractor faces are only seen at test, and each experiment only had one type of presentation at test, it had to be assumed that the FP rate would be the same for both types of presentation.

Items analyses were also carried out on correct recognition rates, to assess the effects of Viewpoint/Plane, Expression/Gesture and Presentation on recognition rates for different targets. These are reported only where there is a difference from the subjects' analysis. Because of the small numbers of targets, the items analyses lack power, but nonetheless they generally confirm the statistically significant effects found in the subjects' analysis.

Pilot study

A pilot study was conducted to assess if the FF views might be recognised at ceiling levels, and TQ performances to be close to floor. A group of fourteen participants viewed a single static FF image of each of the ten targets to be used in the main experiments (using the Superlab application on a Mac). The participants were involved in the same incidental learning task used in the main study (making an 'arts' or 'science' student judgement). At test, they saw some of the targets from the FF viewpoint, and some from the TQ viewpoint; also several distractors were seen from an FF or TQ viewpoint; the series of faces was displayed in a random order. Their recognition decisions were indicated by a button press, to measure both accuracy and speed.

The accuracies were analysed using a one-factor ANOVA, looking at the effect of Viewpoint (same or different): the means are shown in Table 2.1.

Table 2.1
Mean percentage Hit and FP rate in pilot study

	VIEW		
	Same *(FF)*	Diff *(TQ)*	FP's
Hits	66	51	38

The ANOVA revealed no significant difference between recognition rates for faces shown in either the same (FF) or different (TQ) perspectives (F (1,13) = 2.76, p > 0.1), although the trend was for more accurate performance when the test was the same image as studied (66% same vs 51% different). This pilot work indicated that a task of this general design was of a suitable level of difficulty to avoid floor and ceiling effects.

The latencies were not analysed, as there was huge variability in decision times (for example, the RT's for one participant ranged from 540m/sec to 2700m/sec; one consistently took over 1700m/sec, another under 1100m/sec: see Appendix Five).

Experiments One and Two

In both experiments, participants studied moving and static full-face (FF) images, which were carrying out an expressive movement, the smile-to-sad gesture. At test, participants either saw a single, static image of each target and distractor (Experiment One), or a series of short, dynamic films showing these types of faces (Experiment Two).

Methods

Participants: There were 40 participants in Experiment One: 19 males, 21 females, aged between 18 and 30 years, with ten participants randomly allocated to each of the four conditions outlined below. There were 32 participants in Experiment Two: 16 male, 16 female, with eight participants in each of the four conditions. They were all either students or staff at the University of Stirling.

Design: In both experiments, the four between-subjects test conditions were constructed from all combinations of the two between-subjects factors of Viewpoint at test (either FF or TQ view) and Expression at test (either the same or different to the one studied).

Condition One: FF-same expression: This tested recognition of targets posing the same facial expression as was studied (i.e. a smile), and faces were tested from the FF viewpoint (i.e. the same as had been studied). In Experiment One, the static test images showed the apex of the smile gesture, and it was one of the frames that had been studied initially: for half of the faces, this exactly matched the format it had been studied in. In Experiment Two, the moving test images were the same as had been used in the study phase. For half of the faces, these exactly matched the format they had been initially studied in.

Condition Two: TQ-same expression: This tested recognition of faces posing the same expression seen during study (a smile), but from the TQ viewpoint.

Condition Three: FF-different expression: This tested recognition from the same viewpoint as was studied (FF), but the target and distractor faces were posing a different expression to that in the presentation phase, the 'eeh to ooh' speech sound. In Experiment One, the test phase used single static images of the apex of the 'ooh' speech sound. In Experiment Two, the dynamic sequences showed the faces varying from an 'eeh' to an 'ooh' speech sound.

Condition Four: TQ-different expression: This tested recognition from a TQ viewpoint, and target and distractor face were posing the 'ooh' speech sound. In Experiment One, the test phase used a single static image of the apex of the 'ooh' speech sound; Experiment Two showed dynamic sequences of these speech sounds

Procedure - Study Phases: As described above.

Procedure - Test Phases: In Experiment One, participants were tested for recognition of targets using Superlab, which presented the test series of 20 static images (ten targets, and ten distractors) in a random order, in one of the four conditions outlined above. Superlab measured each participant's forced-choice recognition decisions, which were indicated by a button press. Participants in the various conditions were told about how the faces would appear in their particular test phase. They were also informed that they should press the corresponding button as soon as they had reached their recognition decision, and that the face would be on the screen only for as long as it took them to make their decision. There was a two second interval between their response and the next test face.

In Experiment Two, each of the 20 test sequences was seen in a previously assigned random order. As the dynamic test sequence was constructed the same way as the dynamic study sequences (five frames X 150 m/sec per frame X four repeats), each face was seen for three seconds. Again, participants were informed of the nature of their test (according to their assigned condition), and that they were to give recognition decisions verbally, for the experimenter to record.

Results of Experiment One

The mean hit rate across all conditions was 64%: the FP rate was 28%. Table 2.2 shows the results in each condition. There was a significant main effect of Viewpoint on the number of Hits ($F (1,36) = 12.63$, $p < 0.01$), with fewer targets being recognised from a different viewpoint: this was also found in the analysis by items ($F (1,9) = 14.37$, $p < 0.05$).

Although the analysis of FP's showed no significant effects, the analysis of A' (see Figure 2.1) also demonstrated a higher discrimination was used when the faces were tested in the FF viewpoint ($F (1,36) = 15.89$, $p < 0.01$).

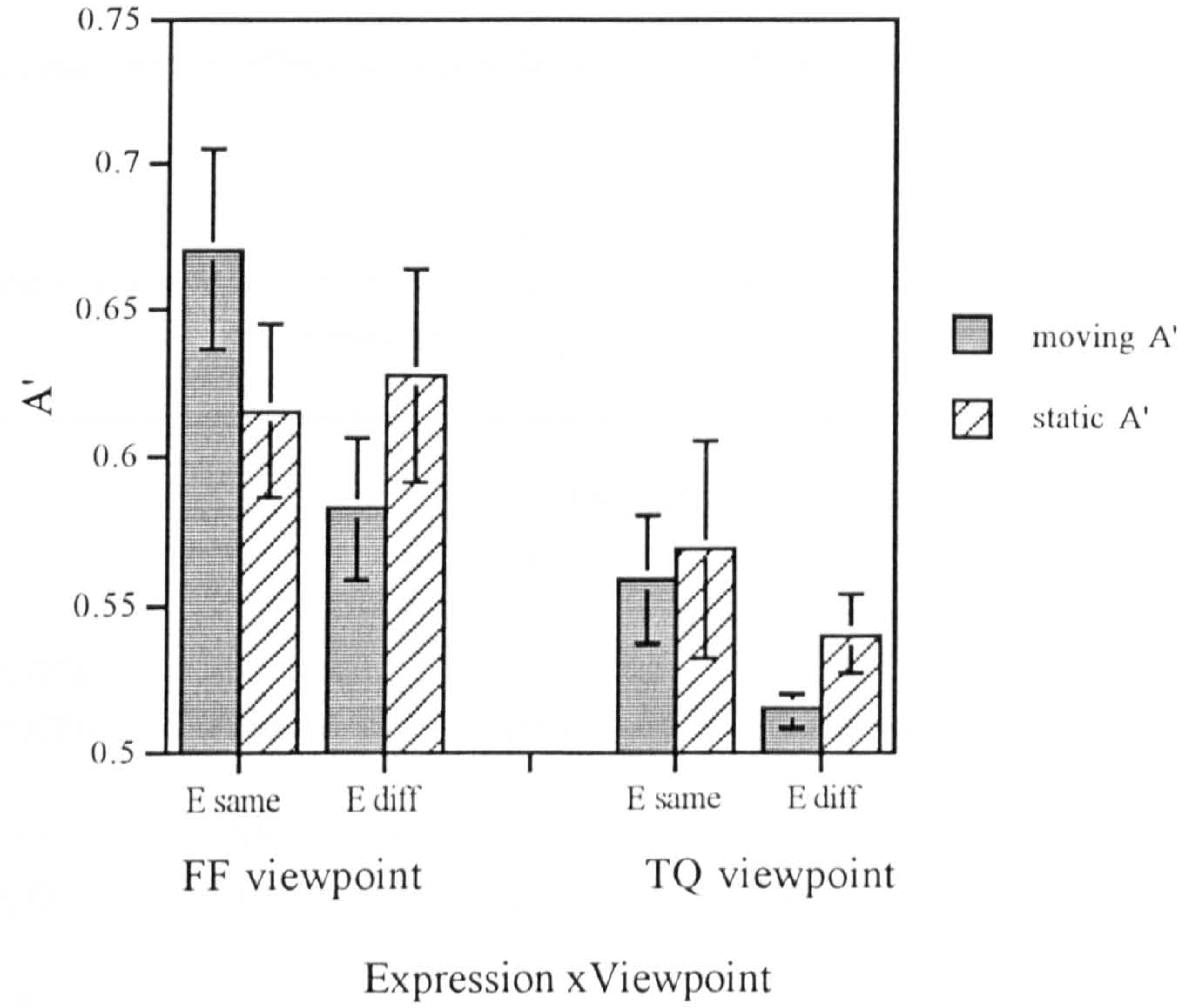
Table 2.2

Mean percentage Hit and FP rates, with Standard Deviations (S.D.) in each of the conditions of Experiment One (static test), where EXPR refers to Expression at Test.

	PRESENTATION							
	moving				*static*			
VIEW	*FF*		*TQ*		*FF*		*TQ*	
EXPR.	*same*	*diff*	*same*	*diff*	*same*	*diff*	*same*	*diff*
Hits	82	64	58	48	70	76	58	60
S.D.	17	25	22	19	22	21	22	19
FP's	23	27	29	35	23	27	29	35
S.D.	9	16	12	13	9	16	12	13

Figure 2.1

Mean A' in each condition of Experiment One (static test). The error bars show the standard errors.



There were no other main effects or interactions in the analysis by subject or items on Hits, FP's, or A' (all F's < 3.53, p's > 0.1). However, in the analysis of Hits by items, the Expression x Presentation format interaction approached significance (F (1,9) = 4.585, p= 0.06); this showed a trend where the lowest hit rates occurred when faces were studied in a dynamic sequence, and tested posing a different expression, and the highest hit rates were found where the faces had been studied in motion, and tested using the same expression.

Thus while there seems to be some advantage for dynamic study sequences when expression is the same, this benefit is lost when the test comprises a single, static image of a different expression.

Results of Experiment Two

The mean overall hit rate was 64%: the FP rate was 28%. Table 2.3 summarises the effects of variables on Hit and FP scores.

Table 2.3

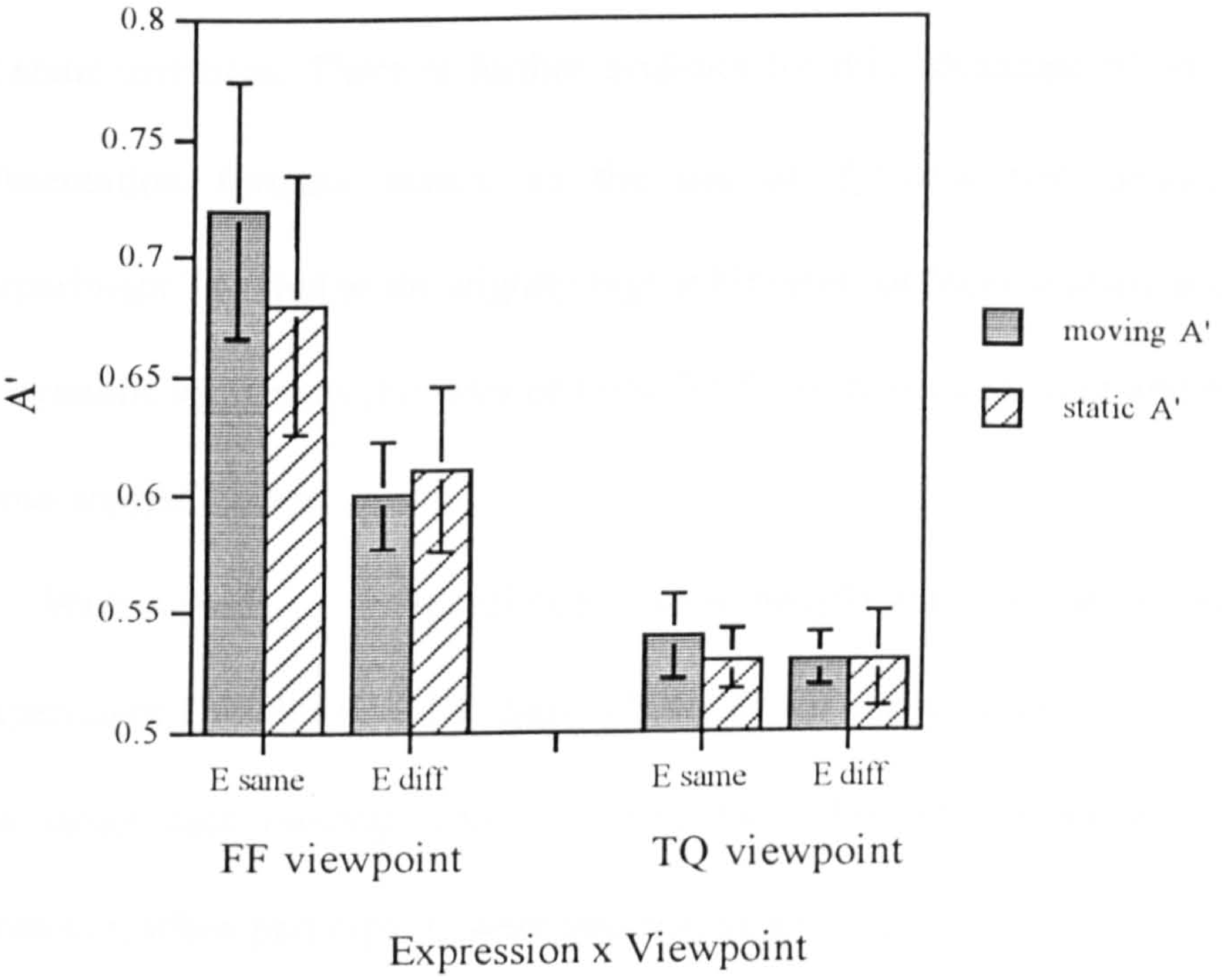
Mean percentage Hit and FP rates, with Standard Deviations (S.D.) in each of the conditions of Experiment Two (dynamic test).

	PRESENTATION							
	moving				*static*			
VIEW	*FF*		*TQ*		*FF*		*TQ*	
EXPR.	*same*	*diff*	*same*	*diff*	*same*	*diff*	*same*	*diff*
Hits	85	75	50	52	77	75	50	50
S.D.	14	18	18	21	23	21	21	19
FP's	20	30	29	34	20	30	29	34
S.D.	23	9	12	19	23	9	12	19

As found in Experiment One, there was a main effect of Viewpoint in the analysis of Hits (F (1,28) = 25.76, p < 0.01), with fewer targets being recognised from a different viewpoint; the same effect was found in the items analysis (F (1,9) = 22.8, p < 0.01). Although there were no significant effects on FP's, the effect of Viewpoint was also significant on A' (see Figure 2.2) (F (1,28) = 16.88, p < 0.01).

Figure 2.2

Mean A' in each condition of Experiment Two (moving test). The error bars show the standard errors



No other main effects or interaction reached significance in the analysis of Hits, items, FP's nor A' (all F's < 2.56, p's > 0.1).

Discussion of Experiments One and Two

Neither Experiment One, nor Experiment Two found any significant difference between the moving and static presentation sequences. In Experiment One, slightly more faces were recognised from the series of static images (63% mean hits for faces studied moving, and 66% for those studied as static). There has been evidence in the past of a benefit when the study and test conditions match (e.g. Davies, Ellis and Shepherd, 1978; Tulving and Thomson, 1983); the results of Experiment One would tend to suggest this is the case, as there is a slight advantage for faces that are both studied <u>and</u> tested in static instances. There is further evidence for this advantage when test and presentation formats match, as the use of dynamic test sequences in Experiment Two led to the slightly higher hit rates for faces studied and tested in dynamic sequences (hit rates of 66% for faces studied moving and 63% for those studied static).

With regards to the predicted overall benefit for the use of movement, Experiment One did reveal a slight advantage for recognition in having studied the target face moving, when the test face showed the same expression. However, when participants were asked to generalise to a different expression at test (irrespective of viewpoint) then an actual <u>dis</u>advantage was conferred by having a moving study sequence. Although none of the interactions reached significance, in both experiments the FF-same expression-moving condition in the 3-way interaction gave the highest hit rate of all (82% in Experiment One and 85% in Experiment Two) (also reflected in Figures 2.1 and 2.2), but this apparent advantage for faces studied in movement did not extend to any other conditions in the experiment, and thus dynamic sequences appear not to enable better generalisation to different viewpoints and expressions.

Both experiments showed a highly significant effect of changing view between study and test, with fewer hits, and a tendency for higher FP's in the TQ conditions, but no overall effect of changing expression. Participants were better able to generalise across differences within the same plane (i.e. to a different expression), than they were able to generalise across differences between planes of viewing and test. This is in accordance with the findings of Bruce (1994), and Cabeza, Bruce, Kato and Oda (1996), who used a rather different prototype-learning paradigm to show that various viewpoints appear to be stored separately in face memory. They are also consistent with Bruce and Young's (1986) suggestion that the structural codes stored in memory which mediate face recognition are viewpoint-dependent, but are independent of expression.

However, this lack of any effect of the variable Expression may be because the learning sequences showed sufficient variation in the smile-to-sad gesture (with intermediate stages within that transition), to allow for generalisation to a different facial expression (internal change). The poor performance with a change in view at test may be because no variation in viewpoint was studied during the learning phase.

Experiments Three and Four examine whether generalisation to novel viewpoints is better when variations in head angle are experienced during the initial study phase, as would follow from the predictions of Wallis and colleagues discussed earlier (e.g. Wallis and Rolls, 1997; Lawson et al, 1994)

Experiments Three and Four

In Experiments Three and Four, the emphasis was on rigid, whole-head rotations. Two of the variables under manipulation at test were similar to those in Experiments One and Two, i.e. the effect of presentation format (either moving or static), and the effect of changing viewpoint between study and test. In these two Experiments, this last variable is labelled "Plane", as it refers to the plane in which the head rotates. In the previous two experiments, problems in generalising to new viewpoints may have been because the study sequences only comprised a full-face perspective studies, whereas other studies had shown that invariants could be extracted from a coherent structured series of images (e.g. Wallis, 1996; Wallis and Baddeley, 1997).

When the head shakes, as in disapproval, the face is seen in profile (or TQ) for part of the time, and there is a rotation within the horizontal plane. Exposure to a variety of viewpoints during study may lend itself to more successful generalisation when there is a different plane during the test phase. When the head nods, the viewpoint the face is seen from in front (FF) throughout the whole gesture; the transition is within the vertical plane.

In this experiment, different groups of participants studied faces showing the nod or the shake gesture. The plane shown at test was either the same, or different to that studied (corresponding to the change in viewpoint in the previous two experiments). The variable of "Gesture" cannot be investigated in terms of which type of gesture (nod or shake) facilitates more effective generalisation, it can only be reported in terms of the effects of the Gesture seen at Test, particularly as the distractors are only seen at test.

In Experiment Three, targets were tested using single static images of the apex of the relevant gesture: in Experiment Four they were tested with dynamic sequences showing the rotational head movements according to the experimental condition.

Methods

Participants: In both experiments, these were 32 staff or student members of the University of Stirling, aged between 17 and 37 years. In Experiment Three, there were equal numbers of males and females; in Experiment Four, there were 15 males and 17 females. There were eight participants per condition in each experiment.

Materials - Moving V Static presentation: The study phase for the nod gesture comprised a series of three frames shown from a FF plane/head-on perspective. For the moving sequences, each series of three was played seven times in the correct running order. As with the dynamic learning sequences in Experiments One and Two, the point of rotation at which the faces were first seen was randomised, to prevent any effects of initial exposure. There were two blank, black frames at the beginning and end of each face, i.e. the run of 21 frames. There was also the same two second blank screen (I.S.I.) as Experiments One and Two, during which time participants stated their 'artist/scientist' decision.

The static nodding sequence was shown in a method similar to the static study phase in the first two experiments, with each individual frame now being repeated seven times in succession; two blank, black frames separated each 'block'. The order that these blocks were shown in was designed to minimise any potential coherence of transition between them, so that the face seemed to 'jump' between each constituent, static, element of its sequence.

The shake gesture was also portrayed by a series of three frames. Instead of a full sweep (either left-to-right, or right-to-left), the head was shown carrying out only half of the sweep, i.e. from side to centre. Six independent observers judged that this was a realistic gesture (when shown using Xrastool animation at 150 m/sec per frame).

The moving and static shake sequences were produced in the same way as their nod counterparts. For the shake gesture, targets were randomly allocated a left-to-centre, or a right-to-centre sweep, and the points at which the displays started were randomised.

Materials - Test Phases: Participants in Experiment Three were tested using the Superlab application on a Mac. This showed a single static frame, which was the apex of the appropriate gesture (upwards for the nod, and the corresponding side-view for the shake) for the ten target and ten distractors.

For Experiment Four, the methodology used was similar to that in Experiment Two, i.e. using two Xrastool movies on the Sun Workstation; verbal recognition decisions were based on animated moving test sequences. These were constructed in the same way as the learning sequences used in

Experiments Three and Four. The order in which these faces were shown was maintained from Experiment Two, with six targets in the first test film, and four in the second.

Design: The 2x2x2 factorial design of this experiment examined the variable of Presentation format, either moving or static (within-subject); the effect of changing the Plane of transition between learning and test (between-subjects variable); and the variable of TG (test gesture), with the heads being seen either nodding or shaking at test (between-subjects).

Condition One: same plane-shake: This tested recognition of targets which had been studied performing a shake gesture sequence, and were tested with an image showing the apex of the shake gesture (Experiment Three) or sequence showing the (side-to-centre) shake gesture (Four). The test phase was therefore in the 'same' Plane.

Condition Two: same plane-nod: This tested recognition of targets which had been studied performing the nod gesture, and were tested with an image showing the apex of the nod gesture (Experiment Three), or the nod gesture sequence (Experiment Four). The test phase was therefore in the 'same' Plane.

Condition Three: different plane-shake: This tested recognition of targets which had been studied performing the nod gesture, and were tested with the shake gesture, either with an image of the apex (Experiment Three), or a sequence (Experiment Four), of the shake gesture, which was therefore in the 'different' Plane.

Condition Four: different plane-nod: This tested recognition of targets which had been studied performing the shake gesture, and they were tested with an image of the apex (Experiment Three), or a sequence (Experiment Four) of the nod gesture, which was therefore in the 'different' Plane.

Procedure: This was the same incidental learning situation as Experiments One and Two.

Results of Experiment Three

The mean Hit rate across all conditions was 58%: the FP rate was 26%. Table 2.4 summarises the results for each condition in the experiment.

Table 2.4

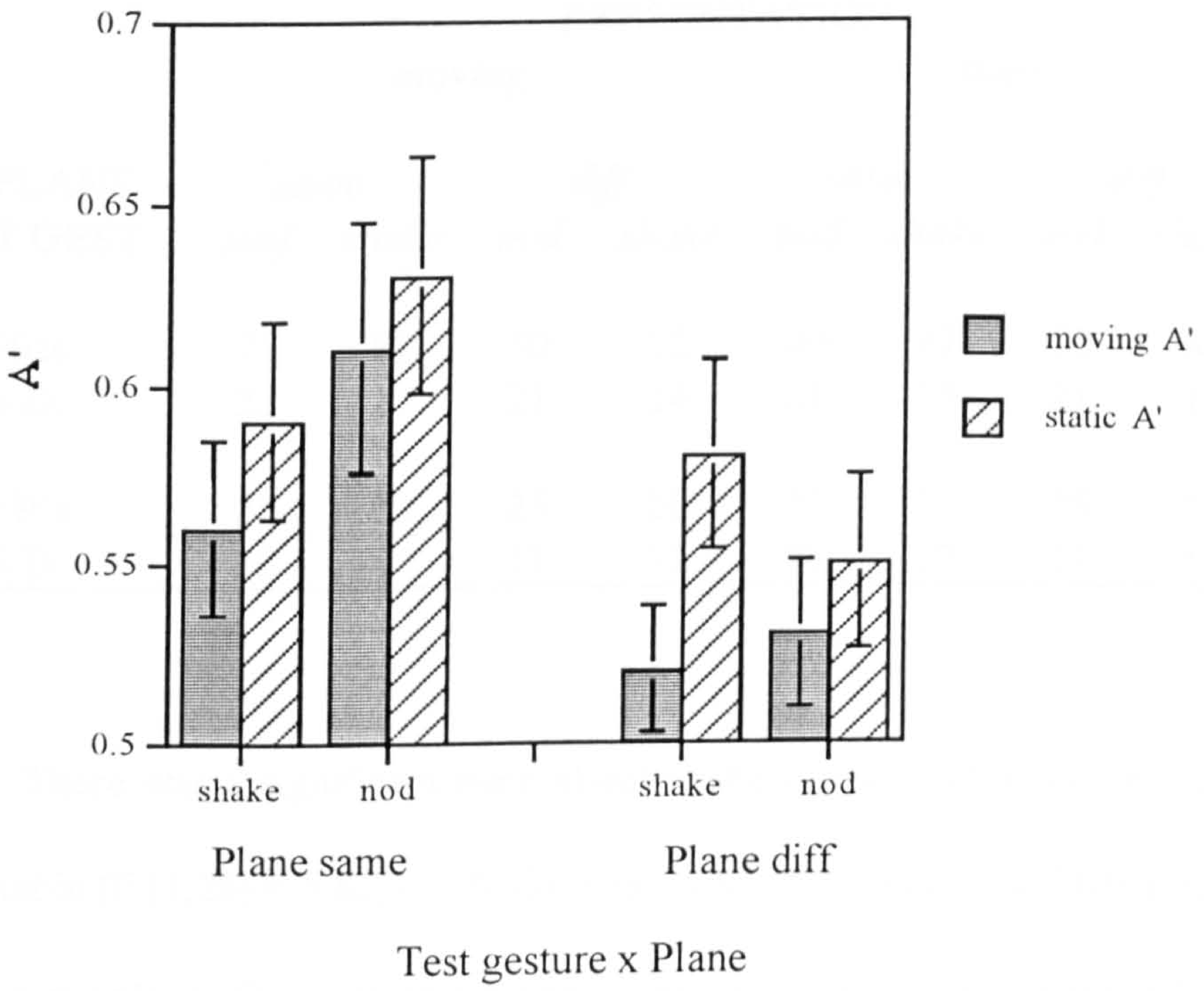
Mean percentage Hit and FP rates, with Standard Deviations (S.D.) in each of the conditions of Experiment Three (static test).

	PRESENTATION							
	moving				*static*			
PLANE	*same*		*diff*		*same*		*diff*	
T.GEST	*nod*	*shake*	*nod*	*shake*	*nod*	*shake*	*nod*	*shake*
Hits	65	55	47	37	72	72	57	60
S.D.	23	26	24	23	22	15	29	26
FP's	31	29	20	22	31	29	20	22
S.D.	14	16	8	13	14	16	8	13

(F (1,9) = 4.31, p = 0.068). There was a tendency for more FP's to be made if the Plane of rotation was different from the learning phase, but this was not significant (F (1,28) = 0.3, p > 0.5). Figure 2.3 demonstrates the significant main effect of Plane on A' (F (1,28) = 5.99, p < 0.05).

Figure 2.3.

Mean A' in each condition of Experiment Three (static test). The error bars show the standard errors



There was a main effect of Presentation format in the analysis of hit rates (F (1,28) = 8.32 p < 0.01), with more hits occurring if the face was learned from a static series. This was also found to be significant in the analysis by items (F (1,9) = 39.35, p < 0.01), and in the A' measurement (F (1,28) = 5.39, p < 0.05). No other main effects or interactions reached significance in any analysis (all F's (1,28) and (1,9) < 2.4, p's > 0.1).

Results of Experiment Four

Performance in this experiment was a little higher overall, with an average Hit rate across all conditions of 75% and an FP rate of 23%. Table 2.5 shows results obtained in each condition.

Table 2.5

Mean percentage Hit and FP rates, with Standard Deviations (S.D) in each of the conditions of Experiment Four (dynamic test).

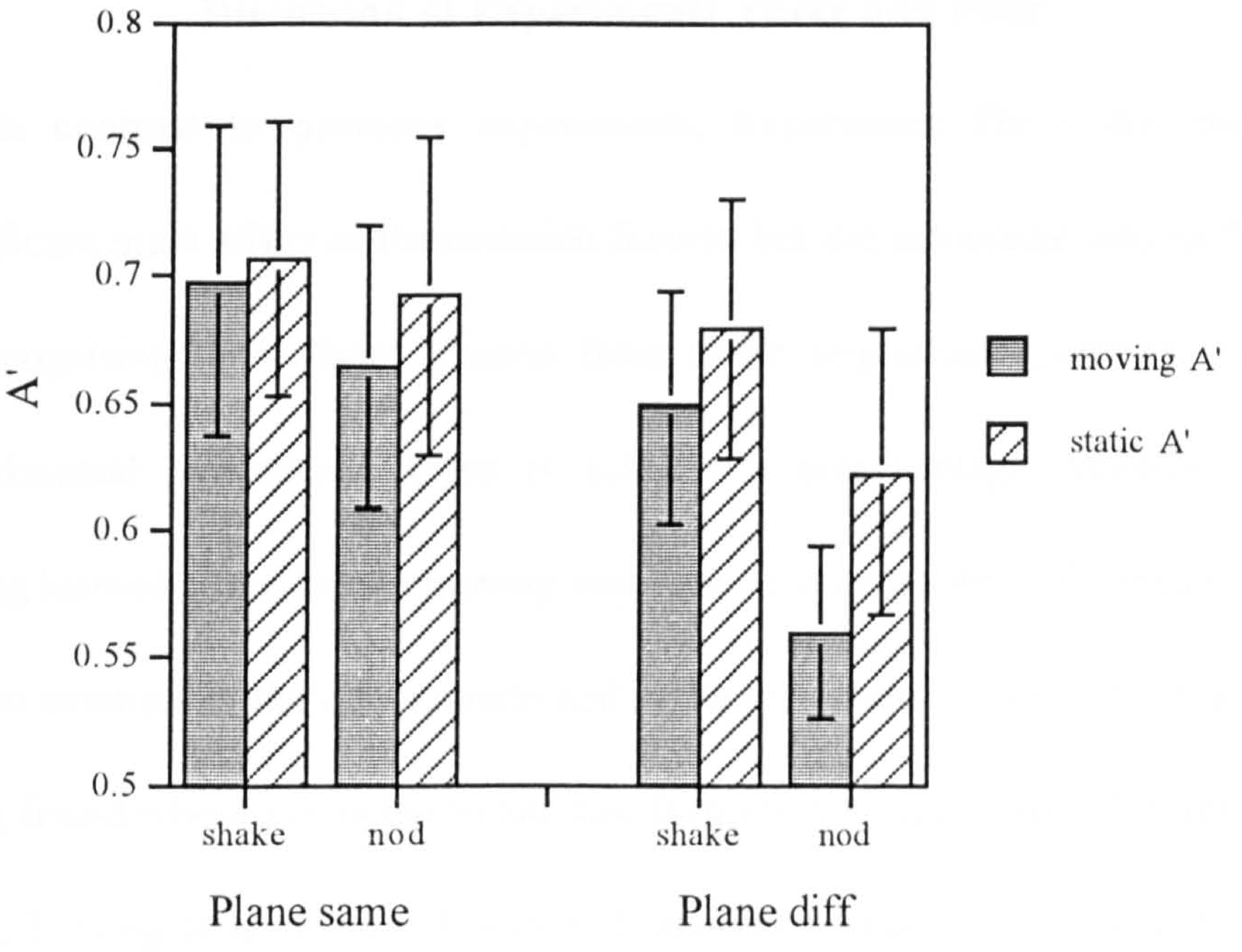
	PRESENTATION							
	moving				*static*			
PLANE	*same*		*diff*		*same*		*diff*	
T.GEST	*nod*	*shake*	*nod*	*shake*	*nod*	*shake*	*nod*	*shake*
Hits	77	82	50	72	80	87	70	80
S.D.	22	17	21	24	21	15	21	19
FP’s	25	22	25	20	25	22	25	20
S.D.	20	17	13	12	20	17	13	12

There was a significant main effect in the analysis of Hits for the Plane variable ($F(1,28) = 5.82$, $p < 0.05$), with more faces recognised when tested in the same plane; this was also found to be significant in the analysis by items ($F(1,9) = 6.44$, $p < 0.05$). The analysis of A' (Figure 2.4) reflects the same trend, but it was not significant ($F(1,28) = 1.65$, $p > 0.1$).

The variable of Presentation format approached significance, in the analysis of Hits, with a trend towards an advantage for a static learning sequence (by subjects, $F(1,28) = 4.06$, $p = 0.054$: by items, $F(1,9) = 2.92$, $p > 0.1$). However, the A' analysis showed no significant effect ($p > 0.1$).

Figure 2.4

Mean A' in each condition of Experiment Four (moving test). The error bars show the standard errors



Test gesture x Plane

The only other significant effect which arose in any of the analyses was an interaction in the items analysis between the Plane variable, and the Test Gesture (F (1,9) = 10.56, p = 0.01); this interaction just failed to reach significance in the analysis of Hits, where F (1,28) = 3.89, p = 0.058. Calculation of the Simple Main Effects of this interaction revealed a significant effect of Plane when combined with the shake Test Gesture (F (1,18) = 6.36, $p < 0.05$). There was a significant disadvantage for participants being tested with the shake gesture if they had studied the nod sequence (i.e. different plane), compared to participants who studied and were tested with the shake gesture.

There were no other main effects or interactions (all other F's (1,28) and (1,9) < 2.92, p's > 0.1).

Discussion of Experiments Three and Four

In contrast to previous experiments, Experiment Three did show a significant main effect of Presentation format, but the advantage was in favour of recognising those faces learned from static sequences. Contrary to the experimental hypothesis, there is actually a disadvantage conferred from having learned a face from a moving sequence. It may be that this result was a further example of the effect mentioned in the earlier discussion, of advantages being found where presentation and test formats correspond (e.g. Davies et al, 1978; Tulving et al, 1983). However, Experiment Four, which used dynamic test sequences, did not show the same effect, and there was still slightly better performance for the faces studied as static instances.

Within both experiments, participants were again significantly better at recognising targets within the same Plane, and a comparison between the two experiments shows that there seems to be no major differences between studying the nod (based on FF, vertical rotations), and studying the shake (based on TQ, horizontal rotations) gestures. The fact that both FF-based and TQ-based study sequences produced a similar decrease in performance when the plane was changed at test demonstrates that the large effect of changing view in Experiment One was not simply a consequence of the FF study gestures used there. What is surprising is that studying the shake sequence did not provide better performance when the test was in a different plane, as

Bruce et al (1987) had demonstrated that a 3/4 view during study produced better subsequent recognition of unfamiliar faces (in a matching paradigm). In the significant interaction between the Plane and Gesture at test variables in the analysis of items, seeing the head shake in both phases of the experiment resulted in 85% recognition rates, where the effect of seeing the head producing the nod gesture in both phases was lower, at 79% (but this was not statistically significant, with $F = 0.4$, $p > 0.1$).

Whilst Experiments Three and Four generally confirm the effects found in Experiments One and Two, where there is a decrement in performance caused by a change in viewpoint, the size of the effects seem to be less overall (for example, p's< 0.001 in the analysis of Hits in Experiments One and Two, p's < 0.023 in Experiments Three and Four). This was explored further, by a post-hoc analysis combining the results of all four experiments. As there was considerable variability within performances of each experiment (illustrated by the error bars in the A' graphs), this combined analysis should add power to the findings, and suggestions posed. It would assess the overall effects of the Presentation of learning (moving vs static), Viewpoint (same vs different) as before; it would also give the opportunity to assess the effects of type of Gesture at test (Expression from Experiments One and Two, the Test Gesture from Experiments Three and Four), and Type of test (whether the test phase was dynamic or fixed).

Combined analysis

This post-hoc meta-analysis of all participants' A' and B" performances across all four experiments was calculated using a 2x2x2x2 factor ANOVA (Presentation x Viewpoint x Gesture at test x Type of test). Attention is again drawn to the fact that in order to analyse the discrimination indices, the FP rates could only be measured for one Type of test, i.e. within each experimental test presentation; these FP rates were extrapolated to the other type of test.

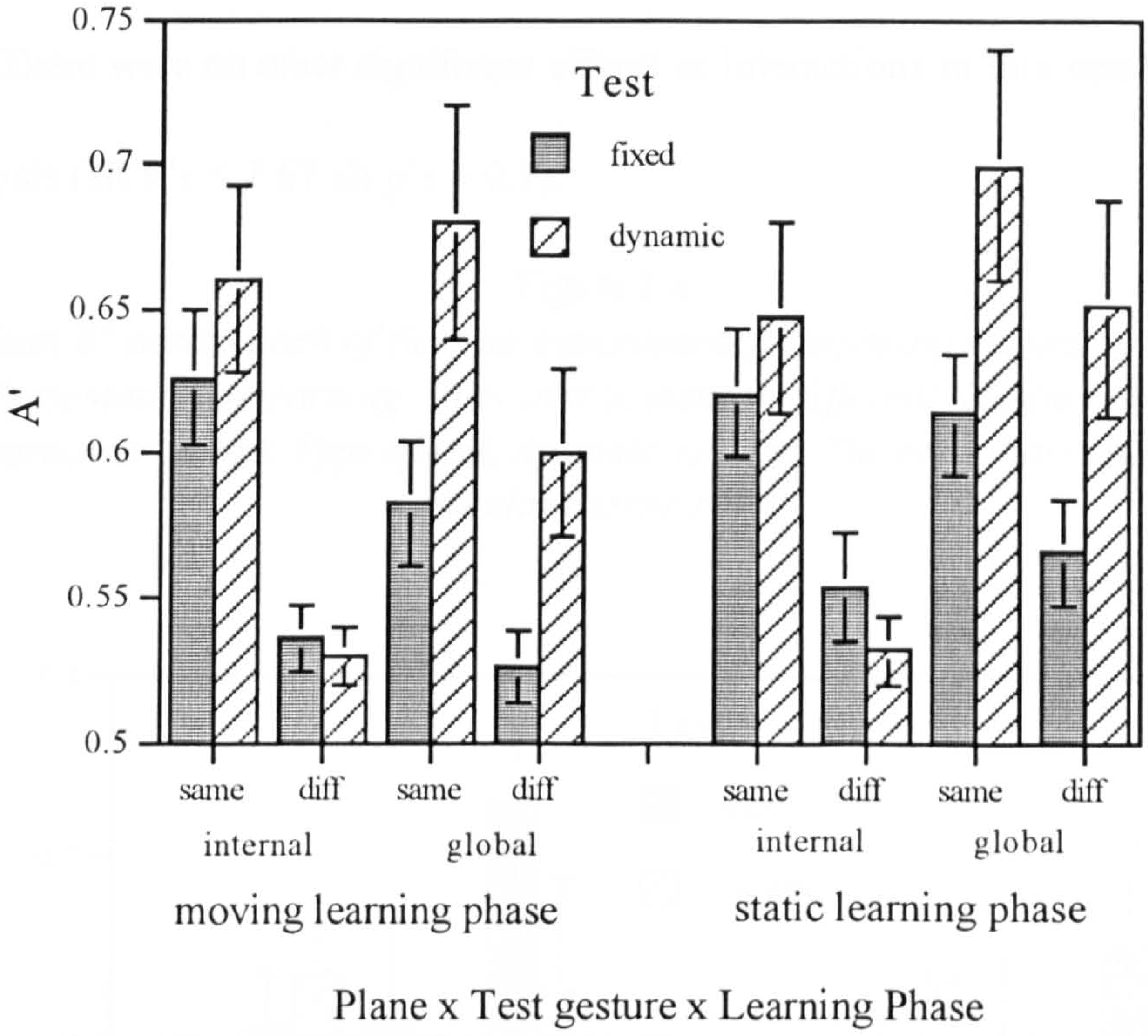
Results of combined analysis

Figure 2.5 shows mean A' scores; it illustrates that participants were significantly better at detecting targets when those faces were studied and tested within the same Viewpoint/Plane (F (1,128) = 25.78, $p < 0.01$).

There was a main effect of Type of test, with significantly higher A' when the test phase was dynamic, rather than fixed (F (1,128) = 8.94, $p < 0.01$). The effect of Presentation (studying a moving or static sequence) just failed to reach significance, with a trend for slightly better discrimination on the basis of initially studying a series of static images (F (1,128) = 3.5, p= 0.063). The effect of the Gesture at test just failed to reach significance (F (1,128) = 3.16, p = 0.078), with a trend for higher A' when participants had studied the rigid head changes, rather than internal feature changes (i.e. performance in Experiments Three and Four reflected higher A' than Experiments One and Two).

Figure 2.5

Mean A' across each of the four experiments, comparing moving vs static Presentation of learning; View at test, same vs different; Gesture at test, internal vs global; Type of test, dynamic vs fixed. The error bars show the standard error rates



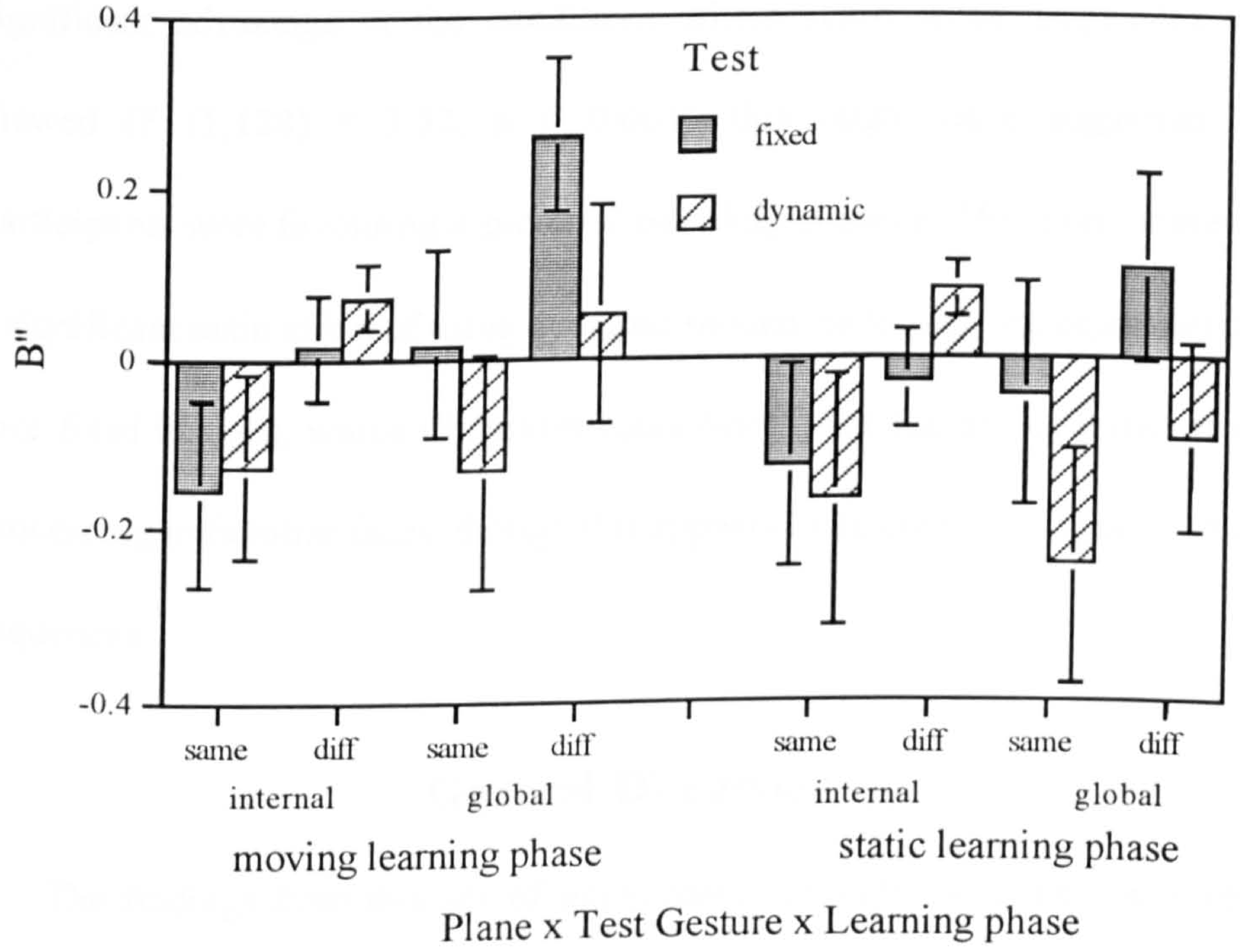
There was also a significant interaction between the Type of test and Gesture type (F (1,128) = 5.72, $p < 0.05$). Analysis of the Simple Main effects revealed that dynamic test sequences of rigid (global) head movements (i.e. Experiment Four), produced the highest recognition rates of all four experiments, and these rates were also significantly higher than fixed test sequences of rigid head movements (A' dynamic 0.66 vs 0.57 for still). When dynamic test sequences were used in testing expressive changes (in Experiment Two), there was little effect compared to recognition rates from the fixed test images (A' 0.59 dynamic vs 0.58 for still). The interaction between

Presentation and Gesture at test tended towards significance, with F (1,128) =3.51, p= 0.063. The trend was for slightly higher A' to be found in the cases where rigid gestures were used at test (global head movements rather than internal gestures) in both the moving and static study conditions.

There were no other significant effects or interactions in this combined A' analysis (all F's < 1.67 all p's > 0.1).

Figure 2.6

Mean B" across each of the four experiments, comparing moving vs static Presentation of learning; View at test, same vs different; Gesture at test, internal vs global; Type of test, dynamic vs fixed. The error bars show the standard error rates



In this B" analysis, there was a main effect of Viewpoint, with participants being more biased to signal when the test phase was in the same

Plane (B" same = -0.12 vs. different +0.05, i.e. bias to noise) (F (1,128) = 8.48, $p < 0.01$). This is illustrated in Figure 2.6.

There were no other significant main effects or interactions in the combined B" analysis (all F's (1,128) < 3.68, $p > 0.05$)

Discussion of meta-analysis

This post-hoc investigation of results highlights the significant decrement in participants' performance (A') when the faces are tested in a different viewpoint/plane from the one they were originally studied in. Although there was no main effect of presentation during the study phase; there was a near significant advantage in the conditions where static study sequences were viewed (F (1,128) = 3.52, p = 0.063); this might have suggested that participants were favouring a pictorial encoding strategy. However, there was a significant main effect of using dynamic sequences to test the representation (not fixed images), which illustrates some benefit for the use of movement in processing unfamiliar faces, though this appears to be confined to the rigid test sequences.

General Discussion

The findings from this set of experiments provide evidence that motion per se is not an important factor in establishing representations for unfamiliar faces. Throughout the experimental series, the trends tended to favour recognition following a study phase comprising a series of static instances (as revealed in analyses of hit rates in three of the experiments, as well as the trend in the combined analysis of A'). In contrast, Pike (1994), mentioned earlier had found a significant advantage for using movement (a video sequence) in the study of unfamiliar faces rotated in depth: his test used a single (static) photograph. He suggested that movement, as opposed to static sequences, helped in building up a 3D representation, based on shape from shading details. Experiments Three and Four presented in this Chapter used a similar type of gesture (the shake sequence), but unlike Pike, an advantage was found (significant in Experiment Three) for a static learning phase. In view of other issues discussed in this chapter, Pike's results may now be interpreted as being due to an increased information content inherent in his moving condition.

However, there is a basic disadvantage in using the methodology employed in Experiments One to Four: in order to equate the information-content of the static and dynamic study sequences, very parsimonious displays had to be used (particularly only three frames showing the rotational changes in Experiments Three and Four). As each of these frames could be examined and scanned for about a second in the static presentation condition, this may have encouraged a "pictorial" encoding. Indeed, the black frames that were inserted between each block of static images may have encouraged the use of a picture-specific, instance based strategy, allowing each block to be processed separately (as different individuals, perhaps).

If, as Davies et al (1978) and Tulving et al (1983) suggest, there is some 'event-specificity', where recognition is facilitated by reinstating encoding events during retrieval, then this could also be used to explain the findings of Experiment Three. However, it is not clear why the effect of presentation format is not significantly reversed in favour of motion in Experiment Four, when both phases of the experiment comprise dynamic sequences (thereby reinstating the "event"/context of learning at test). Alternatively, there may have been *too little* change between each of the static frames (instances), and the close proximity of spatial and temporal information may have afforded the *same* sort of facilitation of *generalising* from the static training phase as from the moving sequences (as perhaps Wallis and colleagues might suggest occurred, e.g. Wallis and Rolls, 1997).

In addition to the options already offered concerning where the benefits for motion might lie, there are other issues which need to be addressed when trying to explain the effects found, such as those arising from the use of parsimonious displays during learning. One problem is that they might provide insufficient grounds for extracting invariants, or too little diversity within the sample to determine any individual modes of gesturing. In other words, more fundamental aspects of movement may have been lost, as there was no opportunity to sample more naturally occurring changes, such as articulatory gestures made during speech, or an unconstrained expression, e.g. a genuine smile. Even though independent judges had reported that the moving sequences seemed to represent a coherent progression, perhaps the something 'extra' that dynamic production seems to convey may have been missing. Secondly, it has already been pointed out that most three-second moving sequences displayed as video footage usually show approximately 100 frames; here only 20 or 21 were used. Nonetheless, it should be acknowledged that attempts to equate (yet minimise) static and dynamic information content, whilst preserving realistic moving sequences, have their own limitations. It is unlikely that a three second video sequence showing 100 randomly-presented static clips would be perceived as just that, without any effects of apparent motion. Either the rate at which the frames were shown would be too quick to prevent that occurring, or the footage may simply look disjointed. This might interfere with the ability to extract anything useful from the rapid succession of static images.

All experiments showed a decrement in performance (Hit rates) when the faces were tested from a different viewpoint ("View" in Experiments One and Two; "Plane" in Experiments Three and Four). The main effect of the Viewpoint/Plane variable in the combined analysis of A' and B" was evidence that participants were significantly less accurate in their decisions when faces were tested from a different view/plane. In terms of both Hit rates and discriminability, this effect was irrespective of whether the changes being studied were of an internal nature, arising as the facial expression changed, or if they were rotations of the whole head in depth. The experimental hypothesis postulated that a face learned via a moving sequence should have provided additional information (over-and-above that given in a sequence of static instances) about the 3D structure of the face. The lack of such an effect has important implications, as it shows that even when the study conditions most favour the construction of a 3D representation of the face, by sampling rotations of the head in depth (i.e. in the last two experiments), there is still limited generalisation to a different Plane/viewpoint.

This inability to generalise outside of the 'experienced range' across viewpoints is in disparity with the findings of Wallis (e.g. Wallis and Rolls, 1997); it also contrasts with an ability to generalise outside the 'experienced range' but within viewpoints found in Experiments One and Two. There was no significant effect of changing Expression between study and test here, showing that experiencing one type of expressive change (the "smile-to-sad" transition) did allow for generalisation within the same plane to a new facial expression (the "ooh" speech gesture). Contrary to the experimental hypothesis, this facilitation occurred equally for moving and static study sequences. The use of moving sequences at study and/or test does not facilitate the extraction of invariants of previously unfamiliar faces any more than does a series of static instances, providing the amounts of information in each of the types of presentation are equal. This may have been due to the static instances being within legitimate spatial and temporal parameters to constitute the same type of description as the moving sequence. More extreme variations (e.g. an exaggerated apex) may have prevented this occurring, but it is possible that such image sequences would not have provided the same perception of smooth facial action when animated in the correct order.

Therefore, it would seem that in learning unfamiliar faces, a viewpoint-specific representation is formed in memory: it appears to tolerate changes in expression, provided that a range of internal feature expressive changes have been studied. This is in accordance with the Bruce and Young model (1986) discussed earlier, where the structural encoding process results in a viewpoint-dependent representation, which is independent of facial expression; it is also consistent with the results of Bruce (1994), and Cabeza et al (1996), where seeing slight variations in a face enables extraction of the underlying prototype within viewpoints, but not between.

In this series of experiments, it seems that the information provided by multiple instances of unfamiliar faces allows for poor generalisation to novel viewpoints. When our viewpoint of someone changes, this affects the sorts of information available for analysis, and also the assessment of a match with the stored representation. If multiple instances (with, or without movement) actually afforded the establishment of a 3D model (representation of the face), it is difficult to understand why generalisation to a different viewpoint of that same model (face) is so poor.

Recent research on 3D object recognition (e.g. Bulthoff and Edelman, 1992) suggests that the visual system represents and recognises objects using 2D view approximations (or multiple viewpoints), and not 3D representations. As such, moving images would be matched against a series of stored viewpoints. The results of the experiments described here are consistent with a similar "viewpoint-sensitive" description, with hit rates being worse for conditions where the view at test is most unlike the one studied. Perhaps it is the case for faces that multiple instances only facilitate the extraction of invariants within the same plane, for there is little decrement in recognition performance when the expression is different to the one studied. Recognition of (unfamiliar) faces seems to occur only when most aspects of the image at test are closest to their stored representation, hence changes within the same viewpoint can be tolerated, but not changes between viewpoints. This may be because the degree of overlap between the trajectory descriptions of the study and test stimuli in different planes is too small to be accepted as being derived from the same face.

However, what these experiments do suggest is that there may be benefits in using dynamic sequences to test unfamiliar face recognition. Schiff et al (1986) also found advantages for testing unfamiliar faces using moving sequences, rather than a static image. In their experiments, recognition rates were best when a moving sequence showing different viewpoints of the face were seen; this condition was achieved by shifting the location of the camera around the head. The meta-analysis of the first four experiments reported in this thesis showed the same advantage for a moving test sequence (Presentation at test) in the overall in A' measurements. There was also a significant interaction between Presentation at test and Gesture at test, which showed significantly higher recognition rates when a dynamic test portrayed rigid head rotations. This may be because the rigid head rotations gave rise to a representation based on structural invariants, which would facilitate some generalisation at test, or because the test sequence provided a greater overlap of cues with the stored representation. Alternatively, motion at test may simply provide more information. In either case, motion at test may favour access to a representation using a more essential description of the 'dynamics', i.e. how a face might be able to move; however, part of the advantage for motion may also be due to the provision of more instances to sample. This issue cannot be resolved on the basis of these results, as there was no attempt made to equate the information content of the static and dynamic test sequences.

If movement is not important in constructing the representation in memory of an unfamiliar face for the purposes of recognition, but it is important in accessing it, then perhaps movement may be shown to be beneficial in another method which taps facial descriptions, i.e. in a matching task. Experiments in the next chapter examine the role of dynamic information in matching the identities of unfamiliar faces, and also in matching the expressions shown. As the Introductory chapter discussed, where matches are made on the basis of emotional expression, then dynamic information may be beneficial in completing the task compared with the cues given by static images; where matches for identity are required, there is no predicted advantage from the use of moving sequences.

Examples of Images

Smile - Sad gesture as seen in Experiments One and Two.

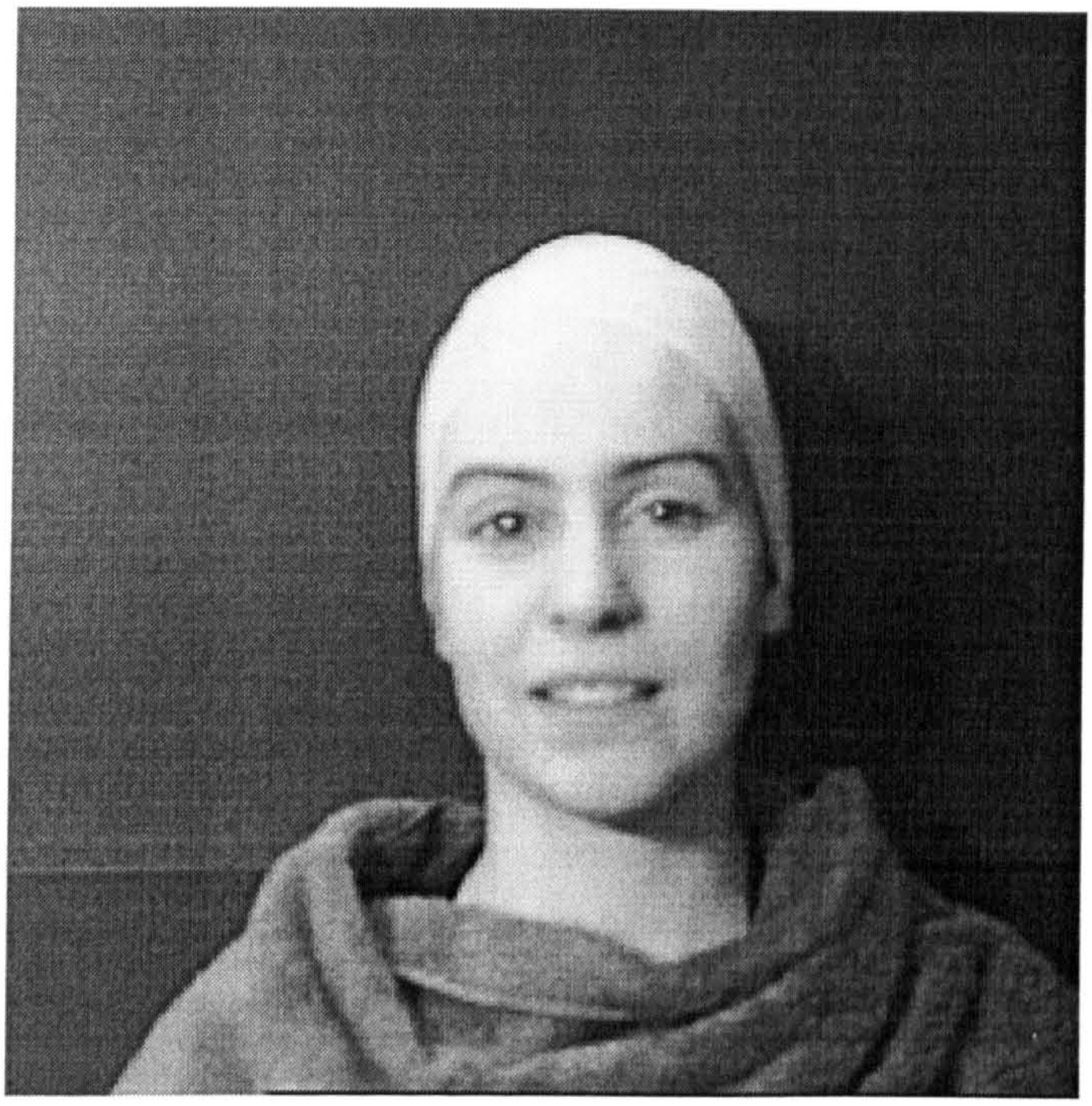
Dynamic sequences = 2 blank frames, then 4 cycles, running through frames 1-5 in correct order, then 2 blank frames

e.g. blank blank 12345 12345 12345 12345 blank blank

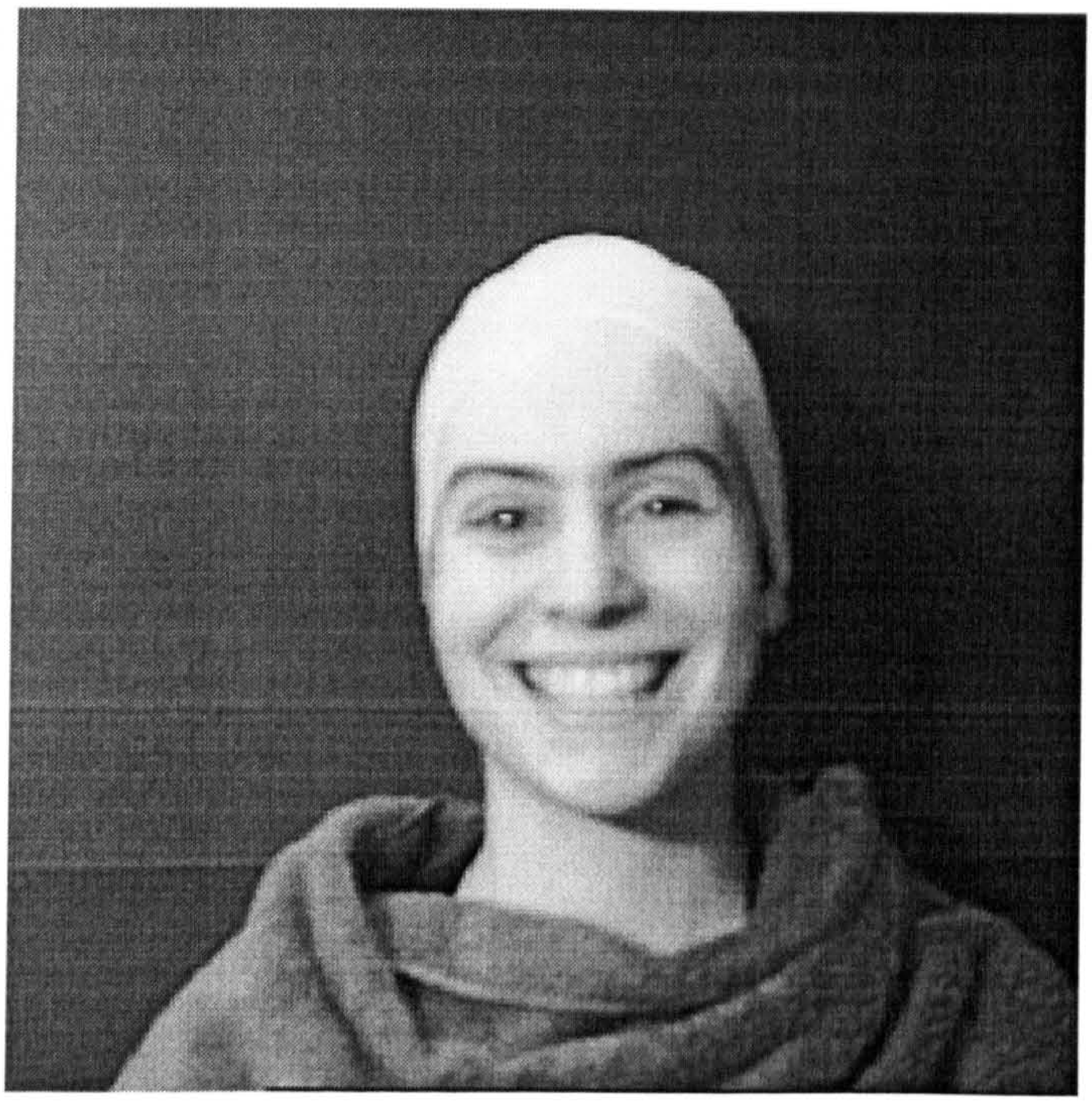
Static sequences = each frame repeated 4 times in random order, with blank inserted after each block

e.g. 2222 blank 4444 blank 1111 blank 5555 blank 3333

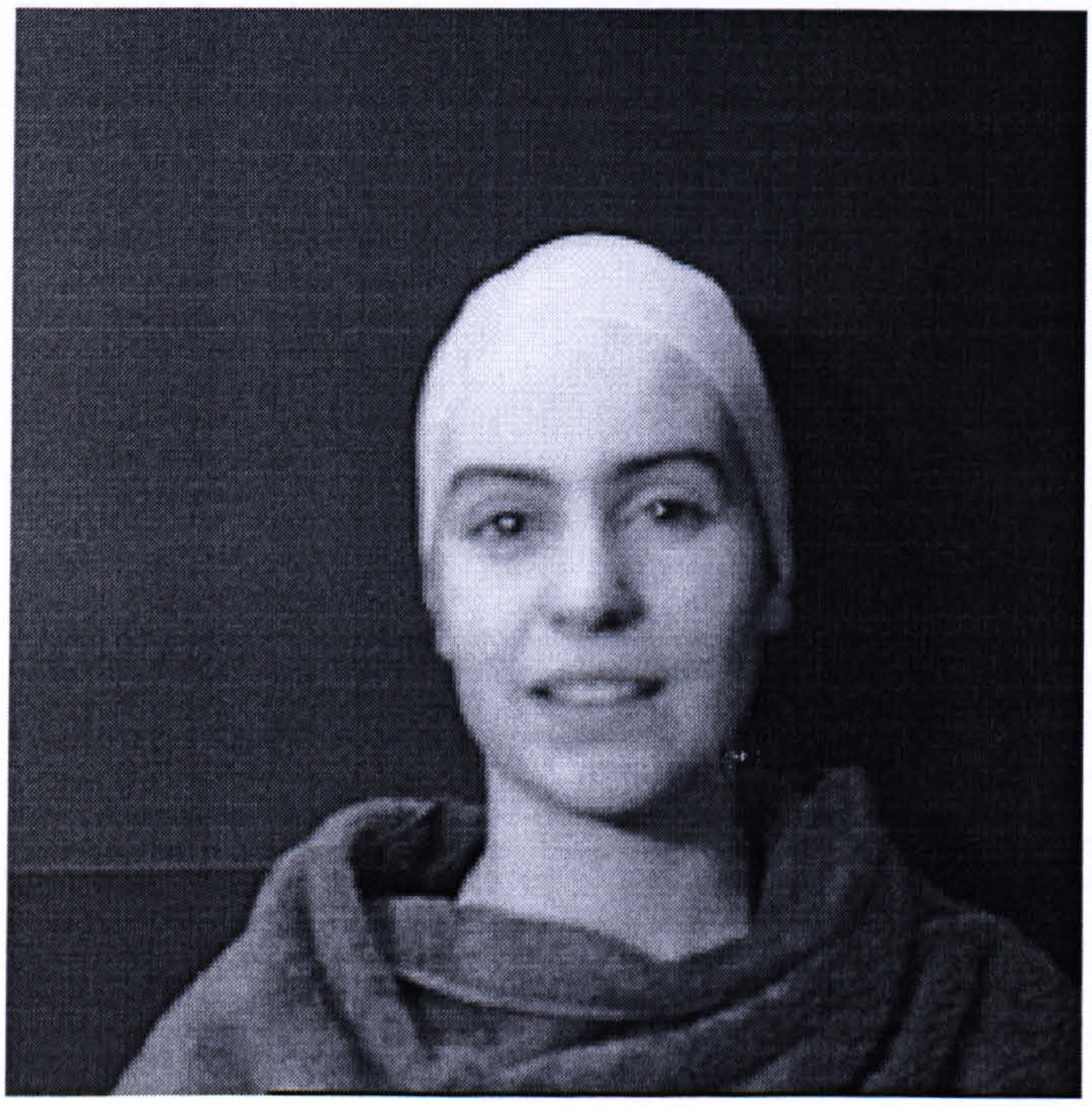
Frame One



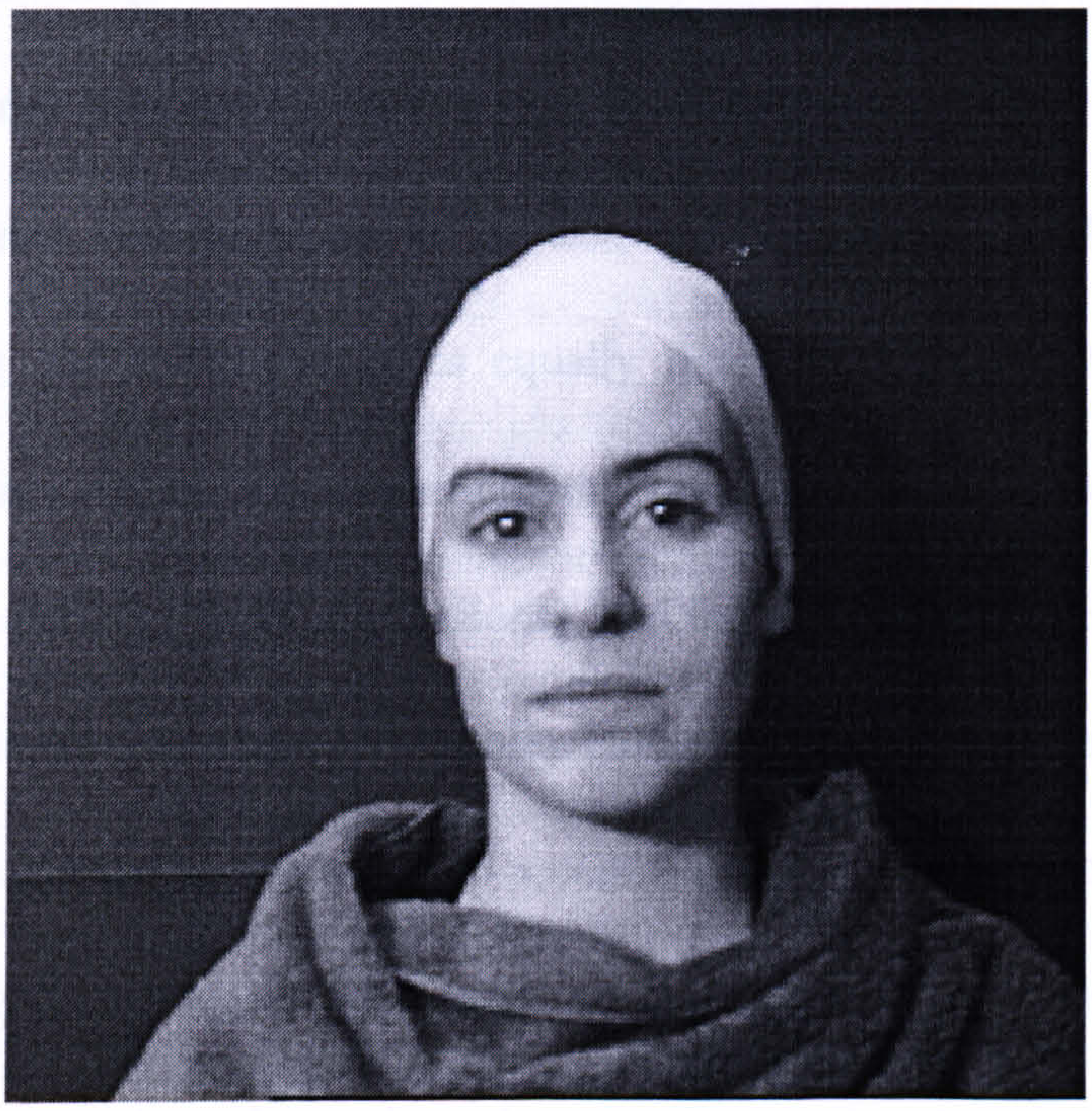
Frame Two



Frame Three



Frame Four



Frame Five

Chapter Three

Matching Unfamiliar Faces

Introduction

The previous chapter looked at the role of movement in building up a representation in memory for a previously unknown face. It had been hypothesised that studying moving sequences might facilitate the extraction of invariants; this would (potentially) allow for the face to be recognised outside the range in which it had initially been experienced. However, there was no such advantage to be found from studying the faces in moving sequences, compared with static instances. In terms of reconciling what had been studied with what was being shown at test, the representations built up by both moving and static sequences equally facilitated the extraction of 'internal' invariants (which led to participants being able to recognise the same faces posing different facial expressions), and both were equally poor at facilitating generalisation to a novel viewpoint. However, there was a significant advantage for using dynamic sequences to access (i.e. test) the representation, in terms of (on average) a higher discrimination measurement (A'). The source of this benefit may have been through a greater overlap between study and test representations and descriptions, where the dynamic test may have provided a more general description of the face; or, it may have been because of the extraction of invariants, which facilitated more successful access to the stored representation.

This chapter aims to assess the role of movement in the processing of unfamiliar faces under a different type of methodology, that of matching. A face can be matched on a variety of criteria apart from identity, such as age, or expression, and as the Introductory chapter outlined, it has been found that these aspects can be processed independent of identity. As the studies in the previous experimental chapter seemed to show no additional benefit in viewing moving sequences (compared to static information) in order to establish a representation of an unfamiliar face in memory, it may similarly confer no beneficial processing during matching of unfamiliar faces for identity. Instead, it may be the case that this task can be achieved by using a more instance-based strategy; performance is expected to be quite low, especially in trials where there are conflicting gesture elements, but where the identity is the same. In contrast, movement might be more useful in a task involving matching faces on the basis of the emotional expressions shown, because each element in the trial can be categorised as a particular type of gesture, as the dynamic production of the expression reveals less misleading cues. Where static elements are to be matched on the basis of expression, there may be several alternative labels which could apply equally to either element, and so performance in these trials would be more error-prone.

Matching

There is a variety of measures on which familiar and unfamiliar faces can be matched, such as gender, age, lip-read speech, and emotional expression (e.g. Young, Newcombe, de Haan, Small and Hay, 1993): the processing of each of these attributes has been shown to be independent of recognition and other types of face processing. The evidence comes from neuropsychological patients, as well as normal participants. Other studies have shown that both matching task and the processing leading to recognition can be similarly affected by a variety of modifications; these include differences in viewpoint (e.g. Bruce et al, 1987; Logie et al, 1987), or format, such as filtered or inverted images (e.g. Kemp, McManus and Pigott, 1990). The ability to match faces across experimental manipulations on the basis of gender, expression, or any other criteria does not require participants to actually know the faces involved, because, unlike recognition, the strategies involved in this task may be as simple as discriminating on the basis of shape (Bruce and Young 1986). Such discrimination is an element of recognition, but the processes underlying it need not rely upon access to a stored representation in memory in order to be achieved.

The following experiments investigate the contribution of dynamic information to the task of matching. If movement per se is not important for establishing the initial representation of a new face (details which may be important for subsequent recognition), then perhaps it may be significant for other processing tasks, such as making a comparison (matching) between elements of the face which are displaying emotional expressions. Movement may provide specific information about the timing and the amount by which certain features are displaced in a given emotional display, and this dynamic information might lead to better discrimination between elements than would a static presentation. For example, the amount by which the upper cheeks rise in a smile may be related to how fast and how high the corners of the mouth are turned. This would lead to an alteration in the area around the eyes, and the sorts of movement associated with the eyes narrowing due to smiling may be different to the movements seen in this area when they narrow in anger. If (as the previous four experiments suggest) movement is not preferentially involved in processing the identity of unfamiliar faces, and this tends to be carried out using a picture-matching strategy, then it is not expected to be of particular benefit if the task involves matching on the basis of identity. If movement is beneficial in the analysis of emotional expression, then performance on a dynamic expression-matching task should be more accurate than using static instances

This possibility was tested in experiments where participants were required to judge if either the *expression* or the *identity* of two halves of a face matched, or mismatched when shown as static or moving displays. The static condition showed only the apex of the expression; with less information about the events leading up to the onset, one would expect more incorrect expression-matching decisions. There was no predicted advantage for motion in the identity-matching trials, as the faces were unfamiliar; indeed, it was predicted that the levels of performance in this task would be significantly lower than in the expression-matching groups.

Methodological Issues

There are several methodologies that can be employed in the presentation of stimuli in a matching task, and there now follows a brief discussion of factors which influenced the actual procedure used.

Simultaneous vs Sequential Presentation: If the two items are shown on the screen simultaneously (e.g. using a split screen), then visual processing can be assessed independent of a load on memory. However, such a strategy could result in the decision being purely pictorial in nature, which may undermine the fundamental contribution of other, more structural, dimensions which may be relevant to the 'match' (such as a different facial expression, or identity). This may lead to an incorrect termination of the processes of comparison underlying matching.

A different type of problem in using a simultaneous matching technique was shown by Young, Hellawell and Hay (1987). When sections of a face were shown to participants, they were unable to isolate the processing of, or attention to, the top and bottom halves of faces when these parts were shown simultaneously. When faces were divided along a horizontal line, presented simultaneously, and when these two portions were aligned, they tended to process the two as comprising a complete, whole face rather than re-directing, or changing, their normal processing to analyse the two elements separately. If the two elements were upright, but off-set, or not aligned, participants did not process them as if they seemed to form a new 'whole'.

They could name the two constituent halves more quickly and accurately than those aligned upright composite faces.

Young et al (1987) suggested this method of presentation tended to encourage a 'facial Gestalt' effect: the parts seemed to form a new identity. One would expect this to arise if the faces were unfamiliar, when participants do not know the true appearance of that person, but Young et al (1987) found the effect when the top and bottom halves were of familiar faces. Participants could not tease out (and therefore identify) the constituent elements of familiar faces, and there was the perception of a new configuration, which was that of an unfamiliar person. However, when these composites were inverted, then participants seemed able to overcome this 'Gestalt' effect, and they could correctly name the two people involved in the same picture.

Young et al (1987) proposed that the upright aligned composites initiated some sort of automatic processing, causing the parts to be experienced as the configuration of a new person. Hole (1994) argued that these findings were possibly due to the nature of the task that participants were undertaking, and that it was not that participants could not (under different circumstances) differentially process the two upright elements independently. He suggested that the task demands of Young et al's experiment encouraged this sort of holistic analysis, because the process of naming and identification normally require identification of the whole face, not the separation of the face into constituent parts, or individual features.

Therefore, when using parts of faces in matching tasks, in order to segregate the processing of these elements, and also minimise pictorial strategies being used, an alternative method of sequential matching can be employed. This involves the target (item-to-match) item being shown first, this element is then replaced by the second item/s-to-be-matched. Showing each half sequentially gives participants a chance to scan each part separately, although this does also place some load on memory.

The task itself can involve a single forced-choice decision to be made to the second stimulus ("Is this item the same as the one just seen?"), or the methodology could involve multiple-choice decisions ("Which of these faces is the same as the one just presented?"). Sequential matching tasks may rely on visual memory for a match to be perceived, or they may depend upon some other form of short-term store that is not simply image-based. This store may, instead, depend on a more abstract level of description; this might involve holding on to categorical information, that, e.g. the first element was 'a female' rather than retaining the actual picture in memory. Alternatively, it could store the opinion that the face 'looked angry', rather than the representation of the visual information showing that the brows were furrowed, etc. In such instances, it may be that moving sequences lead to better performance, as they may allow a more abstract representation to be accessed, which would reduce the load on actual visual memory.

In order to carry out the self-terminating search for differences, or to ensure that all relevant aspects of the second stimulus matched, the original image needs to be held on to long enough for the decision/ or reconciliation process to be completed (Humphreys and Bruce, 1989). If pictorial strategies cannot be used (e.g. when matching using different viewpoints), then there would have to be another type of processing involved. This abstract description might be based on a visual 3D representation (in which case there could be potential advantages in seeing dynamic sequences), or it might be based on an emotional expression category label.

Factors affecting choice of elements to be matched: Most matching experiments tend to use full-face or head-and-shoulder stimuli, but the task can also be carried out using halves of faces; these can be divided horizontally or vertically. The first of those would divide the face into top and bottom halves, using some line below the eye area: this retains the 'consistency' or symmetry of the face. A vertical division is usually along the length of the nose, but this type of presentation is problematic for several reasons. For example, each side of the face is not transformed by identical amounts of muscle movements when producing facial expressions (either naturally, i.e. spontaneous, or posed), or when talking. The left side of the face is consistently judged as being more expressive, which may be due to right hemisphere dominance in the processing of emotion (e.g. Hager and Ekman, 1985). More importantly, it may be the case that the detection of mis-matches between different expressions or identities may be too easy when using vertically divided faces, and so the performance by participants in either group could be at ceiling.

The Present Studies

In this next set of experiments, it was decided that the faces would be divided along a horizontal line, to make the matching task more difficult than a vertical division would. As discussed earlier, the processing undertaken in simultaneous matching may lead to the two halves being analysed as a composite ('Gestalt' effect). In order to avoid this, and also possible ceiling effects (which may arise from a strategy based purely on shape information), each of the elements was shown alone.

The prediction is that there will be an advantage for using moving displays for expression matches, as the dynamics may be more informative about the gesture being produced than would the static apex. For example, the way that the eyes wrinkle at the corners may give an indication of what type expression is being posed in the bottom half of the face. Such cues presented in a static image would be ambiguous (i.e. they could be showing a smile, anger or disgust). A dynamic sequence may provide cues in the build-up to that apex, which would clarify the gesture. This should lead to a more successful analysis of each part, and hence better detection of a match. In contrast, there is no predicted benefit for the use of motion in a task involving matching the identities of unfamiliar faces, on the basis of the results of Experiments One to Four.

Experiment Five

In Experiments Five and Six, the matching of sequentially presented halves of faces was studied. The emphasis here is on the participants' ability to judge a likeness between two sub-sets of details, or even extrapolate from the information given in the first part to a set of details about a different area of the face in the second element of the trial. Participants in one experimental group were required to match the elements in blocks of trials according to whether they showed the same person. As unfamiliar faces were being used, the task could not be achieved by referring to a stored representation to compare the two elements with. There may therefore be limited ability to generate a mental representation of what the other half might be, in order to decide if it would constitute a good 'match' (using some process of extrapolation). As only one half is presented at a time, it may be that resolving their respective identities proves to be almost impossible.

Of interest to this thesis was whether motion would be beneficial in this difficult process, perhaps by providing cues to the underlying structure. However, as only half of each actor's face was presented at a time, even if movement did provide some cues to the underlying structure, or even if the dynamic sequence generated some generalised description, the amount of extrapolation from this description to the other half of the face would be very limited. Furthermore, the first four experiments might lead one to conclude that there would be no advantage in using moving sequences for any type of task relating to the processing of the identity of unfamiliar faces. There is no pre-existing representation in memory of either their facial 3D structure, idiosyncratic patterns of dynamic change, nor could the dynamic sequences be useful in providing an overlap of trajectory descriptions.

In the other experimental group, participants saw identical blocks of trials, but had to match them on the basis of expression; the prediction was that there would be more correct matches in the expression task group than in the identity-match condition, as this task can be achieved using more abstract processing. The reason proposed is that the participants will have a representation in memory of an angry face (a prototypical expression), and that they would evaluate/compare each of the two halves with reference to that description, and not necessarily just make the comparison between each constituent part. This type of analysis may, therefore, be more effective for expression-matching, as participants may be assessing such factors as, for example, “That mouth was Happy: are these eyes Happy?”. The further prediction is that expression matching may be assisted when the two halves are shown in motion, compared with a static presentation.

To conclude, the predictions were that significantly more faces would be correctly matched on the basis of expression than those matched on the basis of identity. In addition to this, movement was expected to be more effective for expression matching than it would be for identity matching.

Method

Participants: These were 48 students (26 female, 22 male), aged between 25 and 58. They had normal, or corrected to normal, vision. They were attending the D309 Cognitive psychology module of the Open University Summer School, held at the University of Stirling in 1995.

Materials: Films were taken of ten of the experimenter's colleagues, aged between 22 and 26. These people would not have been familiar to the participants. The actors were instructed to pose a variety of facial expressions, and were seated approximately 0.5 metres way from a Sony Hi-8 camera. They were filmed from the front (full-face) against a black background. There were three sources of lighting (overhead; from in front, i.e. behind the camera, and to the left of the camera); the overall pattern of illumination appeared uniform. The actors were wearing black bathing caps, eliminating cues to identity being derived from their hairstyles, but this in turn would accentuate the shape of the face, as well as focus the attention of the participants onto the internal features.

The actors were first requested to produce a series of facial expressions, each time starting from a neutral pose. They were to progress naturally to the facial gesture they felt to be representative of the following emotions: happy; surprise; fear; anger; sadness, and disgust. These first sets of gestures were called "non-instructed". They were then given a series of instructions to generate those same emotional displays. For example, for anger, they would be told to "Bring your eyebrows down and together in the middle, as if frowning. Open your eyes wide, and flare your nostrils. Purse your lips. Now, try and put those all together, starting from the neutral position". The instructions were based on Kearney's machine interpretation of emotion (1993) (see Appendix Two).

The Hi-8 film was edited onto a VHS tape comprising the moving-instructed and non-instructed expressions, as well as a selection of (moving) spontaneous expressions that were elicited as part of the general filming session. During this editing, it was found that most of the expressive sequences (from neutral to the apex) lasted approximately one and a half seconds, irrespective of the type and nature of the gesture (instructed, non-instructed, or spontaneous). A total of 47 gestures were chosen by the experimenter as being the best exemplars from the whole sitting (i.e. for some actors, there was more than one expression chosen).

These 47 clips were copied in an arbitrary order onto another VHS tape, with a ten second gap inserted between each. This tape was then shown to ten colleagues of the experimenter (not those used in filming) for verification of the type of gesture purportedly represented in the sequence. These colleagues were given a list of the six expressions used in the filming, and asked to name each of the expressions they saw. They also had to rate how typical the exemplar was (good, average, or unclear), during the ten second gap. This resulted in 27 items being judged as good examples of a particular emotion by at least eight out of the ten viewers (four exemplars each of Happy and Sad; five Fear; six Angry, and eight Disgust). Each of the ten actors was chosen as an 'illustrator' at least once.

In order to fully counterbalance a range of criteria (see below for details), it was decided that 20 of these items would be used, with four examples of each gesture. The full-face moving sequences of these 20 expressions were copied onto another VHS video. For the experiment, the full-face static counterparts of these were made by selecting the apex of the expression, and recording it onto another tape as a freeze-frame for the same duration as the moving sequence (about one and a half seconds).

The moving and static films were to be used to investigate both experimental variables, i.e. the same films of these pairs of elements would be matched by different groups for identity or expression. These 20, full-face stimuli (moving and static) were then split into top and bottom halves, to be transformed into the experimental items. The division of each face was horizontal, across the mid-length of the nose. Each element was shown in its correct spatial location (upper, or lower part of the TV screen). When the expression was 'Happy' for example, the upper part of the TV screen would show the 'top' element, with the upper cheeks, above the tip of the nose, and the wrinkling folds around the eyes being visible. The bottom half would show the lower area of the cheeks, and the tip of the nose (i.e. without details of the eye area wrinkling), and part of the neck was also visible (see pp 138-141 for examples).

Some of the actors had been filmed slightly off-centre, and in order to prevent the possibility of participants using a spatial-matching strategy (involving the relative positions of the elements' location to the left or right of the screen), the 'tops' and 'bottoms' were arbitrarily shifted to the left or the right of their original position on the screen by between 0.5cm and 1.5cm. Both the division of the face into two halves, plus their horizontal re-location were achieved using the 'wipe pattern' facility on a Panasonic Video Editing Suite. The 'wipe mix effect' system was also utilised, which left the rest of the frame as black, above or below the element selected.

The order in which the twenty pairs of stimuli were to be shown was arbitrarily assigned, and maintained for both types of presentation. Each top and bottom element was spliced into its relevant position on the test video, with one element of the pair immediately following its counterpart (no gaps). There was a blank screen for five seconds between each pair, for participants to make their verbal decisions.

Design: This experiment used a 2x2x2x2 factorial design: the first variable was Task, where participants were either matching for expression (*EXPM*) or identity (*IDM*) (between-subject variable). The second variable was Presentation format, where participants made their decisions based on either *moving* or *static* pairs of elements (between-subject variable). The third variable manipulated was Gesture, which refers to the status of the expression shown in the two halves (*gs*, gesture same, or *gd* gesture different) (within-subject variable). Finally, the variable of Person refers to the status of the identity of the actor shown in the two halves (*ps* person same, or *pd* person different) (within-subject variable).

Counterbalancing: There were no cross-gender matches, nor were there any two elements which were always paired together, as this may have resulted in a predictive strategy (such as "the smiling face elements are always seen with the surprise face elements"; or "the square chin is always seen with the freckled eye area").

Four different presentation sequences were constructed: A (both identity and expression match, or "person same, gesture same": this is now denoted as *ps gs*); B (person same, but gesture different: *ps gd*): C (person different, but gesture same: *pd gs*): D (both person and gesture different: *pd gd*). For participants in the conditions where matches were to be made on the basis of expression, there were two types of trial, A and C which would constitute a correct match (Hit), i.e. all *gs* trials. For participants matching on the basis of identity, the correct matching trials (Hits) were A and B, i.e. all *ps* trials.

There were 20 test items used in all four experimental groups, i.e. four different exemplars of each of the five expressions chosen; each of the four different faces within a particular expression was randomly assigned a number between 1 and 4. As mentioned earlier, some of the actors were used to portray more than one expression, but they were never combined with the same person across different expression trials.

Table 3.1 illustrates how the trials were constructed by combining identity and expression elements for the 'Fear' expression; the pattern of combinations for the other expressions was similar. For B and D 'Fear' trials (where the construction used the same or different person combined with a different gesture in each part), some of the 'Happy' 'H' exemplars were used. In C and D trial types (where different people were combined with either the same or different gesture in each half), there were always different pairs of faces used as exemplars in other expressive gestures (to prevent participants learning to associate one face with a specific correspondent, across different trials).

Table 3.1

To illustrate the principles used in the construction of sequence types in Experiments Five and Six

Presentation	**Order**	**Expression**	**Stimuli**
A (*ps gs*)	TB + BT	fear fear	F1 F1
B (*ps gd*)	TB + BT	happy fear	H2 F2
C (*pd gs*)	TB + BT	fear fear	F4 F3
D (*pd gd*)	TB + BT	happy fear	H3 F4

For any expression, there were eight different combinations used to illustrate it. For example, the top (T) and bottom (B) elements of the first 'Fear' face (F1) were used in type A trials (*ps gs*). In type B trials (*ps gd*), 'Fear' face #2 was combined with the elements of 'Happy' face number 2 (H2, where 'Happy' face #2 was the same person as F1). For type C trials (*pd gs*), the elements comprising 'Fear' face #3 were combined with the elements of 'Fear' face #4 (which was a different person); in type D trials (*pd gd*), 'Fear' face #4 was combined with 'Happy' face #3 (which was another person). In the construction of the 'Happy' expression trials, the different expression it was combined with was 'Anger'. This was to prevent participants from learning to associate particular expressions with each other in non-matching trials.

It was also felt there may be potential benefits, or disadvantages, due to seeing the top or bottom element first. To account for this, the order in which the participants saw the two halves was counterbalanced, i.e. top then bottom (TB), or bottom then top (BT). This meant that each element of any one pair would become a 'target', i.e. the second stimulus presented and therefore decided upon; hence there were eight ways of presenting each expression. Viewing each pair in both TB and BT order gave a total of 40 trials for each experimental set, with each of the five expressions being presented in eight kinds of trials as illustrated in Table 3.1.

The two experimental variables of Task and Presentation type gave rise to four test conditions that each involved testing these 40 trials.

Group One: identity-moving (IDM-moving): In this experimental group, participants were to decide if the two dynamic sequences (from neutral to apex of the gesture) were of the same person, i.e. to match on the basis of identity, irrespective of the expressive gesture shown in both parts.

Group Two: identity-static (IDM-static): This group of participants were shown two halves of faces, at the static apex of a gesture and had to decide if the parts matched on the basis of identity, irrespective of expression.

Group Three: expression-moving (EXPM-moving): In this experimental group, participants saw the same film as Group One, but on this set of trials, they had to decide if the two dynamic sequences (from neutral to apex of the gesture) were of the same expression, irrespective of the identity of the actors used in both parts.

Group Four: expression-fixed (EXPM-fixed): This group of participants saw the same film as Group Two, and had to decide if the static gesture seen in each part matched on the basis of expression, irrespective of the identity of the actors.

Procedure: Participants were arbitrarily assigned to one of the four experimental groups. They were informed that they would see a series of top and bottom halves of faces for approximately one and a half seconds. They had to decide whether the two parts matched according to the experimental criteria of their group.

It was explained to the participants in the IDM group, the criteria on which to base their decision could either be derived from two elements of the same person with the same expression, or the same person with a different expression. For the EXPM groups, their decision could be based on either the same actor in both halves who was producing the same expression, or it could be based on the same expression that was produced by two different people: there was no requirement explicitly to name the expression.

They were instructed to give their 'match' or 'no match' decisions aloud during the five second (blank screen) interval for the experimenter to note on the score sheet.

Treatment of results: There were two sets of ANOVA's calculated: the first series was a between-groups comparison, looking at the effects of the Task and Presentation variables across groups of participants, and ignoring the within-subjects factors. These analysed the total numbers of "correct decisions" made by participants, i.e. correct match detection (Hits) plus correct non-match rejections. These scores are therefore % correct out of 40 (total number of trials). For participants in the EXPM groups, these scores would be calculated from correct *gs* match detections and correct *gd* rejections; for IDM participants, these scores would be calculated from correct *ps* match detections, and correct *pd* rejections. This 'correct decision' data was analysed using a 2x2 factor ANOVA (Presentation x Task).

There was a further set of four ANOVAs calculated, considering the overall effects of Task and Presentation between-groups (2-factorial design). Firstly, there was an analysis of 'Hit' rates, which refer only to correct 'Yes' decisions to matching trials. For EXPM participants, these would be percentage correct scores out of 20 (i.e. *gs* trials); for IDM participants, these would be percentage correct scores out of 20 (i.e. *ps* trials). Secondly, there was an analysis of FP's; these would be based on incorrect 'Yes' responses to non-matching trials (out of 20 for each of the Tasks). To clarify, for EXPM groups, FP's are incorrect 'match' responses to *gd* trials; for IDM subjects, FP's are incorrect 'match' responses to *pd* trials. There were also analyses of the non-parametric measurements of discrimination and bias (A' and B") to assess the effects of Presentation and Task on signal detection criteria. These were based on the Hits and FP data from the correct and incorrect 'match' responses (i.e. % out of 20).

The second set of analyses looked at within-group factors, considering performance of participants within each of the experimental Task groups separately. Such analysis of the data from EXPM participants would allow for an examination of the effect of using the same or different person on the ability to match overall for expression; for the IDM participants, it would allow for an investigation into the effects on the overall ability match identity, when the same or different gesture was being posed in each half.

The Hit rates for the EXPM participants were calculated from the number of correctly detected *gs* trials, and the FP's occurred when *gd* trials were incorrectly judged as matching. Thus, these rates are each % out of 20 (20 matching and 20 non-matching trials). The Hits and FP data were analysed using a 2x2 factor ANOVA, using the variables of Presentation (between-subjects) and Person (within subjects). For the IDM participants, the Hit and FP data were calculated on the correct detection of *ps* trials, and incorrect judging of *pd* trials respectively; again, scores shown were % correct out of the 20 matching or non-matching trials. A 2x2 factor ANOVA was calculated for these results, using the variables of Presentation (between-subjects) and Gesture (within-subject). Non parametric (A' and B") measures were also calculated separately within each Task type using these Hit and FP scores. The non-parametric measures of A' and B" are only discussed where there were significant effects or interactions.

Results

Between-groups analyses

Correct decisions (between groups): The overall rate at which participants made correct decisions (Hits, i.e. correct 'match' detection plus correct 'reject' rates) was 58%. Table 3.2 details the mean performance in each condition (percentage scores out of 40). A 2-factor ANOVA Task x Presentation) showed a main effect of Task on correct decisions (F (1,44) = 7.6, $p< 0.05$), with significantly more being made by participants in the EXPM groups (62%), compared to the IDM groups (55%).

Table 3.2

The effects of Presentation and Task variables on percentage mean correct decisions(Hits plus correct rejections), with Standard Deviations (S.D.) in each of the between-groups conditions of Experiment Five.

	PRESENTATION			
	moving		*static*	
TASK	*EXPM*	*IDM*	*EXPM*	*IDM*
% correct	66	55	58	55
S.D.	7.5	12	6.9	8.1

There was no main effect of Presentation on correct decision rates, although they tended to be slightly higher for those viewing the moving trials than static (60% moving vs 55% static) (F (1,44) < 2.0, $p > 0.1$). There was no significant interaction between these two variables affecting the rates of correct decisions made (F (1,44) < 2.4, $p > 0.1$).

Hits and FP's (between-groups): Table 3.3 shows the means for the 2x2 factor ANOVA used to analyse the effects of Task and Presentation on the Hit and FP rates. Hit rates refer to correct "Yes" decisions to matching trials: the FP's are incorrect "Yes" responses to non-matching ones (both are percentages out of 20).

Table 3.3

*The effects of Presentation and Task on mean percentage Hit and FP rates *, with Standard Deviations, in each of the conditions of Experiment Five.*

	PRESENTATION							
	moving				*static*			
TASK	*EXPM*		*IDM*		*EXPM*		*IDM*	
	Hits	FP's	Hits	FP's	Hits	FP's	Hits	FP's
rates	63	31	52	42	52	36	51	41
S.D.	12	12	19	17	12	7	9	9

(* Hit rates are % correct match detections out of 20; FP rates are % incorrect match decisions out of 20)

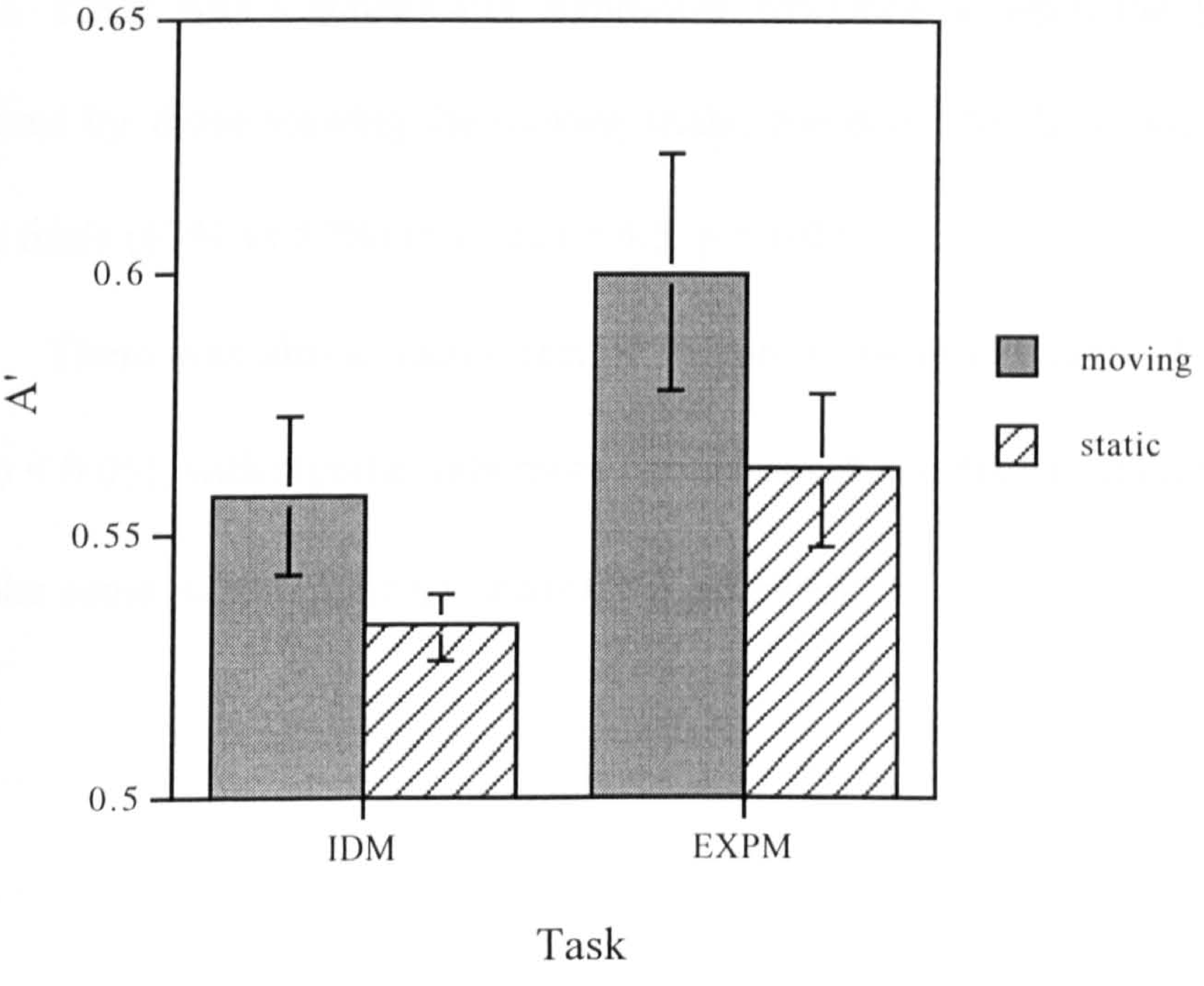
There was no significant main effect of the type of Task on Hit rates, with EXPM participants scoring 58% overall, and IDM participants 51% (F (1,44) = 2.8, $p > 0.1$). There was a main effect of Task on FP rates (F (1,44) = 5.4, $p < 0.05$), with statistically more FP's made by participants in the IDM groups (42% errors by IDM participants, compared to 34% by EXPM participants).

There were no other significant main effects nor interactions (all other F's (1,44) < 2.1, p's > 0.1).

Measures of discriminability (between-groups): The only significant result in either measurement was a main effect of Task, which was found in the A' (discrimination) analysis; this is illustrated in Figure 3.1. There was a statistically higher discrimination rate shown by participants in the EXPM groups than in the IDM groups (0.58 vs 0.54) (F (1,44) = 5.4, p < 0.05).

The analysis of B" showed no significant effects on bias for either variable, and there were no interactions in either analysis (all F's (1,44) < 3.9, p's > 0.1).

Figure 3:1
The effects of Task and presentation on mean A' for each condition in the between-groups comparison of Experiment Five; error bars show the Standard Errors.



Within-groups' analysis

This concerned the effects of Presentation and *either* the same or different Person, *or* the same or different Gesture on the ability to correctly detect matching-only trials within the EXPM and IDM conditions respectively.

EXPM conditions

The analysis for these participants investigated the effects of Presentation format (between-subject) and Person (within-subject) on the ability to detect the 20 trials which matched on the basis of expression (i.e. *gs* trials only). The calculation of FP's refers to the effects of those two variables on incorrect 'Yes' decisions to the 20 non-matching (*gd*) trials.

Table 3.4 shows the mean percentages in each condition. The overall Hit rate (collapsed across conditions) was 58%; the overall FP rate was 34%.

There was a statistically significant difference between the Hit rates achieved by those viewing the moving trials, compared to those viewing the static trials (63% vs 52%) (F (1,22) = 4.5, $p < 0.05$).

There was also a main effect of Person on these Hit rates (F 1,22) = 5.1, $p < 0.05$), with significantly more correct matches detected when the actor was the same in both parts (*ps* trials 62%, *pd* 54%).

Table 3.4:
EXPM groups: the effects of Presentation and Person variables on the % mean Hit and FP rates (out of 20), and Standard Deviations (S.D.) in each of the conditions of Experiment Five

	PRESENTATION							
	moving				*static*			
PERSON	*ps*		*pd*		*ps*		*pd*	
	Hits	FP's	Hits	FP's	Hits	FP's	Hits	FP's
rates	64	34	62	33	59	37	46	35
S.D.	12	15	17	12	15	12	14	10

There were no other significant effects or interactions for either Hits, or FP's (all F's (1,22) < 2.7, p's > 0.1).

Measures of discriminability (EXPM conditions): These were calculated using the Hit and FP rates detailed above; there were no main effects nor interactions in either the A' discrimination measurements, or the B" bias indices (all F's (1,22) < 2.27, p's > 0.1).

IDM conditions

For these groups of participants, the calculation of Hit rates involved the effects of Presentation (between-subject) and Gesture (within-subject) on the ability to detect matches on the basis of identity, i.e. in *ps* trials. The calculation of FP's refers to the effects of those two variables on incorrect 'Yes' decisions to non-matching (*pd*) trials.

The overall Hit rate for IDM participants across combinations of variables was 51%; the overall FP rate was 42%. The details are shown in Table 3.5.

There were no statistically significant main effects, or interactions in either the analysis of Hits or the analysis of FP's (all F's (1,22) < 3, p's > 0.1). There was a trend in the FP's analysis for slightly more to be made when the same gesture was seen in both parts (*gs* 45%, *gd* 38%), but not significantly so (F= 2.6, p= 0.099).

Table 3:5

IDM groups: the effects of Presentation and Gesture variables on the mean % Hit and FP rates (out of 20), and Standard Deviations (S.D.) in each of the conditions of Experiment Five

	PRESENTATION							
	moving				*static*			
GESTURE	*gs*		*gd*		*gs*		*gd*	
	Hits	FP's	Hits	FP's	Hits	FP's	Hits	FP's
rates	56	48	48	37	55	42	47	40
S.D.	20	19	25	19	17	14	14	14

Measures of discriminability (IDM conditions): These were calculated using the Hit and FP rates detailed above (on *ps* and *pd* trials respectively). There were no significant main effects, or interactions on either measurement (all A' and B" F's (1,22) < 1.96, p's > 0.1).

Discussion

The initial analysis of correct decisions (i.e. Hits plus correct rejections) revealed the predicted main effect of Task, with significantly more trials being successfully judged when participants matched on the basis of expression, rather than identity. This statistically significant difference was also found in the A' discriminability measurement: this was largely due to lower FP rates in those conditions, where there were fewer incorrect matching responses made in the EXPM conditions.

The variable of Presentation failed to reveal any significant effects overall for the use of moving vs static displays, although the trend throughout was for movement to assist decision-making, particularly when the task involved expression-matching.

In terms of the within-groups analyses, only the EXPM conditions showed a statistically significant advantage for the moving sequences in correctly detecting matches. For the participants in the IDM conditions, the effects arising from the use of moving sequences were minimal, and no comparisons reached a level of statistical significance.

The Introduction to this chapter predicted that there would be a main effect of Task, in favour of expression-matching. It was proposed that this would arise because participants might be referring to a representation in memory of 'a happy' or 'an angry' face, with which to compare the test stimuli. In the case of participants matching for identity, it was thought that they would not have access to an analogous representation, and so performance in the IDM task might have been close to floor. It is of interest to note that IDM participants performance was indeed only just above chance (55% correct decision rate). In collapsing across the effects of Presentation within the IDM groups' analysis, for trials where there was the same expression in both elements, there was only an overall successful detection rate of 51%, and there was no significant effect on results from using the same or different gestures (F (1,22) = 2.52, $p > 0.1$).

In contrast, there was a significant difference between using the same or different elements for those in the expression-matching groups; indeed their performance in detecting their criteria-matching trials (*gs*) was significantly assisted by viewing the same identities.

In an attempt to improve the poorer, more error-prone performance of the IDM groups, it was decided in the next experiment to familiarise participants with the faces of the actors before completing the experimental trials. It may be that prior exposure to the full face of each of the actors (no matter how limited) might lead to some form of representation for that face in memory which could either be accessed directly, or be overlapped with by the description provided by the moving sequences; in either case, overall rates of performance should be increased. Therefore, in the next experiment, there is an examination of whether a period of prior exposure/training improves scores of participants matching on the basis of identity, which might reduce the main effect of Task. The prediction remains that there will be an advantage for the use of moving sequences in the matching of expressions.

Experiment Six

By establishing a representation in memory for the faces to be used in the trials, it was predicted that there would be improved performance on the identity-matching tasks, as there could now be access to a stored reference for each of the parts of the faces being seen in the trials. With regards to forming this description in memory, there seemed to be no specific advantage for using either moving or static images in building up this representation, and so both types of sequences were shown to participants in the learning/study phase. As the moving and static test sequences comprised images that had not been viewed during study: this would prevent participants resorting to some form of event-specific matching strategy in either of the tasks (e.g. Davies et al, 1978). In addition, it was predicted (again) that there would be a significant advantage for the use of dynamic sequences in the expression-matching task.

This next experiment, therefore, set out to compare the effects of using moving and static presentations of horizontally divided faces, on participants' ability to match these elements on the basis of expression, or identity, when the complete faces had been studied immediately prior to completing the test phase.

Method

Experiment Six was identical to the previous experiment, except that preceding the matching trials, participants saw whole of each of the faces involved for a total of 10 seconds.

Participants: These were 48 volunteers, aged between 22 and 55 (28 females and 20 males). They were attending the weekly D309 psychology course held during the summer session of the Open University 1995. They were arbitrarily allocated to one of the four experimental groups.

Materials - Training Phase: Each actor involved in the experiment was initially seen full-face, and from a head-on viewpoint in a ten second learning phase. This comprised footage of a five-second moving and a five-second static clip of each. The clips were taken from the original VHS footage used in manufacturing the experimental stimuli. The actors were seen posing a range of facial expressions, none of which would be seen in the matching phase of the experiment

The first section of the training phase showed each of the faces (in a pre-determined, but arbitrary, order) in a static neutral pose for five seconds; then each actor was shown in a five second moving sequence that included the neutral expression (in the same order).

Materials - Test Phase: The same ten faces were used for the matching trials as in Experiment Five, and the video test films of half-faces were identical to those used in Experiment Five.

Design: The four experimental groups were the same as previously: IDM-moving, IDM-static, EXPM-moving, and EXPM-static.

Procedure: This was the same as Experiment Five, except that participants were informed that prior to the experiment (matching decisions), they would see each of the actors involved in a still pose for five seconds initially, and then the faces would be seen in the same order, but each in a dynamic sequence for five seconds. Participants were instructed to look carefully at the faces, as they would be asked to match separate top and bottom elements in the second phase of the experiment.

Results

Treatment of Results: As with Experiment Five, there were two sets of ANOVA's calculated: a between groups comparison, looking at the effects of Task (IDM or EXPM) and Presentation (moving vs static) variables across groups of participants. The second set of ANOVA's reported within-subjects analyses of the effects of the variables Presentation, and Gesture or Person.

Between-groups' analyses

Correct decisions (between-groups): The mean overall correct response rate (Hits and correct rejections) was 63%. The results of each of the four conditions are shown separately in Table 3.6. There was a main effect of Presentation on correct decisions, with significantly more being made by participants who were shown the moving sequences (65%) compared to those viewing static images (61%) ($F(1,44) = 4.2, p < 0.05$).

No other effects were significant (both F's $(1,44) < 0.6$, p's > 0.5).

Table 3.6

The effects of Presentation and Task on percentage mean correct decisions (Hits plus correct rejections), with Standard Deviations (S.D.) in each of the between-groups conditions of Experiment Six.

	PRESENTATION			
	moving		*static*	
TASK	*EXPM*	*IDM*	*EXPM*	*IDM*
% correct	64	66	60	61
S.D.	5.1	8.7	6.1	7.0

Hits and FP's (between-groups): The 2x2 ANOVAs which calculated the effects of Presentation and Task on Hit (correct match decisions only) and FP data showed only a main effect of Presentation on the FP rates: this is detailed in Table 3.7.

Table 3.7

The effects of Presentation and Task on percentage mean Hit and FP rates (% out of 20) with Standard Deviations (S.D.) in each of the conditions of Experiment Six

	PRESENTATION							
	moving				*static*			
TASK	*EXPM*		*IDM*		*EXPM*		*IDM*	
	Hits	FP's	Hits	FP's	Hits	FP's	Hits	FP's
rates	57	29	55	23	55	34	52	30
S.D.	15	9	13	9	9	7	11	12

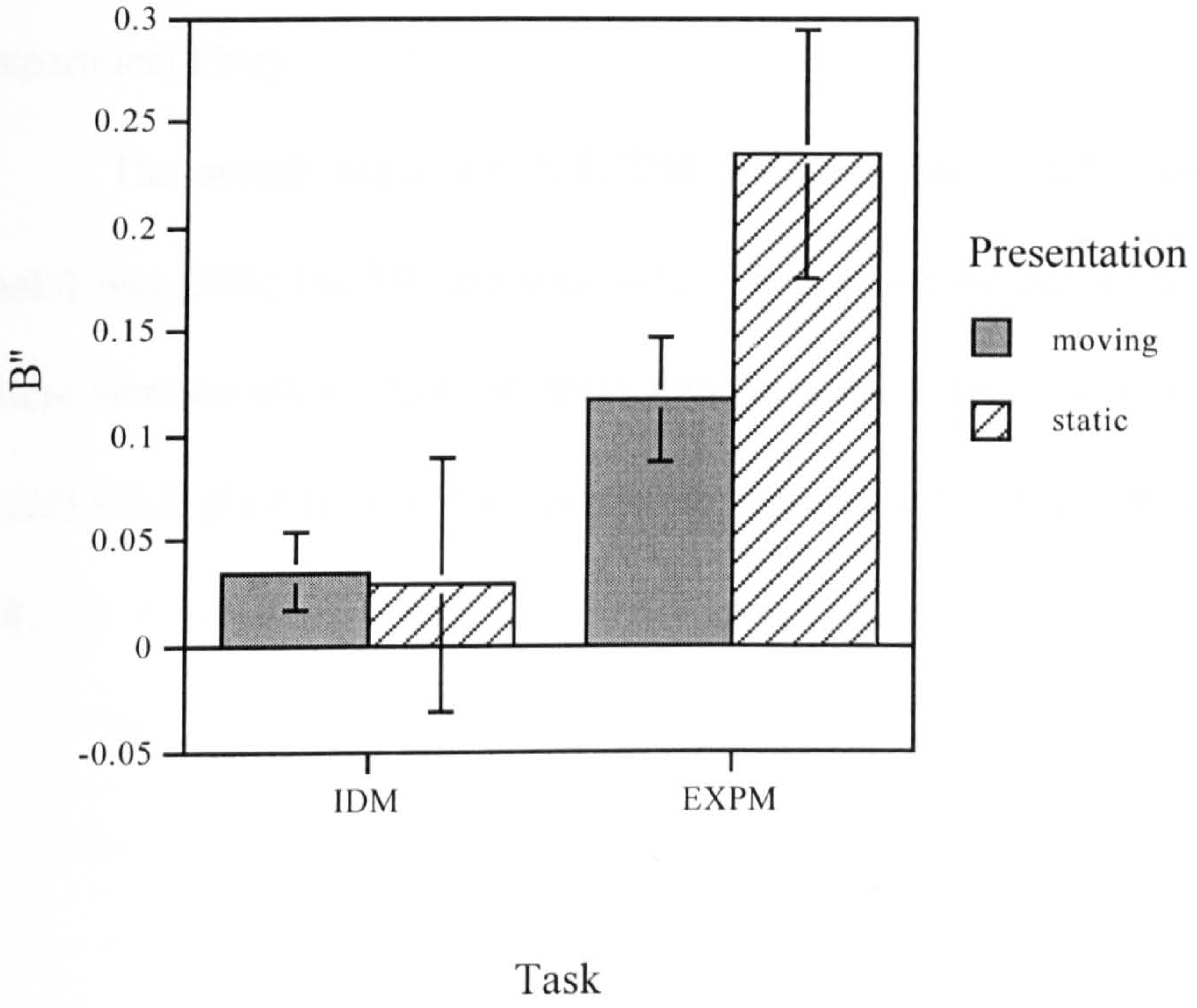
There were significantly more FP's made by participants matching static trials (32%) than in matching moving ones (26%) (F (1,44) = 4.77, p <

0.05). There were no other significant effects or interactions on Hit or FP rates (all other F's (1,44) < 3.5, p's > 0.05).

Measures of discriminability (between-groups): These are based on the Hit and FP data just reported. There were no effects of either the Presentation or Task variables on the A' discrimination index, nor was there a significant interaction (all F's (1,44) < 3.6, p > 0.05).

There was a main effect of Task on the B" bias measurement (F (1,44) = 9.8, p < 0.01); this is illustrated in Figure 3.2.

Figure 3.2
The effects of Task and Presentation on mean B" in each condition in the between-groups comparison of Experiment Six; error bars show the Standard Errors.



There was a significant difference in the bias to noise shown by the participants matching on the basis of expression (0.18, compared to 0.03 for IDM participants). There were no other main effects or interactions on this measurement (all F's (1,44) < 1.81, p's > 0.1).

Within-groups' analysis

This concerned the effects of Presentation and *either* Person, *or* Gesture variables within EXPM and IDM conditions respectively, on the ability to correctly detect matching trials.

EXPM conditions

Here, Hits refer to correct 'Yes' decisions in *gs* trials, and FP's to incorrect 'Yes' decisions for *gd* trials (percentage scores out of 20, as in Experiment Five).

The overall rate at which EXPM trials were successfully detected (*gs* trials) was 56%; the FP rate was 31% (when collapsed across conditions). There were no main effects or interactions in either type of analysis: all F's (1,22) < 3.3, p's > 0.05. The average score in each condition is shown in Table 3.8.

Table 3.8

EXPM groups: the effects of Presentation and Person variables on mean percentage Hit and FP rates (% out of 20), with Standard Deviations (S.D.) in each of the conditions of Experiment Six.

	PRESENTATION							
	moving				*static*			
PERSON	*ps*		*pd*		*ps*		*pd*	
	Hits	FP's	Hits	FP's	Hits	FP's	Hits	FP's
rates	62	25	51	32	56	37	53	32
S.D.	20	12	20	12	16	13	16	10

Measures of discriminability (EXPM conditions): These are based on correct decisions to *gs* trials and incorrect match decisions based on *gd* trials (i.e. Hit and FP rates just reported). There were no significant effects or interactions in either the A' or B" measurements; all F's (1,22) < 2.1, p's > 0.1.

IDM conditions

The calculation of Hit rates for these groups involved the effects of Presentation (between-subject) and Gesture (within-subject) on their ability to judge trials matching on the basis of identity, i.e. *ps* trials, as in Experiment Five. The calculation of FP's refers to the effects of those two variables on non-matching *pd* trials.

The overall Hit rate across combinations of variables was 54%; the overall FP rate was 26%. The mean scores in each condition are detailed in Table 3.9.

Table 3.9

IDM groups: the effects of Presentation and Gesture variables on mean percentage Hit and FP rates (% out of 20), and Standard Deviations (S.D.) in each of the conditions of Experiment Six.

	PRESENTATION							
	moving				*static*			
GESTURE	*gs*		*gd*		*gs*		*gd*	
	Hits	FP's	Hits	FP's	Hits	FP's	Hits	FP's
rates	60	20	49	26	54	22	51	37
S.D.	10	14	21	9	7	9	21	18

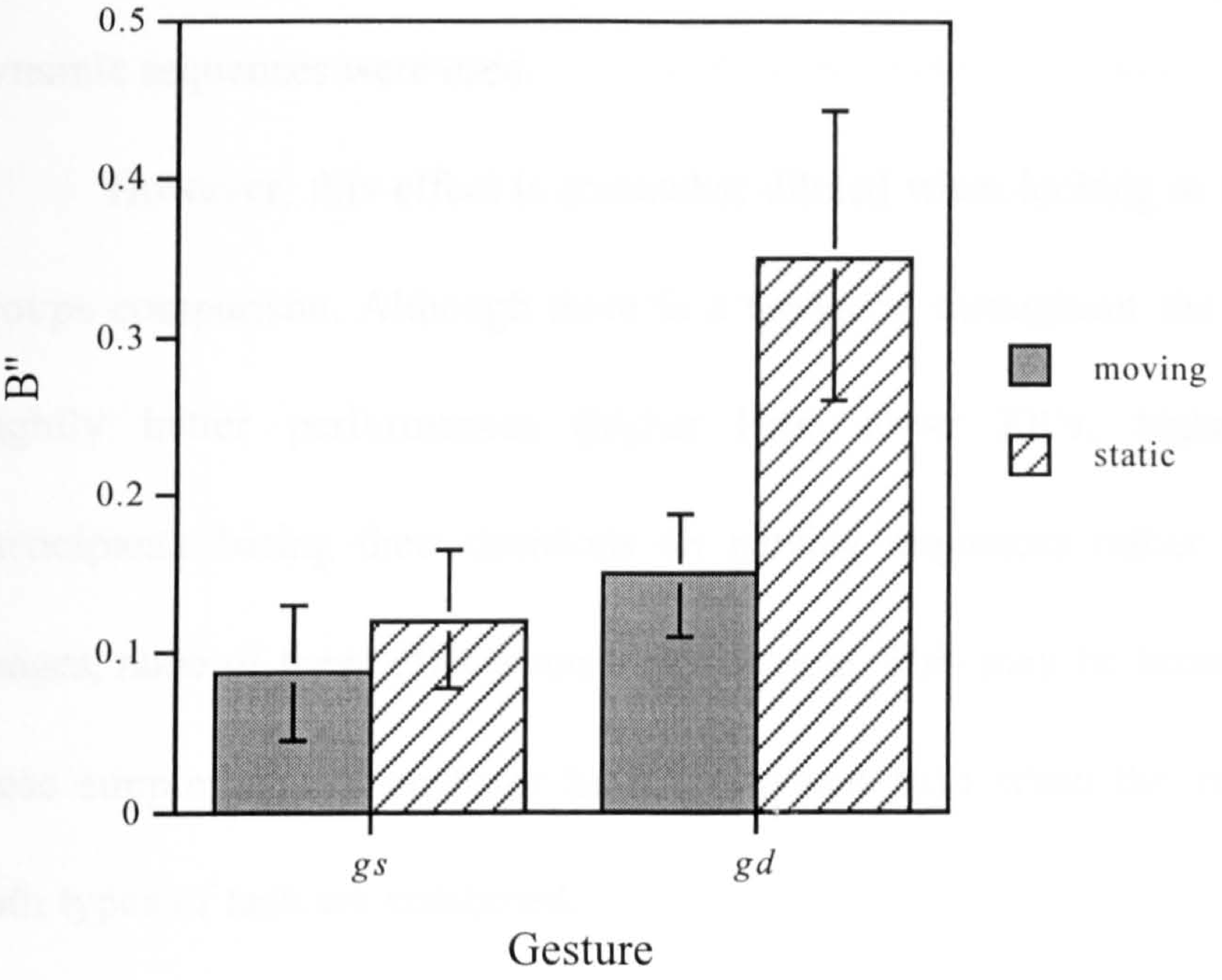
There were no main effects or interactions in the analysis of Hits and FP's (all other F's in both Hit and FP analysis (1,22) < 3.17, p's > 0.05).

Measures of discriminability (IDM groups): In the A' discrimination measure, there was a trend for there to be an advantage in viewing the same gesture in both parts, but not significantly so (F (1,22) = 3.75, p= 0.066). No other main effects or interactions approached significance (all F's (1,22) < 1.57, p's $>$ 0.1).

There was a main effect of Gesture on the B" measurement, which is shown in Figure 3.3. This illustrates how significantly less bias to noise was found in the *gs* trials, i.e. when the same gesture was seen in both elements (F (1,22) = 9.22, $p < 0.05$). There were no other significant effects or interactions (all F's (1,22) < 3.1, p's > 0.05).

Figure 3.3

IDM groups: the effects of Gesture and Presentation variables on mean B" in each condition in the within-groups comparison of Experiment Six; error bars show the Standard Errors



Discussion

In this experiment, where participants were pre-familiarised with the faces to be used, there were no significant differences found between those matching for expression and matching for identity. It had not been predicted that there would be an advantage for movement for the processing involved in both types of matches, yet there was indeed a significant overall advantage for both expression and identity matches to be made using moving stimuli. For those matching for identity, without the familiarising phase in the previous investigation (Experiment Five), performances were just above chance. For participants in this condition in Experiment Six, limited exposure prior to the matching task led to a better overall performance. Indeed, the overall between-groups' comparison of correct decisions (Hits and correct rejections) showed there was a significant benefit for the use of movement. In the between-groups analysis of overall False Positives, significantly fewer were made when dynamic sequences were used.

However, this effect is somewhat diluted when looking at the within-groups comparison. Although there is a tendency throughout the results for slightly better performances (higher Hits, lower FP's, higher A') for participants basing their decisions on moving sequences rather than static images, none of these effects reach significance. This may be because each of these supplementary analyses have less power than when the results from both types of task are combined.

General Discussion

A comparison between the results of Experiments Five and Six show that it seems prior exposure to faces provided higher, and more accurate performance across combinations of variables and conditions; it also led to a significant advantage for the use of moving sequences. In the introduction to this chapter, it was suggested that movement may be more important than static information when processing things we have prior knowledge of, and it seems that this is not only the case for expression analysis, it is also true for matching halves of previously unfamiliar faces for identity, after a very brief period of prior exposure.

Even when only viewing part of the face at a time, it was shown that we can accurately make decisions about the expressions seen on unfamiliar faces, and that this processing was significantly better when seeing moving trials. This has ecological implications, suggesting that initially it may not be important who the person is, it may be more pertinent to assess how they are acting towards us, which, in turn, would mediate how we would approach and interact with them. Therefore, one of the reasons why motion is necessarily more useful in the first instance is that it informs us of the expression (and therefore possibly the intention) of the person approaching, rather than their identity (which might be of secondary importance to the outcome of the encounter).

If we consider our abilities to encode identity and expression at a distance, Jenkins, Craven, Bruce and Akamatsu (1997) showed that our ability to detect some facial expressions (vs a neutral face) is accurate at distances up to 50 metres (although the detection of identity and expression were not directly compared experimentally). This is explained in terms of processing the areas of contrast created by certain expressions. When looking at the information the retina would receive from such stimuli at such a distance, the processing of identity would be hard to resolve.

The unfamiliar faces used in these experiments were only studied as a moving sequence for five seconds, and so the representation in memory built after the familiarisation phase would have limited dynamic pattern information, yet significantly more faces were matched correctly in the dynamic conditions. In considering some of the earlier explanations offered behind the advantageous processing of moving sequences, it could not really be claimed that the short period seen here facilitated the extraction of idiosyncratic characteristic gesture patterns. Instead, to explain the advantages for motion in the identity matching conditions, we might consider that they may be attributable to accessing this pre-existing description in another way.

It may be that the moving trials provided an overlap between descriptions, i.e. the exemplar derived from the test presentation comprised trajectories which showed the actual direction and size of the motion, as well as giving cues to likely changes. This would then have been compared with the description stored in memory, and so it would be easier to match two moving halves of Rachel's face, because all of Rachel's face had been studied earlier. Each dynamic element would act as a separate source of activation or comparison with that particular face in memory, and provide its own generalised candidate description. Alternatively, the access to the representation afforded by the moving trials may be by virtue of each of the elements providing cues to the stored 3D description, or the invariants, and this type of more abstract information could be equally applicable to resolving both expression and identity.

Another more general approach in attempting to explain the significant main effects found for motion might propose that such advantages demonstrate other types of strategies. These are only employed when the normal processing of facial information is made more difficult, and might require reference to a more abstract description of the person, not simply a static pictorial instant. As an example, the use of moving sequences may be more informative than any static pose could be, if they describe idiosyncratic actions, such as the timing or size of relative changes across the face during speech or expressive mannerisms. In such a case, motion might be more beneficial than static information where the test of recognition is carried out under difficult circumstances, e.g. under bad lighting, or 'degraded' quality of the footage. These conditions could be achieved by, for example, presenting the faces at a distance; by experimentally manipulating, or degrading the image quality (their resolution); by spatial- frequency or Gaussian filtering, or by transforming the images into photographic negative.

The investigation now turned from assessing the role of movement in unfamiliar face processing, to determining the possible benefits which might be found for using movement in the recognition of highly familiar faces. The activation of an existing FRU would be made difficult by transforming the format of presentation. As proposed earlier, it is predicted that the task of recognition may be more successful using dynamic sequences rather than static images. At this stage, we cannot discount the possibility that this may be due to a higher information content (i.e. more frames embedded in the moving sequences); this may lead to each frame (instance) being used to activate the representation, or there may be a cumulative effect of responses taking the activation of that stored description above a certain recognition threshold. Other possible explanations concerning benefits for moving test sequences could be due to more generalised descriptions (such as 3D) derived from these types of displays, or some property of the dynamic acts which are specific to each known face (such as trajectories of features, rhythm and timing of articulation, etc.).

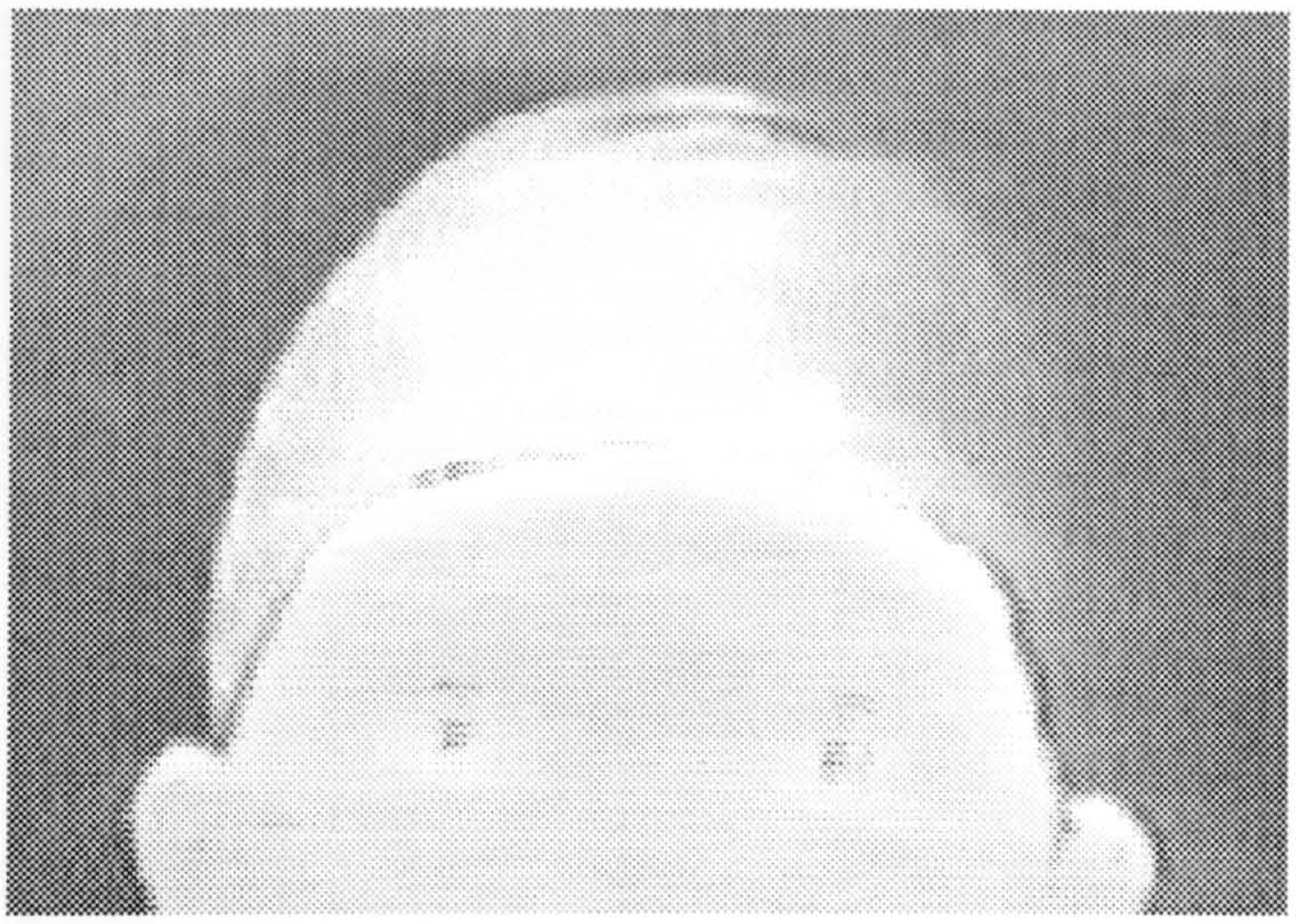
PAGE

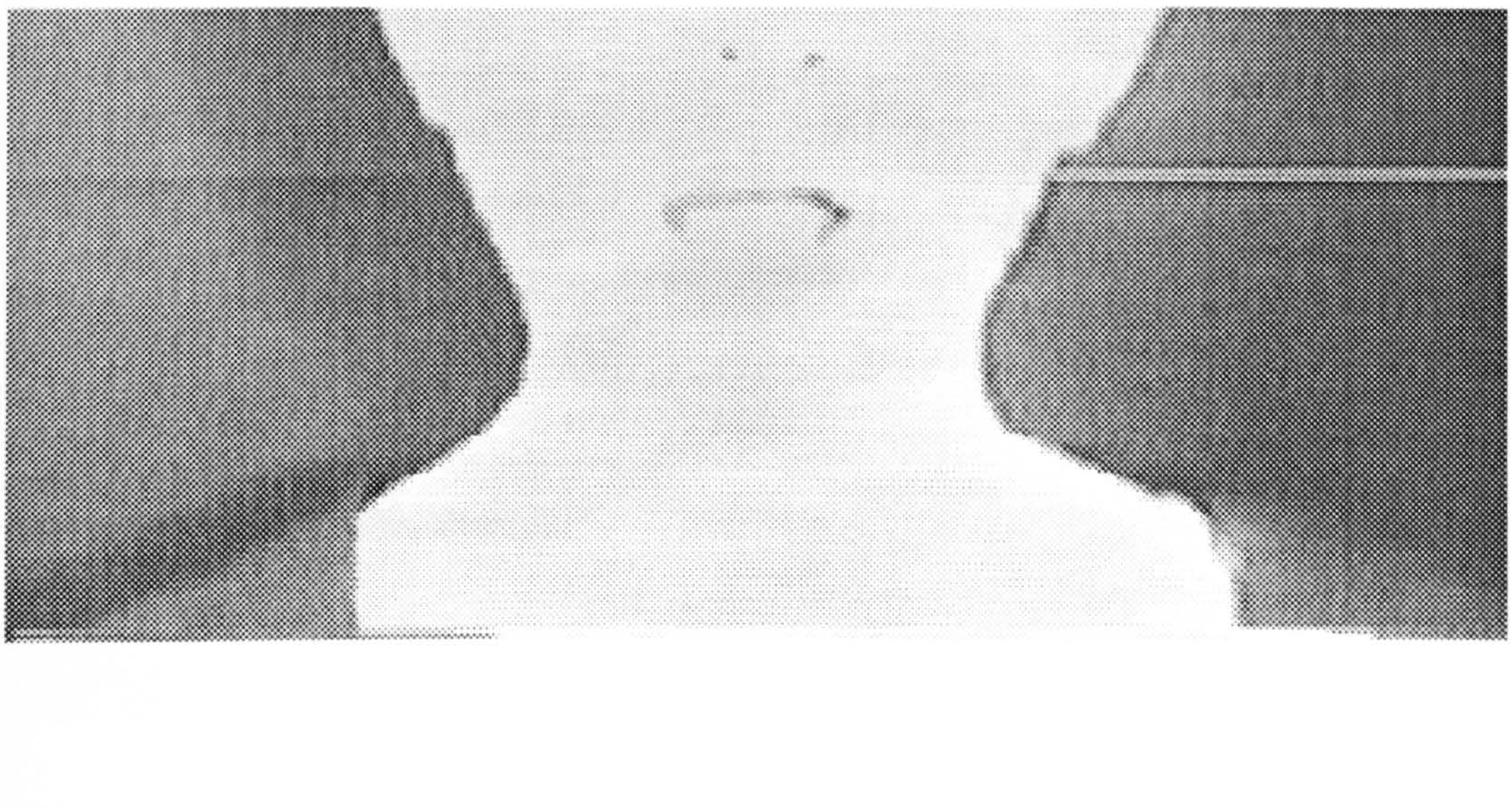
NUMBERING

AS ORIGINAL

Example of Images

PS GS





Example of Images

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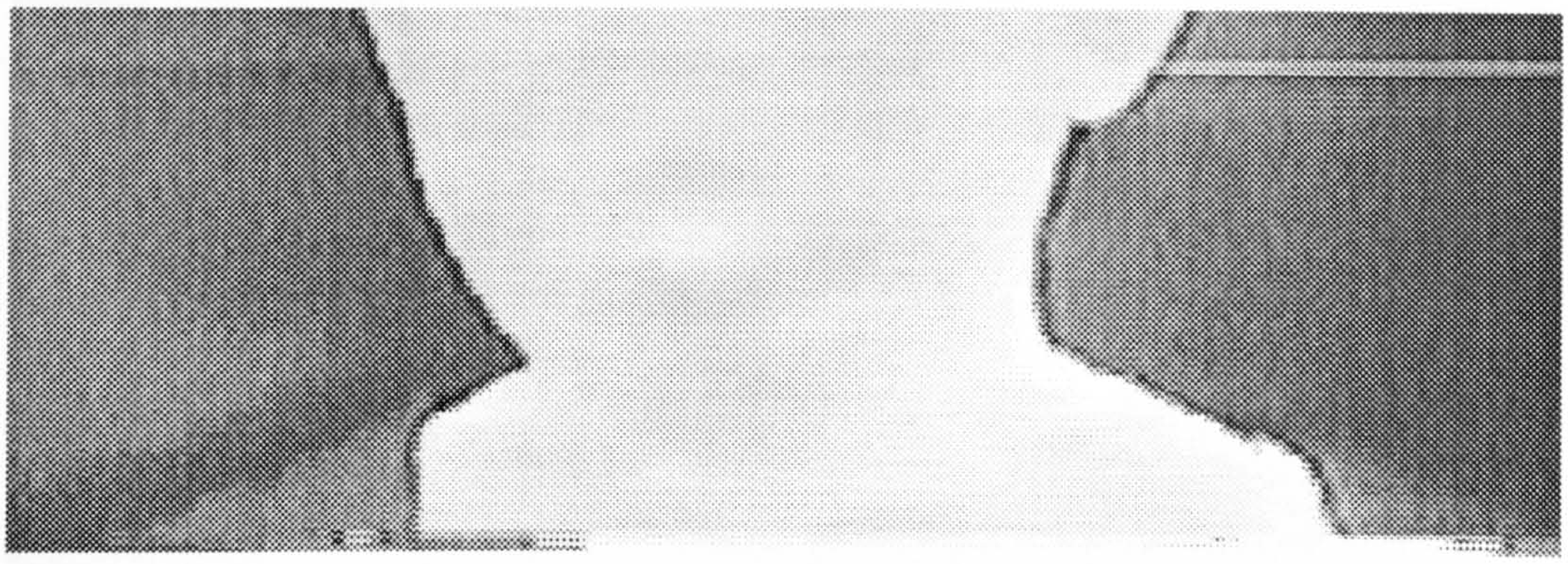

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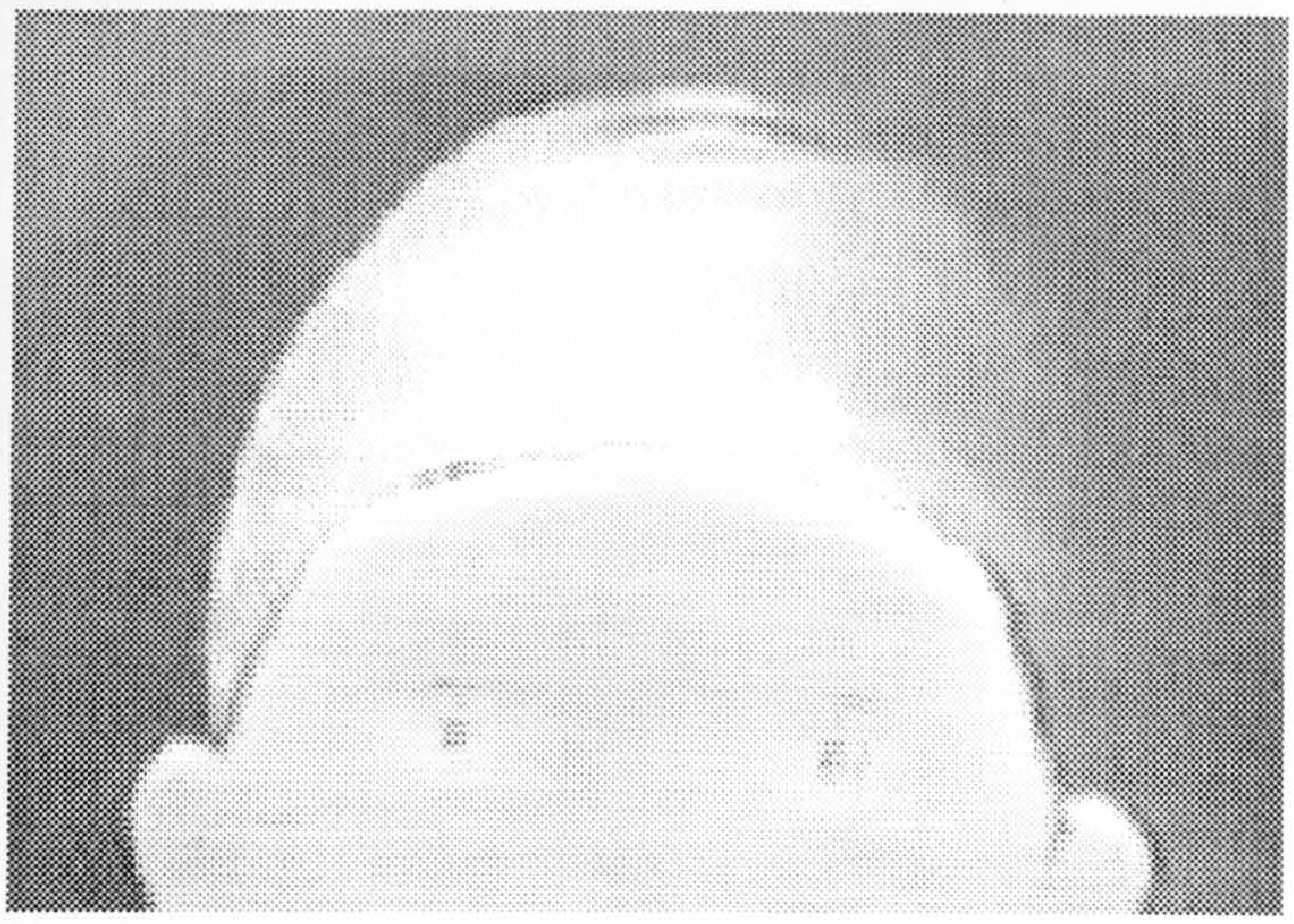

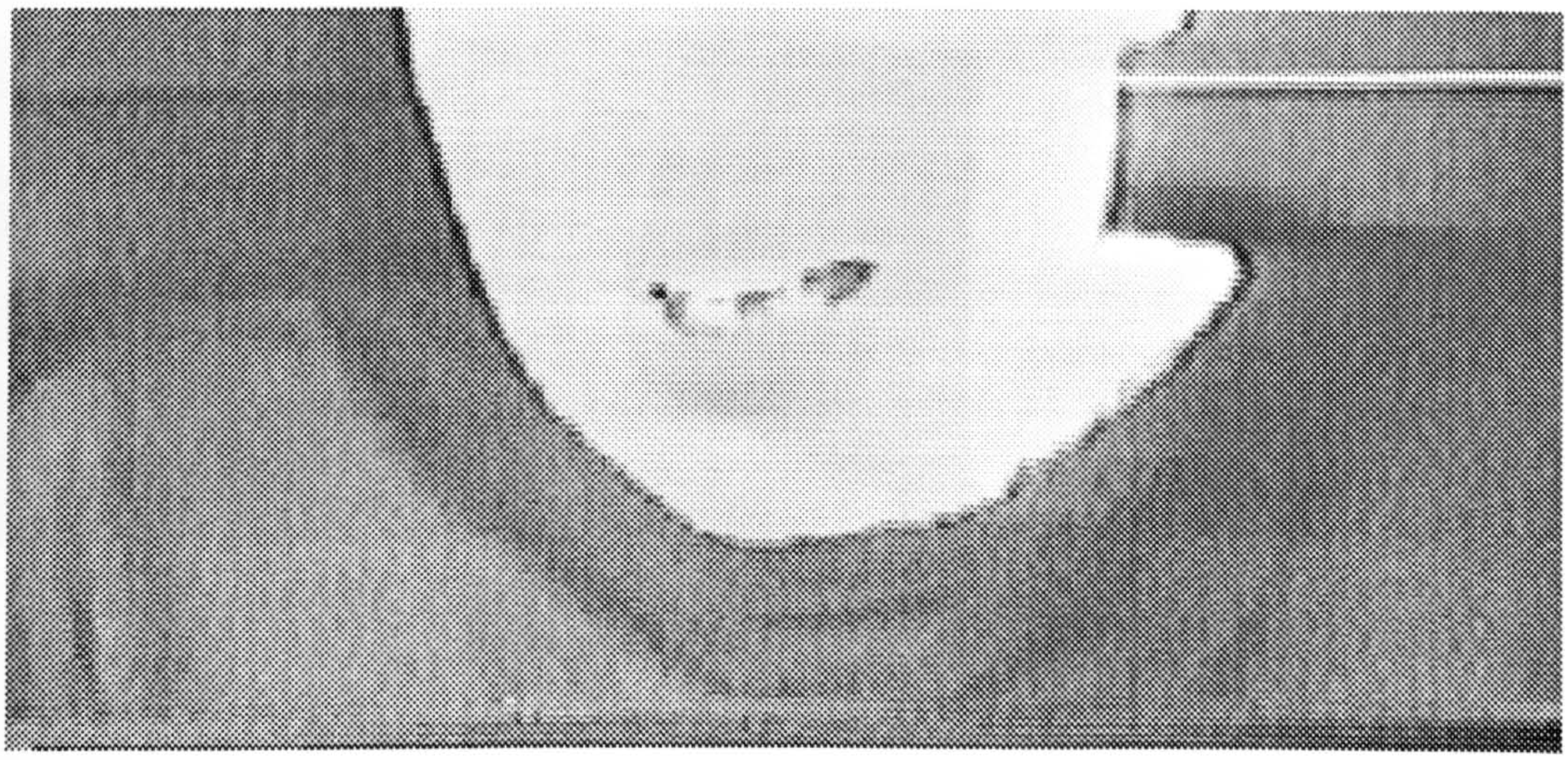

Example of Images

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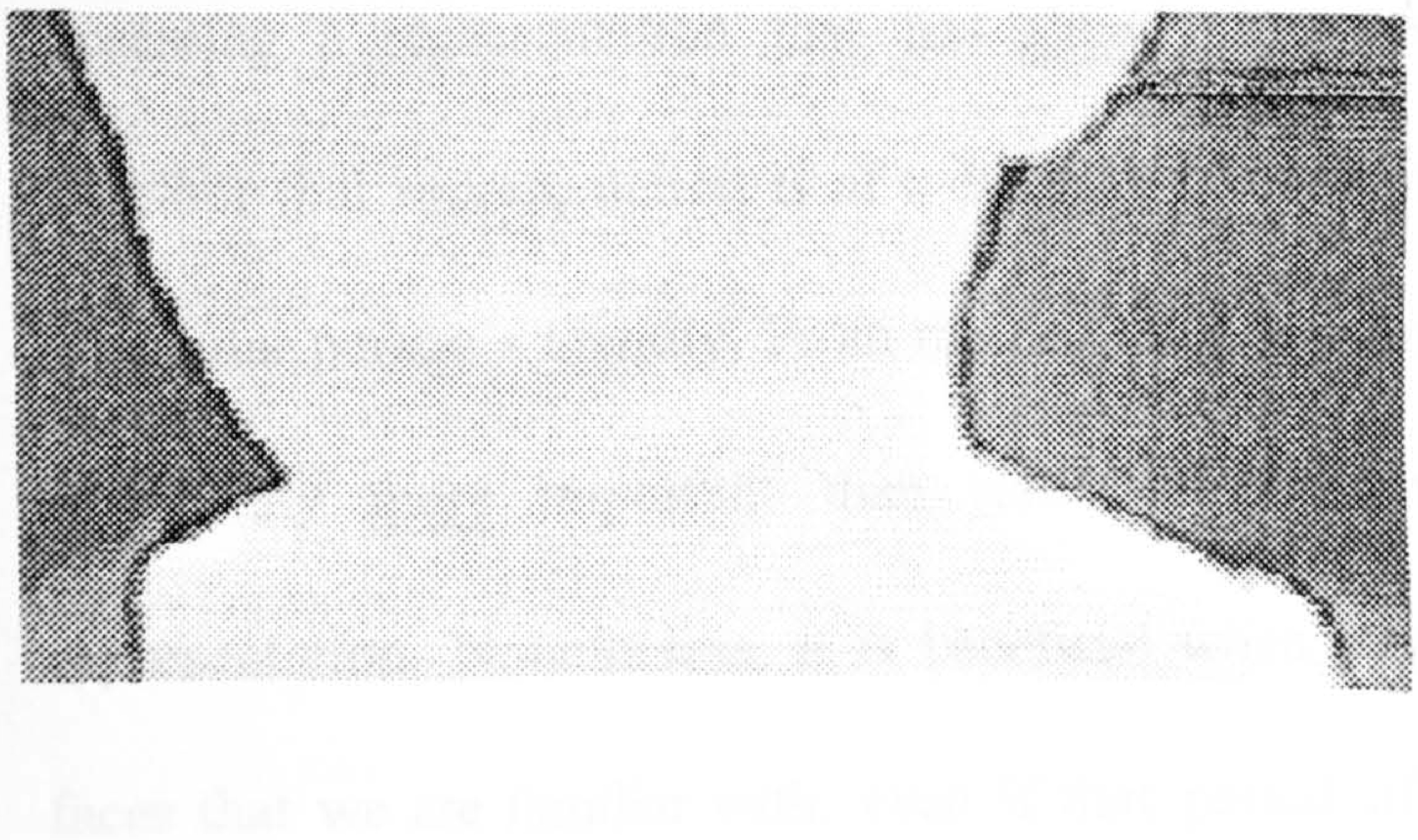


Chapter Four

Recognition of Familiar Faces in Difficult Formats

Introduction

In the first four experiments, any advantages for movement were only found in terms of higher A' when participants were shown dynamic test sequences. In the matching tasks, when the faces were completely unknown, there was only a significant advantage for the use of dynamic sequences within the groups of participants who were matching trials for expression. After a brief study phase of each of the faces concerned, there were significant overall benefits for using dynamic sequences compared with performance using static images for both expression and identity matching tasks. This could be interpreted as showing that advantages for motion can be found when accessing a representation that has already been established in memory, whether that representation is of a category of emotional expression, or of a particular person's identity. From the first four experiments, it does not seem to be any more important than static information in building up that representation. Nonetheless, it is beneficial when processing the identity of faces that we are familiar with, even if that period of familiarisation is very brief. Motion also has an important role to play in the analysis of facial emotional expressions.

Familiar faces

There is considerable evidence in the literature to show that the processing of familiar faces differs from that of unfamiliar faces. Indeed, the model of face processing being considered in this thesis (Bruce and Young, 1986) proposes that the pathway involved in the recognition of familiar faces is separable from pathways processing other types of face-specific information, although some tasks can be carried out using familiar and unfamiliar faces alike, e.g. expression analysis, and matching tasks.

The Introductory chapter drew attention to the Young, Newcombe et al (1993) paper, where several case studies together illustrate selective impairments in three different aspects of face processing, and which suggest that in some respects, these tasks are independent of each other. The accuracy data provided by a variety of tasks showed there were different patterns of preserved abilities and dysfunction in tasks involving familiar faces (problems were found both on deciding if the face was familiar, and also in naming them), unfamiliar face matching (simultaneous, sequential, and multi-choice format presentations), and expression analysis.

Benton and Van Allen (1972) described a prosopagnosic patient who could not recognise familiar faces, but whose performance on tasks matching unfamiliar faces was within normal range. Young, Flude, Hay and Ellis (1993) found the opposite pattern of performance between tasks using familiar and unfamiliar faces. In an initial investigation, patient JT described in the paper was able to recognise familiar faces (i.e. was not prosopagnosic), but he was unable to categorise novel faces as unfamiliar correctly. He showed additional problems in processing unfamiliar faces, as he was unable to successfully match pictures of these new faces. When JT was reassessed several years later, it was found that he was now able to discriminate unfamiliar faces from familiar ones (i.e. he had resolved <u>those</u> problems in discrimination); however, he was still unable to match the unfamiliar faces successfully. Further evidence of the independence of impaired abilities in familiar face recognition and unfamiliar face matching has also been shown by, for example Benton (1980) and McNeil and Warrington (1991).

Familiar faces and Movement

Usually, our experience of familiar people involves having seen them in motion at some point, and thus our stored representation of their faces should involve some knowledge of dynamic transformations. Indeed, it is hard to imagine a scenario when all prior exposure to a highly familiar famous face could be based solely on static instances; most magazine articles typically show two or three images, whereas over 25 images per second are viewed in video, or film footage. Highly familiar famous and non-famous faces (family and other associates) are also seen from various viewing angles, in many different exposure durations, etc., etc. Through face-to-face interactions and a variety of opportunistic sightings, we normally learn and re-encounter such faces dynamically, although we can still recognise them successfully from a static presentation (e.g. photographs).

This thesis began by addressing the question of whether movement assisted in the processing of previously unfamiliar faces: if recognition was instance-based, such processing would require static information only; if it relied on a more abstract representation, e.g. an invariant code, then there may be benefits in using dynamic sequences, perhaps because some intrinsic property of movement facilitates the extraction of such a description. In trying to assert this advantage, there was an additional factor which needed to be considered, that the use of dynamic sequences also involves viewing more instances. Therefore, we must attempt to discount the possibility any advantages found might be due to this additional information content, by somehow ensuring that there is an equivalent amount of material in each type of presentation. The resolution of this issue is complex, particularly as there are two components of recognition, i.e. establishing a representation in memory, and accessing that description later; movement might be important for both, or only one of those components.

As indicated in the discussion of Chapter Two, there are inherent problems in trying to equate the amounts of information in moving and static learning phases. Experiment Six showed that differences can be found between presentation types, which could be explained in terms of preferential access to part of that representation when movement is used at test, and where the 'test' was a matching task using halves of faces that were recently familiar (but previously unknown).

In this chapter, experiments are described which examine directly whether movement can help the recognition of already familiar faces (famous people), which are presented in formats previously found to make the processing of identification difficult. There are various ways in which images of familiar faces can be manipulated to examine potential benefits for motion, such as point-light displays (when stationary, the dots reveal little information about the underlying surface or 3D form), or other kinds of image transformation. The findings that dynamic point-light displays can help in the recognition of familiar faces (colleagues, friends) at rates above chance suggests that there is something fundamental embedded in movement per se (e.g. Bruce and Valentine, 1988). This advantage may be due to the fact that we will have normally seen these familiar faces in action, displaying both rigid and non-rigid changes, which in turn may provide information about the 3D structure of the face. When stationary, the random collection of lights is not perceived as a face, but when animated, cues about the 3D structure of the face, and its identity, can be recovered. However, in order to explore such benefits more rigorously, a larger number of familiar faces would have to be shown than the Bruce and Valentine study utilised, and such an investigation would also necessarily require the use of famous faces. However, it is unlikely that celebrities would be available to participate in the techniques necessary to compile point-light footage.

Instead of using point-light displays, recognition in the following experiments was impaired by using images that were subjected to the manipulations of negation or inversion. Several previous experiments (e.g. Galper 1970; Yin 1969; Young, Hellawell and Hay, 1987; Valentine and Bruce, 1988) showed that presenting images of faces either in photographic negative format (reversing the brightness), or inverting the image (a rotation of the image through 180 degrees in the picture plane) had detrimental effects on recognition performance. These results were achieved using only static presentations, without considering the effects of using moving displays. Knight and Johnston (in press) compared recognition rates of famous faces shown as moving or static negative or inverted images, or a combination of the two. They found that there were significant advantages for the recognition of these familiar faces when shown as moving negative image sequences, rather than single static negative images. There was no significant difference between the recognition rates for moving inverted images, compared to static inverted images.

The experiments described in this chapter build on the Knight and Johnston methodology (in press), and investigate whether motion assists in the recognition of negated and inverted faces. However, we must understand how such transformed images are normally processed, before assessing if, and why, there are benefits for using moving sequences. There now follows a brief review of studies of the effects of negation and inversion on static face processing.

Format Manipulations: Negation

Galper (1970) was one of the first experimental psychologists to show that the recognition of faces shown in monochrome negative photographs was significantly lower than those shown in a normal format. Investigations of this effect since then have centred around several issues: relative brightness or luminance; shape from shading; and spatial frequency.

Luminance: In some respects, there are essentially no differences between negative and positive images: although the luminance is reversed, and the light and dark areas are reversed, both formats are upright. They have the same configuration; they maintain the same contrast, and they are as bright and as complex as positive images. Despite these similarities, they are still harder to recognise than 'normal', or positive upright faces (Galper, 1970). One possible explanation of differences in recognition rates could be that although both types of images are upright, they are not treated in an identical manner; for example, Luria and Strauss (1978) recorded the eye movements of people studying such reversed luminance photographs, and noted there were different fixation patterns recorded for negative and positive images: this may lead to a different type of processing being undertaken.

The eyes in particular are an important frame of reference; if these are inappropriately light (white pupils against the, now dark, sclera), then such 'novelty' may disrupt the conventional processing of not only this area, but others too; dark and light areas of skin and hair are reversed, e.g. a blonde person is now 'seen' as a brunette. The decrements in recognition performance may be due to factors affecting attentional or processing capacity, which may be inappropriately directed to resolving the luminance problem, rather than resolving the question of identity per se.

Shape from shading: Despite the fact that both the contrast and luminance gradings are maintained, it has been proposed that the reversal of these caused by negation gives rise to a pattern of shadows and shading which are not naturally, or commonly seen, and so these images are not processed as if they are 'ordinary' faces (Hayes, Morrone and Burr, 1986). This reversal may disrupt the usual interpretation of shading and shadows (Cavanagh and Leclerc, 1989), and in some respects, the picture gives image intensities which are incompatible with any normal representation of a 3D illuminated face (Horn, 1990).

The importance of shading can be shown when line drawings of famous people are to be identified; these contain only the outline of the features, without any shading or contrast; this type of image is not recognised as well as photographs (Davies et al, 1978). Merely outlining wrinkles around the eyes and mouth is not as beneficial for identity processing as shading the areas themselves (the term 'mass' was used to describe this type of shadow; Bruce, Hanna, Dench, Healey and Burton, 1992). When this 'mass' is re-instated by shading the dark areas on the drawing to coincide with where they occur in the photograph, then identification is enhanced (Bruce et al, 1992).

A negative image may retain the 2D shape of the face, and position of features, but reversing the sign of luminance causes changes in shading, borders between light and dark areas, and also disrupts the representation of the 3D shape-from-shading, leading to impaired recognition (Kemp et al, 1990; Johnston, Hill and Carman, 1992; Bruce and Langton, 1994).

Ramachandran (1988) described how the visual system uses information from shadows and shading to compute the 3D structure of an object. An important assumption in his discussion is that of 'lighting from above'; the fact that most sources of lighting found in our environment are above us (sun, and room or street illumination). This aspect is crucial in allowing us to interpret the 3D shape from cues given by the shadows and from shading. This principle may also be applicable in face recognition, and so a possible explanation of the disruptive effects of negation is that we can no longer resolve shape-from-shading, due to these unusual patterns of light and shadow.

A face shown in negative looks like a face lit from below, and areas that were shadows are now bright, as if there is a change in the normal direction of lighting (Johnston et al, 1992). The lower areas of the face, which are normally dark in the positive format, are now bright in the negative image, as if the whole face is lit from a different direction. The converse is also true, where an image of a face lit from below is difficult to recognise, because of changes in the luminance of certain areas. However, if this bottom-lit image is transformed into a negative picture, we can more easily re-interpret the details (and recognise the person). As the distribution of patterns of light are now consistent with the image of a convex surface, the display now looks like a face which is illuminated by normal, or natural lighting conditions (i.e. from above).

Most of the images used to investigate the effects of negation were monochrome representations, but Cavanagh et al (1989) showed that the visual system generally uses darker areas (irrespective of colour) to denote shadow, so it is the relative luminance, not the hue which is important. In a task where participants had to detect changes in the position of features, Kemp, Pike, White and Musselmann (1996) found that colour images could be used to ascertain shape-from-shading (so the effects of negation are not simply due to grey-level changes). The patterns of shadows and shading are important in describing not only the surface, but also the structure of the face; any image transformation that disrupts the perception of 3D structure will also therefore disrupt face processing.

Spatial frequency: Information about the structure and configuration of faces (as well as objects) come from patterns of dark and light, and edges; low and high spatial frequency details together combine to make such images, and these two sources have different roles to play in face recognition, according to the task being undertaken.

A picture displaying low-level frequency preserves only coarse-scale information, i.e. shadow and shading. Sergent (1986) showed how low spatial frequency conveys information about configuration, the spatial layout of the features; she found that such information supported adequate performance on face-processing tasks such as gender identification and matching. Hayes et al (1986) found that negatives of faces shown using only low spatial frequency information were harder to recognise than positive images of low spatial frequency. They found that high-pass filtered faces were less sensitive to the effects of negation, for these were as recognisable in negative formats as they were in positive. If an image undergoes high-pass filtering, gradual changes in intensity are filtered out, and so fine details of the features can be detected; these images are almost like a line-drawing, but without details of shading (Hayes et al, 1986). As described earlier, images without details of shading or 'mass' tend to be poorly recognised in positive, when compared with recognition from 'normal' photographic images. When these high-pass filtered images are shown as negatives, there is little decrement in their recognition rates (Bradshaw and Wallace, 1971; Bruce et al, 1992).

Sergent (1986) suggested that the difficulties in recognition caused by negation are due to impaired processing of the configural information, as negation seems to affect low-spatial frequency more than high-spatial frequency information. It seems that shading and shadow are utilised in the processing of 'normal' facial images, and poor recognition of negated images may be due to the sensitivity of, and interruption to, these shape-from-shading or low-spatial frequency processing mechanisms, when the luminance is reversed.

Physiological investigations of the visual system have shown that there are at least two distinct streams of information flowing through the visual systems of the primate brain. Livingstone and Hübel (1987) found anatomical and functional separation of the pathways carrying motion information; there was evidence that the parvo system processed static information and the magno system processed movement information. Some later claimed the two streams were processed in parallel (e.g. Lennie, Trevarthen, Essen and Wässle, 1990). Livingstone and Hübel (1987) described how the magno system has much lower spatial resolution than the parvo system; therefore, at lower spatial frequencies, motion can be detected. When this concept is combined with the evidence that face processing can be successfully achieved using a low-spatial frequency description, the implication follows that a moving display of such a transformation might help re-instate some of the missing details, such as depth cues, pointing to a further benefit for motion.

Format Manipulations: Inversion

Explanations of the inversion effect tend to focus on the following arguments: disruption to an expert system; disruption of configural processing and second-order relational features.

Expertise: The opinion that facial processing was something we were experts at dominated the early theories of the source of the effects of inversion: this led to a belief that the effects of inversion were simply due to a lack of expertise/experience with such stimuli, because faces are normally encountered in an upright presentation. Carey, Diamond and Woods (1980) pointed out that six year-olds were as good as adults at recognising inverted faces, but poorer than them at recognising upright faces, because they (presumably) did not have as much experience as adults with processing upright faces. As both had similar levels of experience with inverted faces, the proposal followed that there was a specific mechanism for processing upright faces, which developed with experience. This argument was supported to some extent using neuropsychological investigations, where there was evidence of impaired ability to process upright faces after some types of brain injury, but where the patients performed as normals when processing inverted faces (Yin ,1970).

Results were consistent across several early studies (e.g. Yin, 1969; Scapinello and Yarmey, 1970; Yarmey, 1971; Goldstein and Chance, 1981), showing that face stimuli were more affected by inversion than other types of visual stimuli that we are used to seeing in one orientation, e.g. houses. However, later studies illustrated the effect of inversion was not face-specific; it also applied to any stimuli with which we have a high degree of expertise and where the configuration is used to discriminate between items (e.g. Diamond and Carey, 1986, using expert dog-breeders).

Diamond and Carey (1986) stated the effects of expertise in face recognition lay in the extraction of relational information (between-feature distances, for example): novices were either unable to extract it, or could not utilise it effectively. As we were all considered as novices with regards to inverted faces, the processing of these details would be more prone to disruption. Studies which have been conducted on our recognition of other-race faces (with whom we presumably have less experience) could be used as an example of this. Using Caucasian and black faces and participants, Valentine and Bruce (1986) found a larger inversion effect for other-race faces than same race faces. Although other results have shown inconsistencies with this effect (e.g. Rhodes, Tan, Brake and Taylor, 1989), they may reflect the differences in task, rather than the lack of effect of expertise per se. An interesting experiment to conduct on the effect of race and expertise would be to compare the recognition performance for inverted famous, familiar other-race faces (media and film personalities, such as Lenny Henry, Whoppie Goldberg) with the recognition of familiar, famous same-race faces which are also inverted.

The concept of expertise is found in other theories of face recognition (e.g. Rhodes, Brennan and Carey, 1987; Valentine and Bruce, 1986), and Goldstein and Chance (1980) suggested that this expertise can lead to schema rigidity. 'Good recognisers' may be efficient, but the trade-off is that their encoding of novel stimuli is less flexible, and that is where the inversion effect lies. This leads to the suggestion that performance may be modified by experience, to make processing more efficient.

Rock (1974) proposed that if we could be trained to use more efficient processing strategies, or became used to such images, then perhaps the effects of inversion could be reduced. He argued that the effects of inversion were due to taxing the system responsible for complex pattern resolution, so that the entire face could not be successfully rotated at once. The identity of an inverted image may therefore be resolved via a 'normalising' process, as the image is mentally rotated back through 180 degrees in the picture plane (Tarr and Pinker, 1989).

Practice in the 'mental rotation' of faces would involve rotating the face through a sequence of angles of orientation away from the upright, and back to the upright, normal orientation (as in Shepard and Metzler, 1971). Valentine and Bruce (1986) found that such practice led to improved recognition performance. Valentine (1988) found a linear increase in RT's for recognition as the angle of rotation in the picture plane increased, so there may be a quantitative rather than a qualitative effect of orientation (Valentine and Bruce, 1988).

Configural processing: Ellis (1986) argued that the effects of inversion were because of a disruption to 'facial syntax', or normal face processing, where this normal pattern was no longer recoverable. There are several methodologies that have been employed to illustrate that the effects of inversion are due to disrupting the encoding of the configuration, or syntax: these include the use of schematic faces (e.g. Sergent, 1984); the use of composite faces (e.g. Young, Hellawell and Hay, 1987), feature displacement paradigms, and the 'Thatcher Illusion' (Thompson, 1980).

Sergent (1984) used schematic faces (such as Identikit) in a matching paradigm to illustrate that the effects of inversion were due to the disruption of configural processing. Pairs of faces were shown with either the same or different distance between the features (i.e. configural details), or they were shown with the same or different eye or face contours (featural details). Sergent found that featural detail differences were detected equally quickly in both the upright and inverted orientations. If the differences were configural, RT's to match were much slower when the faces were inverted.

The second example of the configural processing explanation comes from experiments using composite faces by, e.g. Young, Hellawell and Hay (1987). A 'composite' face can be formed by using the top and bottom halves derived from familiar, or famous people. In an upright presentation, with the two halves aligned, these parts seem to form a legitimate new identity; in order for this to be achieved, the join must not be detectable, i.e. there must be continuity of outline and shading. When these composites are shown, it seems that the new configuration produced interferes with participants' ability to process the individual features, and thus they cannot extract the individual identities, independent of the whole configuration. If the composites are misaligned, the effect is lost.

Surprisingly, when the aligned composites are inverted, participants are more able to detect the separate identities of the people involved, i.e. they can process the elements of the inverted composites individually. Young, Hellawell and Hay (1987) suggest that this is a demonstration of how hard it is to extract configurational properties in inverted faces.

If the purpose of recognition is to detect differences between individual category members sharing the same configuration, then recognition may actually be testing the ability to detect changes in location (or the displacement) of individual features, rather than recognising these features per se. Kemp et al (1990) used a matching task to show the effects of inversion on the extraction of configural details. They found that participants were much more sensitive to changes in the vertical and horizontal position of the eyes when the faces were shown upright than when they were inverted. When the features were shown without a facial surround, participants were as good at detecting spatial differences between features using inverted images as they were from upright images. Again, this illustrates the problem in extracting the configuration within a facial surround if the stimulus is inverted.

The final example to be discussed is the Thatcher Illusion (Thompson, 1980). In his demonstration, an upright face of Margaret Thatcher was seen; the eyes and mouth were in their correct location, but upside down. When presented upright, this picture is reported as looking 'grotesque', but when the whole display is inverted, it does not seem unusual. Participants are no longer able to detect these inconsistencies, where the eyes and the mouth are now in their correct orientation, but relative to the rest of the face, they are in the 'wrong' orientation. It has been proposed that the upright display looks unusual because the relationship between the features is incorrect, and we can detect the incongruous orientation of these parts. When inverted, the details of the configuration are difficult to process, and so the unusual, 'incorrect' appearance of the features is not detected.

Lewis and Johnston (1997) used the format manipulations of inversion and negation in testing participants' abilities to detect differences between members of pairs of faces that had been 'Thatcherised' (inverting the eyes and mouth only). RT's to decide if the pairs were the same or different were recorded when the faces were shown upright or inverted, and in positive or negative formats. The results showed that participants were slower to correctly respond to different Thatcherised inverted faces; there were no differences in RT's to decide that negated Thatcherised images were different. Lewis and Johnston argue that inversion causes a breakdown in configural coding, leading to a slower piecemeal strategy being used.

Format manipulations as tools

It was not the explicit intention of the following experiments to resolve the questions of whether interruption to shape-from-shading, or spatial frequency, etc. underlie the negation effect, or whether the effect of inversion is due to problems in processing configuration, etc. Rather, both these transformations were considered as suitable experimental manipulations to investigate whether there was preferential access to the representation in memory of a familiar face (an established FRU) by using moving sequences compared with static instances.

If movement improved recognition rates for either manipulation, or for both, then it would give an important insight as to the reasons for any beneficial effects observed. For example, if movement increased the recognition rates for faces shown in negative, but not for faces shown as inverted images (or vice versa), then this would suggest that advantages for dynamic sequences were not solely due to the amounts of information (or else both format manipulations should be assisted). If movement helped negated images it could be argued this was because it was facilitating the extraction of details normally provided by e.g. shape-from-shading information (via form-from-motion). If motion improved recognition rates for inverted faces, then this would suggest it was helping to reinstate the configural cues (which are otherwise hard to extract in inverted images).

The Present Studies

The next three experiments were designed to ascertain if there was any advantage to be obtained using moving sequences in the identification of faces shown in either of these format manipulations (inverted or negative image types). The recognition rates of famous faces shown in moving video clips were compared with recognition rates in a static presentation condition. At the outset of the experimental studies to be discussed, it was known that Knight and Johnston (in press) were about to report a finding showing an advantage for movement in the recognition of famous faces, using negative images. The purpose of Experiment Seven was initially to replicate and to broaden their investigation, by including an examination of the effects of movement on inversion. It was only after Experiment Seven had been conducted that it was discovered that Knight and Johnston had also looked at the effect on inversion, but found no significant effects.

The comparison in Experiment Seven was between dynamic video sequences and a single static frame. However, as mentioned above, in order to compensate for imbalances in information normally existing between moving and static presentation conditions, Experiments Eight and Nine used three static frames.

In addition to the individual effects of inversion and negation, Experiment Nine looked at a combination of the two manipulations. If, as some have suggested, these manipulations do not engage the face-specific encoding mechanisms (e.g. Ellis, 1986), then a combination of the two should not necessarily lead to an additional effect in decreasing performance. Alternatively, the combined effects of inversion and negation (which might disrupt configural encoding, and the extraction of shape-from-shading details) may be shown to be greater than any single one (e.g. Kemp et al, 1990; Bruce and Langton, 1994). Experiment Nine explored whether the effects of movement were greater when both types of format manipulations were used than they were when a single manipulation was used.

Experiment Seven

This compared participants' ability to name a series of famous faces that were shown in *moving* and *static* presentations. The faces were shown either in photographic *negative*, or shown as positive images but rotated through 180 degrees in the picture plane (i.e. *inverted*).

Methods

Participants: These were 48 undergraduate participants, which comprised 25 males, and 23 females, aged between 19 and 35 years of age. They had normal, or corrected to normal, eyesight, and had either volunteered to take part in return for a payment of £3 per hour, or they took part in order to fulfil their First Year Psychology course requirements. Half of these were shown inverted faces; the other were shown negative images.

Materials and Apparatus: Initially, a pilot study was carried out to ascertain the level of recognisability of each of the target faces under normal viewing conditions. Ten participants (not included in the main experiment) were shown 30 faces, comprising film and media personalities, each in an upright, monochrome, moving video clip lasting two seconds. These participants were asked to name each of the people shown on the screen. The faces that were used in the main experiment were those that were correctly named by at least eight out of the ten participants: this resulted in a test set of 24 faces.

The experimental clips were selected to display at least the head and shoulders of the person from a frontal viewpoint, but as the materials were derived from excerpts of TV or video productions, some of them were also seen from the waist upwards. The two-and-a-half-second test sequences (which incorporated the pilot study segments) were simply copied from a VHS video (either a feature film, or a TV production) onto another VHS tape. The static presentation comprised a single static freeze-frame shown for two and a half seconds: it was a frame selected from the moving test sequence, and was judged to be typical of those shown in the moving sequence (e.g. avoiding any unusual angles).

A master tape was made incorporating upright positive clips of both the moving and static sequences. The stimuli were converted into a negative format by running this master tape through a Panasonic Production mixer WJMX 30 (using the digital effect negative facility), and downloading it directly onto VHS. The inverted test condition used the upright positive master tape, with the experimental manipulation being achieved by turning the TV monitor upside down. Thus, the actual footage seen by participants in both conditions was identical.

To counterbalance items, so that all faces would be seen in both moving and static presentations, and both formats, two VHS test videos per experimental format were made. Within each of these films, the format type was held constant, but half the items were arbitrarily assigned to a moving presentation, half to a static one: this was counterbalanced between subgroups of participants. The order in which the items were interleaved was arbitrarily ordered, but maintained in each of the four films. There was a five-second I.S.I. (inter-stimulus interval) comprising a blank, black screen.

A JVC TV monitor was used to display the films (screen size: 30cm x 21cm.), and the tapes were played on a Sony VHS recorder.

Design: The experiment had a 2x2 factorial design. The variable of "Format" had two levels, *negative* or *inverted* image type (between-subjects); the variable of "Presentation" had two levels, *moving* and *static* (within-subjects). Participants were arbitrarily assigned to either Format condition; the type of Presentation in which the actual items appeared in each condition was counterbalanced between sub-groups of participants.

Condition One: negative format: Participants were required to name the faces shown in negative which were displayed in either moving sequences or a single static frame.

Condition Two: inverted format: Participants were required to name the faces shown inverted in either moving sequences, or in a single static frame.

Procedure: Participants were given two minutes to study a list of 36 names of film and media personalities, some of whom, they were told, would be shown to them in the experiment (see Appendix Three). The list of 36 items comprised the 24 target names, plus 12 distractors, which were matched with the majority of target names for age, gender, and type of media exposure. If the participants were familiar with more than 27 names (3/4 of them), they continued to the video test phase (recognition of the faces). If they did not feel that the names on the list were familiar, then it was unlikely that they would be able to recognise the faces shown under format manipulations, and they were not allowed to proceed to the test phase.

Participants were seated approximately two metres away from the TV monitor, which was positioned at eye-level on a stand. They were informed that some of the faces they were about to see would be moving, some static: they were also told the format of their test phase. They were asked to name the person on the screen: if they were unsure, they were encouraged to produce a name, even if it was a guess. Those assigned to the inverted condition were requested not to tilt their head in order to compensate for the rotation of the TV monitor.

Each face was on the screen for two and a half seconds, with a five second I.S.I. (black screen), during which the participants were instructed to make their (naming) response aloud for the experimenter to note.

Results

The overall rate at which faces were recognised, across conditions, was 56.2%. Table 4.1 shows the means under each of the experimental conditions.

Table 4.1

The effects of the variables of Format and Presentation on % recognition rates in Experiment Seven.

	PRESENTATION			
	moving		*static*	
FORMAT	*inversion*	*negation*	*inversion*	*negation*
Hits	65	55	60	45
S.D.	19	19	17	20

A 2x2 factorial ANOVA was carried out on the correct naming decisions. There was a main effect of Format on the number of faces recognised (F (1,46) = 6.13, $p < 0.05$): the analysis by items also showed a significant effect (F (1,23) = 12.04, $p < 0.05$), with more faces being recognised in the inverted condition (62%) than in the negated condition (50%).

There was also a main effect of Presentation in the analysis by subject, with significantly more faces recognised in a moving test sequence (60%), than those recognised using a single static frame (52%) (F (1,46) = 9.51, $p < 0.01$). This was not significant in the analysis by items (F (1,23) = 2.72, $p > 0.1$).

There was no significant interaction between Format and Presentation, either by subjects or by items (both F's (1,46) and (1,23) < 1.16, p's > 0.1).

Discussion

In contrast to the findings of Knight and Johnston (in press), the results of Experiment Seven suggest that movement assisted recognition under both types of image manipulation. This may be due to additional information embedded in the dynamic sequences, or due to movement reinstating or resolving cues that are difficult to extract in either format.

There was a further disparity between the results of Experiment Seven and the results obtained by Knight and Johnston, as there was a main effect of Format, with a statistically poorer recognition performance here by participants in the negated conditions, compared to the inverted conditions. The same pattern was observed in Knight and Johnston in their conditions which were equivalent to the trials in the experiment reported here, but the trend was not statistically significant. However, the results of Experiment

Seven do confirm previous findings showing significantly greater detrimental effects of negation than inversion, such as Bruce and Langton (1994), and in Kemp et al's (1990) studies.

The most important discrepancy with the results of Experiment Seven, and the results of Knight and Johnston's study concerns the interaction between Presentation and Format variables. Knight and Johnston found that there was a substantial advantage for using motion when studying negated faces (61% moving compared with 42% for static negative faces) but no significant difference between moving and static inverted recognition rates (75% moving vs 69% static). They suggested that the improved performance was due to some form of compensation, by allowing for the extraction of a 3D description, but only for an image manipulation which was shown in an upright orientation, i.e. it only helped to resolve shape-from-shading details in the negative format, not configural details from the inverted images. They suggested that the role of motion in inverted face recognition is therefore somewhat redundant. However, in Experiment Seven of this thesis, there was no significant interaction found, and movement seemed to help the recognition of inverted faces as well as the negated ones.

Experiment Eight further explored the comparison between the effects of movement on negated and inverted faces. In addition, in the light of the previous experiments reported in the thesis, it seemed to be important to compare the recognition of faces shown in moving sequences with recognition test using more than one static image: this would help to clarify if the benefits found for motion were simply due to the provision of more information.

Experiment Eight

As was later communicated, Knight and Johnston had also tested the effects of movement on inverted images, but found no significant effects. Experiment Eight was conducted to clarify whether the advantages for movement were due to some fundamental property of motion per se, or simply a product of the additional frames. It was proposed that if the effects were genuine, then there would still be a main effect of Presentation in favour of movement even when the number of frames was increased in the static comparison trials (irrespective of format). In order to investigate this, each face was shown in the static conditions using three separate instances (which is now denoted as multi-static).

Methods

The Design and Procedure for this experiment were the same as Experiment Seven, except for the following details.

Participants: These were 48 undergraduate participants, half were male and half were female: their ages ranged between 19 and 45 years.

Materials and Apparatus: The two and a half second moving sequences were the same as Experiment Seven. For the multi-static condition, three separate frames were prepared in the same manner as the single static stimuli; they were selected from roughly the beginning, middle and end of the moving sequence using the Media 100 application. Each frame was shown in succession (without a gap) for approximately 0.8 seconds: this gave a total viewing time of 2.5 seconds for the multi-static items. After each moving and multi-static sequence, there was a five second I.S.I. (a black screen) for participants to give their verbal recognition decisions aloud.

Results

The overall recognition rate, by subject, across all conditions was 52.6%.

Table 4.2

The effects of variables of Format and Presentation on % hit rates in Experiment Eight.

	PRESENTATION			
	moving		*static*	
FORMAT	*inversion*	*negation*	*inversion*	*negation*
Hits	61	57	48	45
S.D.	17	20	19	15

A 2-factor ANOVA (Format x Presentation) was used to analyse the correct naming rates, and the mean scores in each Condition are shown in Table 4.2. There was a main effect of Presentation, with most faces being recognised in moving sequences (59%) compared with multi-static sequences (46%); this was significant in both the analysis by subject (F (1,46) = 15.33, $p < 0.01$), and by items (F (1,23) = 16.03, $p < 0.01$). There was no significant difference between the types of Format, although the trend was still for more faces to be recognised in the inverted conditions (54%), than in the negative format (51%) (both F's (1,46) and (1,23) = 0.7, p's > 0.1). There was again no significant interaction between Format and type of Presentation, in either analysis (both F's (1,46) and (1,23) < 0.12, p's > 0.5).

Discussion

Movement again improved recognition rates of both inverted and negated images, despite the increase in the number of static frames shown. The reason for using more static frames was to assess the possibility that the effects observed by Knight and Johnston (in press) had been simply due to inequalities in the amounts of information used in the test clips. This was not found to be the case, as this experiment confirmed the result of Experiment Seven. This leads to the suggestion that the benefits for movement may be genuine.

In follow-up studies conducted by another PhD student in Stirling, Karen Lander (Lander, Christie and Bruce, submitted) has addressed the need for research to equate the two types of sequence more carefully, by testing the recognition of familiar faces using nine frames to display both moving and static sequences of images. This study has again found a significant advantage for recognition accuracy as a result of viewing the dynamic clips. Therefore, providing more frames in the static condition does not result in closer performance between presentation types.

The results of Experiments Seven and Eight, in conjunction with those of Knight and Johnston, show there is a consistent advantage for using moving sequences in testing recognition; this benefit is circa 10% (a little more in Experiment Eight, and a little less in Experiment Seven), for inverted and negated image manipulations. It may be that motion provides a single additional source of information, rather than two independent sources. The nature of this difference might lie in the re-instatement of 3D or configural information; the overlap facilitated by viewing a range of dynamic changes, or due to participants processing something idiosyncratic in the patterns of changes themselves.

Experiment Nine was used to examine these proposals. Following the results of the previous two experiments, there is the prediction that there will be a main effect of movement when the faces are both inverted and negated. If movement is beneficial when the two manipulations are combined, this could be due to two separate sources, i.e. shape-from-motion *and* configurational reinstatement. If there was a separate benefit conferred to each format, the difference between recognition rates from moving vs static presentations should be larger than the approximately 10% difference found in the last two experiments. If there was a single benefit (which might suggest some alternative type of benefit being conferred), then there should be no greater than a 10% difference between recognition rates from moving vs static conditions.

Experiment Nine

The last experiment in this chapter investigated the recognition of famous faces, using moving and multi-static displays which combined the format manipulations of inversion and negation in the same images.

Methods

This was identical to the previous two experiments, with the following exceptions.

Participants: These were 24 undergraduate participants, thirteen females, eleven males, aged between 18 and 32.

Materials: The same moving and multi-static films were used in this experiment as had been used in the two negative subgroups in Experiment Eight. The TV monitor was turned upside down, to now present these negative films simultaneously as both negative and inverted.

Design: There was a single within-subject variable manipulated, that of the type of Presentation (*moving,* or *multi-static*).

Procedure: This was identical to the previous experiments, with the participants being notified of the type of stimuli they would be seeing, and particularly being requested not to tilt their heads.

Results

The correct recognition decision rate was much lower in this experiment, and highly variable, averaging only 19% overall. The one factor ANOVA showed a main effect of Presentation, with significantly more faces being recognised in the moving sequences (mean 22%, S.D. 12%) than from multi-static (mean 15%, S.D. 9%). This was found for both the analysis by subject, and by items (both F's $(1,23) < 6.74$, p's < 0.05).

Discussion

This result supported the proposal that the recognition of famous faces would be assisted by the use of moving sequences, compared to static instances. A combination of negation and inversion produced much worse overall performance than either manipulation alone; indeed the effects seemed to be additive, causing a decrease in recognition rates of approximately 40% (Bruce and Langton, 1994, and Kemp et al, 1990, found similar consequences in combining the manipulations).

If we assume that movement provides more than just additional sources of information under format manipulations, then alternative explanations for the benefits for motion might involve two separate sources of advantage, which should have led to a greater difference between moving and static presentation types. However, as the observed difference was no more than 10%, this compensation may be due to a single component. The nature of this improvement may be a result of movement providing a description of the 3D representation, or cues to the configuration, but not both. A further alternative to consider is that the benefit found may instead be due to a completely different aspect of motion, i.e. that the action patterns inform us about what that person's face looks like when talking, or making expressive gestures; it shows us what is *idiosyncratic*, characteristic or specific to that person. In our interactions with people we know, the ability to detect differences within their individual range of expressions may be pertinent (such as in detecting a false smile), but the dynamics, or the timing may also become crucial in also providing us with additional cues which allow us to distinguish them. If so, then we could expect around a similar level of improvement in recognition rates for movement over static instances, regardless of the type of manipulation used (whether it is band-pass filtering of the images, point-light displays, etc.).

General Discussion

All three experiments have shown a consistent advantage for famous face recognition using dynamic sequences (as opposed to static images), when the task is made difficult using format manipulations. Even when more frames were provided as a comparison in the multi-static trials, there was still a benefit conferred by motion. As other studies have suggested, the effects of inversion and negation are independent, and may be mediated by different mechanisms (e.g. Kemp et al, 1990; Bruce and Langton, 1994). It is therefore possible that movement has differential benefits for the two processes, by re-instating what may be missing in those format manipulations. Nevertheless, there was still the same degree of improvement from the moving and static recognition rates. It may therefore be the case that movement assists the use of the alternative processing strategies for both manipulations in a similar way.

As discussed earlier, further experiments carried out by Lander, Christie and Bruce (submitted), using degraded and non-degraded upright and inverted images, showed that movement is still beneficial when the amount of information is equated, thus demonstrating it does seem to be the perception of some fundamental property of movement per se that is assisting in the recognition of familiar faces. Therefore, it could be that the effect found is genuinely due to another aspect of motion, which may be the detection of distinctive movements, or a characteristic gesture.

Knight and Johnston (in press) suggest that famous/familiar people may be distinguished on the basis of idiosyncratic movements or facial gestures, and it may have been these characteristics that participants were detecting in their experiments. Perhaps as faces become more familiar, motion is beneficial when processing both identity and expression; this proposal has some support from the results of Experiments Five and Six in this thesis.

When the faces used in the matching tasks were completely unfamiliar, there were significantly more correct match decisions (Hits and correct rejections) made by participants matching on the basis of expression, compared with those conditions where matches were made on the identity of the actors; there was no significant difference between the performances of participants viewing moving trials compared with those viewing static images.

However, after a learning phase, during which time participants studied the faces of the actors, there were significant advantages for completing both types of matching trials using moving sequences. Further to this there was no difference between matching decisions made on the basis of expression or identity (after pre-familiarisation).

In the case of highly familiar and famous faces, advantages for motion may be due to our range of experiences with the individual action patterns (the trajectories of various parts of the face during articulation), or our detection of the manner in which those idiosyncratic changes affect the shape and articulation of features, etc. The timing of their expressions, facial gestures or articulations during speech may be encapsulated and stored in memory as patterns of motion, which therefore rely on changes over time: merely sampling static instances in this pattern, or instances portraying the apex of these acts would not perhaps be as beneficial under less-than-optimal viewing conditions.

In addition to this, our experience with characteristic dynamics might help to reveal the true meaning behind their facial actions more accurately than the end-point of the gesture. In particular, this may be useful when the expression of someone familiar to us is judged by others as being ambiguous (such as 'curious').

It may be that these idiosyncratic movements could mediate the learning and recognition of all faces, i.e. the dynamics of what and when changes happen across the face are encoded. Within this suggestion is an explanation of the phenomenon of impersonation, where cues to recognising Frankie Howerd could be equally provided by his own eyebrow-raising and simultaneous jaw-drop, as the replication of those dynamic gestures by someone else (even a previously unknown artist), because what is stored are the patterns of the movement themselves.

There are two different factors which might be involved in the latter case: firstly, such characteristics might be defined by typical trajectories, or the amount by which the features move. The second proposition involves the way or manner in which these changes occur, i.e. characteristics might be determined by individual acts which are defined in terms of rhythm and timing. One method of teasing out which of these is pertinent to identification could be to play the moving footage in reverse (under format manipulations). If the size or the amount of change across the face is the important factor, then such details should be as easy to extract from the reverse-played sequences as it is from the forward-played sequences, i.e. there should be no differences between recognition rates within each format type as a result of footage played forward or backward. If the advantages for motion under format manipulations were due to the manner in which these changes are manifest, then there should be a difference between footage played forward vs footage shown in reverse. The way in which speech and expressive acts were formed would be the opposite of how they are normally articulated: in some cases, the speech gestures shown would be unlikely under linguistic conventions.

Knight and Johnston proposed that the benefits which they found for movement were due to participants using an alternative strategy, which is only employed under certain format manipulations. The analysis or detection of such idiosyncratic gesturing is only undertaken when the images are presented as upright negatives, not when inverted. They suggested that the detection of such characteristic gestures could not be derived from inverted images, because an upside down gesture could not be considered as ‘characteristic’, or ‘typical’. Yet, Experiments Seven to Nine reported here found consistent improvements for inverted and negated images alike, which poses problems for Knight and Johnston’s explanation.

Perhaps, under ideal or normal viewing conditions, we do not need to base our recognition of familiar faces on this more abstract information, but we can exploit this potential benefit when processing inverted or negated faces, or under conditions combining them. In the case of inversion, for example, recognition generally decreases as the image is rotated away from the upright orientation. If recognition is tested using moving images showing the face inverted (i.e. at 180 degree rotation), then the facial movements take place in the same plane as upright faces, and so the amount by which the features change should be as easy to extract from the inverted sequence as from the upright images, but the trajectories occur in the opposite direction (i.e. the corners of the mouth go up, not down when smiling).

Therefore, if cues to identity lie in the dynamics of the face, such as the detection of idiosyncratic rates or manners of production of these gestures, these transformations should be relatively easy to extract from an inverted moving sequence. If dynamic sequences and static images are rotated though various angles in the picture plane, then recognition from the dynamic sequences might also decrease in parallel with the static recognition rates as the angle increases, i.e. motion may not assist in intervening angles. However, when that rotation reached 180 degrees, there should be a sudden increase in recognition rates from the moving sequences (compared with a continuing decrease in static recognition rates), as the dynamics of change were giving similar cues to identity as an upright presentation (i.e. the changes are seen in the same plane again).A different explanation to consider is that the direction and timing of these changes might be confounded when the sequences are shown in motion, which may also be a factor in the inversion effect.

Although the issue is complex, the role of movement in face processing is perhaps becoming somewhat clearer, in that it seems to be beneficial at test, either by preferential access to an established representation (which might involve characteristic gesture patterns), or by itself giving more cues about the likely changes, by providing an overlap (but not an exact match) between the description which is stored, and the description derived from the test sequence. It may seem paradoxical that motion itself does not seem to provide an advantage in the formation of that description in memory. There were some advantages for testing unfamiliar faces using dynamic sequences illustrated in Experiments One to Four, but there were no effects of motion in establishing that representation. In the matching tasks, there was a significant overall advantage for carrying out both identity and expression -matching tasks using moving trials, only after pre-exposure to the faces (Experiment Six); when the faces were completely unfamiliar (Experiment Five), there was only a significant advantage for movement within the expression-matching conditions (for which, it was argued, there was a pre-existing representation).

Finally, in Experiments Seven to Nine, inverted and negated images of famous faces were recognised more accurately from dynamic sequences than from static instances, but we can be sure they have been seen in motion in the majority of occasions. If there could be some form of control over the type of exposure we have to faces during the development of this property of 'familiarity' (only moving or only static presentation), then we may be more able to say that benefits for motion are due to some dimension of the test phase. This may be as a result of an overlap, where the trajectories described in the test sequence are compared with the stored description, such approximations might facilitate recognition through more successful generalisation. An overlap of this nature need not be sensitive to the conditions under which the representation was formed; how the face was originally learned might not be as important as how it is presented at test. The advantage for motion at test may be because such a display matches the type of stored representation, i.e. the description in memory might comprise similar dynamic information, such as possible trajectories, or characteristic gesture patterns for speech or expression production.

Whilst it is been acknowledged that the conventional way in which we learn faces of people who eventually become highly familiar, and/or famous cannot be restricted (in terms of only having moving or static exposure to them), we can attempt to evoke this sense of familiarity with previously unknown faces in an experimental setting, and the type of prior exposure can be precisely controlled. Although it seems that movement per se is no more important than the same number of static instances when learning unfamiliar faces (shown by the first four experiments), this may have been because such short sequences did not facilitate what was essentially characteristic of that person (in addition to which, they were only really seeing one event sequence, repeated four or seven times). However, this observation raises several issues: such as a need to explain the finding that dynamic test sequences are beneficial for faces that were studied via moving sequences and those that were studied as static images (as shown in Experiments One to Four).

The final experimental investigation turns to assess the role of movement and static information in the familiarisation of novel faces; these are studied initially for a long or short duration, in either moving or static displays. As movement had been beneficial in accessing an established FRU for famous, familiar faces shown in difficult formats, the same format manipulations were applied to test these newly-learned faces. If participants were able to extract similar sorts of information from these relatively new faces only after long training periods, then this would support the proposal that movement per se is important in mediating recognition, either by providing an overlap with the stored general description, or by incorporating descriptions of idiosyncratic dynamic patterns of change, which cannot be successfully represented by any single static stage or instance in its production.

Chapter Five

Recognition of Unfamiliar Faces in Difficult Formats

Introduction

The previous chapter investigated the role of movement in the recognition of famous faces, when the test of that ability was made more difficult by manipulating the image-format. The findings were that when these highly familiar faces were shown in either inverted or negated displays (or a combination of the two), there was an significant advantage when seeing them in dynamic sequences, rather than as static images. Such an advantage was not simply due to the differences in the amounts of information embedded in each type of sequence, as the benefits persisted even when both Experiments Eight and Nine had additional numbers of frames in the static comparison conditions. Lander, Christie and Bruce (submitted), using a similar experimental situation also increased and equated the amounts of information in the moving and static conditions; in each of these cases, there were advantages in viewing dynamic sequences, the sources of which benefits were due to some essential property of movement per se (and not simply additional frames)

The format changes used in the previous Chapter interrupted the normal processes leading to recognition (both inverted and negated faces are harder to recognise than 'normal' image types); but, it was argued that the use of moving sequences helped to re-instate some other useful sources of information about the person. This led to a number of proposals, one of which suggested recognition might involve the detection of something characteristic, (such as manner of gesturing), which by its very nature is dynamic, but that such a description in memory could only exist if the faces were highly familiar. Where they were relatively novel, then this detection of idiosyncratic movements could not be the source of any advantage found for motion in unfamiliar face recognition. Indeed, perhaps the familiarisation phases in Experiments One to Four were too brief to accommodate the extraction of these details. If instead movement at test was beneficial because it provides an overlap between study and test descriptions, then the case may still be argued that the exposure duration to the unfamiliar faces during the learning phase (Experiments One to Four) was too limited to facilitate a robust representation for each individual face. Rather than the results reflecting a genuine advantage for motion during the recognition test, perhaps they were more a product of uncertainty and a bias in responding, because the rather general descriptions derived from the test sequences (both target and distractor) may have potentially matched (or overlapped with the possible trajectories belonging to) several stored target descriptions. A further consideration of the factor of time in the learning of unfamiliar faces shows that after a total of ten seconds exposure in Experiment Six, dynamic sequences were beneficial for both identity <u>and</u> expression-matching tasks; such overall advantages were not found when the faces were completely unknown. Thus, there may be a qualitative change in face processing with more than three seconds of prior exposure.

The prediction made in this final experiment was that if previously unfamiliar faces are made sufficiently familiar through some sort of training period, then the same advantages should be found in testing that representation as was found in the identification of highly familiar (famous) faces. In the experiments described here, the faces were tested using the same format manipulations (inversion and negation), to tease out possible differences between moving and static viewing conditions at test. The items were learned using either long or short training/familiarisation phases. The short moving or static training phase was ten seconds long, which was well above the three seconds used in Experiments One to Four, and the five seconds moving and static study phases in Experiment Six, which may have been a crucial factor in the ability to extract or assimilate characteristic movements. The longer training duration in Experiment Ten was two minutes, to ascertain if there were any further benefits to be gained from extended viewing times.

The Present Study

The main focus of the last experiment was the role of movement in the learning and recognition of unfamiliar faces. As there were suggestions that previous learning phases may have been too brief, and that a qualitative difference seemed to arise after five seconds, there was a comparison between long and short training phases (where the short phase was ten seconds, and the long phase was two minutes). Experiment Ten involved an examination of whether the extended learning phase would lead to better recognition when the test comprised dynamic sequences, and whether the type of learning (moving vs static) was important. As the test sequences would comprise footage outside of the range experienced during the training phase, it was predicted that only those participants viewing the moving learning phases would show advantages for a dynamic test phase. The reason behind this proposal was that the moving training phase may provide information about characteristic facial changes or gesturing of each actor. If this was indeed the case, then there should be the same overall advantage for the use of dynamic test phases as was found in Chapter Four for famous faces (c.10%), but only for faces learned moving. The improved performance proposed when using motion in testing recognition may be due to the extraction of invariants, or a 3D representation: alternatively, this benefit may be due to an overlap between the general description derived from the test sequence itself, and the stored description. In such a case, the prediction would follow that an advantage would be found irrespective of the way in which the face had been studied originally.

A more complex series of predictions might also be made. Firstly, there could be a two-way interaction between the type of learning and test phases, with significantly better recognition rates expected in conditions where dynamic test sequences followed a moving learning phase, due to general descriptions from both phases being matched. If motion at test does facilitate recognition by means of an overlap, an interaction would be expected, between the type of test, the duration of learning, and also possibly the nature of the learning phase, with significantly more face being recognised in conditions where a long duration and/or moving training phase was combined with a dynamic test. The results from Experiment One to Four might lead one to expect this might be irrespective of how the faces were learned, i.e. the overlap provided by a dynamic test would facilitate recognition of faces learned during both long moving and long static training phases.

To conclude, the main prediction was that a period of prior exposure to previously unfamiliar faces should lead to them being processed as familiar faces when tested using format manipulations. This might result in higher recognition rates when they were tested using dynamic sequences, in comparison to recognition rates achieved from static images. If such test sequences were beneficial because they facilitated the extraction of characteristic gestures, then there should be higher recognition performance in conditions where participants had been shown the long training phases, compared with those viewing the short study phases, as ten seconds may be too short a duration to extract, or compile such a description.

Experiment Ten

The final experiment in this thesis was an investigation into the role of movement in the familiarisation and testing of previously unfamiliar faces. The faces were initially studied in either short or long training sequences, to assess whether an increased period of exposure led to more accurate recognition performance; during this phase, participants were given brief descriptions of the person, such as their name, and age (see Appendix Four). All participants in all training phases were given exactly the same details; they would all have the same knowledge of the 'person', irrespective of how long they studied each face. This part of the experiment used either moving or static study clips; the test phase showed footage (or an individual frame) that had not been seen during the learning phase. This was to avoid picture-matching strategies, and also to evaluate the ability of the participants to generalise from what they had seen initially (which may be utilising, or detecting, something inherently characteristic they had extracted).

To further tease out any differences which might be found as a result of studying moving and static, short and long study phases, recognition was tested in negative or inverted image formats. These were presented as either dynamic clips, or single fixed images (which may be in the same or different manner of presentation at test to that initially studied). It was hoped that moving test sequences might elicit the same processing benefits as those found for famous faces, which might have been due to an overlap of descriptions, or the recognition of key gesture patterns (which were essentially dynamic in nature), etc.

Methods

Participants: These were 96 volunteers (44 females, 52 males), who were paid £3 per hour for taking part in a range of experiments. They comprised Stirling University students, and staff and students from the Open University. The latter were at weekly summer schools (Maths, Psychology or Engineering) held at the Stirling University campus (1996). Their ages ranged from 19 to 54, and they all had normal, or corrected to normal vision.

Materials and Apparatus: The training clips and test stimuli were derived from the films used for the expression/identity matching experiments. As these actors were colleagues of the experimenter, they would be unfamiliar to the participants. The actors were filmed from in front, under standardised illumination, producing a variety of facial expressions; they were wearing bathing caps to avoid cues to identity being derived from hairstyle. In addition to the ten faces used in the matching experiments, a further eight were filmed under the same conditions.

A main tape of all eighteen faces was compiled from clips of this master tape, comprising one continuous two minute (dynamic) sequence of each face which would be used for the training phase. There was a further one minute continuous (dynamic) segment of a different section of each actors' sitting; this was used to produce the test stimuli. In manufacturing this tape of two and one minute sections, care was taken to avoid duplication of the gestures between either of the actors' clips.

Study Sequences - Moving: The two-minute extracts included at least one example of the neutral pose, and avoided any lengthy (facially) inactive periods of more than a few seconds. Twelve of the actors were then chosen at random to be targets in the experiment, the other six were used as distractors. The order in which the target faces appeared in each training phase was arbitrarily pre-determined, but maintained for all learning sequences (four in total).

For the film shown to participants in the long moving training condition, the two minute sequences were copied onto a further VHS tape, via the Media 100 video editing facility, attached to a PowerMac. The Media 100 application was also used to insert a five second blank frame between the clips of the targets in each moving and static learning sequence.

The short moving training clips were made by taking ten second excerpts from the two-minute (long) moving training sequences, and were shown in the same order. For each actor, this clip included the neutral expression, and at least one expressive sequence. These twelve moving faces and five-second ISI (a blank screen) were downloaded onto a VHS video, using the Media 100 application.

Study Sequences - Static: The stimuli used in the long static training duration comprised three freeze-frames, shown for a total of two minutes. For each actor, these frames were selected from roughly the beginning, middle and end of their moving training sequence. They were produced using the Media 100 application, which froze each picture for 45 seconds. Each actor was seen in the neutral pose; the other frames were selected from expressive gestures, or parts of speech production. The complete viewing sequence for each actor was copied onto VHS, without gaps between each image; the blank five second ISI was inserted after each actors' set.

The short static training stimuli comprised a single frame seen for ten seconds. The actors were posing the same neutral expression as shown in the long static training film. The Media 100 application was used to download it onto VHS tape, with a five second, blank screen interval between each face.

Test Sequences: The eighteen faces to be used as stimuli in the test phases for both formats came from the separate one-minute segments, which (for the targets) had been selected from a different part of the master tape than the study sequences. Identical clips of the targets and distractors were used in all test films (i.e. the same episodes were subjected to both format manipulations).

The duration of the test clips was one and a half seconds, and they showed the actors portraying facial expressions that had not been seen during the training phases. These clips did not therefore include the neutral expression; also, any exaggerated examples of gestures were avoided. Each test clip was copied onto VHS using the Media 100 application. The order in which the twelve target and six distractor faces were shown in was arbitrarily assigned, but maintained in all test phases. Half of the targets and half of the distractors were shown in a dynamic presentation, the other half in a fixed frame; this was counterbalanced between sub-groups of participants in each experimental condition.

Test Sequences - Inverted: The method of achieving this format manipulation was identical to the famous face experiments, i.e. the TV monitor was turned upside down, whilst the video player showed the positive images.

Test Sequences - Negative: The positive image test film used in the inverted conditions was converted into negative, using the Panasonic video editing suite, with the digital effect negative facility. Therefore, the running order, plus actual footage, for target and distractor items was maintained in both types of test.

A JVC TV monitor was used to show both phases of the experiments, and the training and test tapes were played through a Sony VHS recorder.

Design: The experiment had a 2x2x2x2 factorial design: Duration of training (*brief* or *long*); Type of training (*moving* or *static*); Format at test (*inverted* or *negative*); Presentation at test (*dynamic* or *fixed*). The variables of Duration of training, Type of training and Format at test were manipulated between-subjects; the variable of Presentation at test was manipulated within-subjects, with items being counterbalanced for this in sub-groups of participants.

The experimental groups were derived from the following four combinations of variables manipulated during the study phase. In addition, under the factor of Format at test (*inverted* vs *negated*), items were counterbalanced with regards to Presentation at test; this was counterbalanced within-subjects (*dynamic* vs *fixed*), which lead to a total of eight experimental groups.

Condition One: Brief Moving Training: These participants initially studied moving clips of the target faces producing a variety of gestures, and speech acts for ten seconds. At test, half of the participants saw dynamic and fixed images of inverted target and distractor faces; half were shown dynamic and fixed images of those faces in a negative format.

Condition Two: Brief Static Training: These participants initially studied a single static freeze-frame of each of the targets posing a neutral expression for ten seconds. At test, half of the participants saw dynamic and fixed images of inverted target and distractor faces; half were shown dynamic and fixed images of those faces in a negative format.

Condition Three: Long Moving Training: These participants studied moving clips of each of the target faces producing a variety of gestures and speech acts in two-minute films. At test, half of the participants saw dynamic and fixed images of inverted target and distractor faces; half were shown dynamic and fixed images of those faces in a negative format.

Condition Four: Long Static Training: These participants studied three different static images (including a neutral pose) of each target for a total of two minutes. At test, half of the participants saw dynamic and fixed images of inverted target and distractor faces; half were shown dynamic and fixed images of those faces in a negative format.

Procedure: Before the training films were viewed, the nature of the stimuli was explained, e.g. the bathing caps, and the way that the sequences had been produced. Participants were also informed that their recognition memory for the faces would be tested. As the faces appeared on the screen, participants were given the same semantic details about each actor (see Appendix Four): the name, age, home-town, sport and favourite music of each; they were told that it was not necessary for them to remember any of these details. The relevant format manipulations at test were then described (according to arbitrary assignment to a group), e.g. that some of the faces would be presented in the same manner as in the learning phase (moving or static), but that some would be seen a different type of presentation. They were instructed to make their recognition decisions aloud after each individual test clip, and they were assured (again) that they were not going to be tested on their ability to remember the facts given to them during the study phase.

Results

The overall correct recognition rate, collapsed across conditions, was 60%; the overall FP rate was 41%. Table 5.1 gives a summary of the main effects for each variable, collapsed across combinations.

These overall figures were derived from the 2x2x2x2 factorial ANOVA of the results (Duration of training x Type of training x Format at test x Presentation at test).

Table 5.1

Summary of main effects of variables on mean % Hit and FP rates in Experiment Ten; means collapsed across combinations of conditions

Main effect	Levels	% Hit rate	% FP
TRAINING			
	brief	60	44
	long	61	39
TRAINING TYPE			
	static	59	42
	moving	61	40
FORMAT AT TEST			
	inverted	62	34
	negative	59	48
PRESN. AT TEST			
	fixed	55	38
	dynamic	65	44

Table 5.2 overleaf shows the mean Hit and FP rates in each combined condition (where *f* refers to *fixed* Presentation at test, and *d* refers to *dynamic* Presentation at test).

There was a main effect of Presentation at test in the subjects analysis of Hits (F (1,88) = 11.8, $p < 0.01$), with significantly more being made to dynamic sequences than to fixed images (65% compared with 55%). This significant result was also found in the analysis by items (with F (1,11) = 5.57, $p < 0.05$).

However, there were two interactions in the analysis of Hits, involving the Presentation at test variable, which may be contributing to the main effect found.

Figure 5.2

Mean percentage Hit and False Positives (FP's) with Standard Deviations (S.D.) in each of the conditions of Experiment Ten.

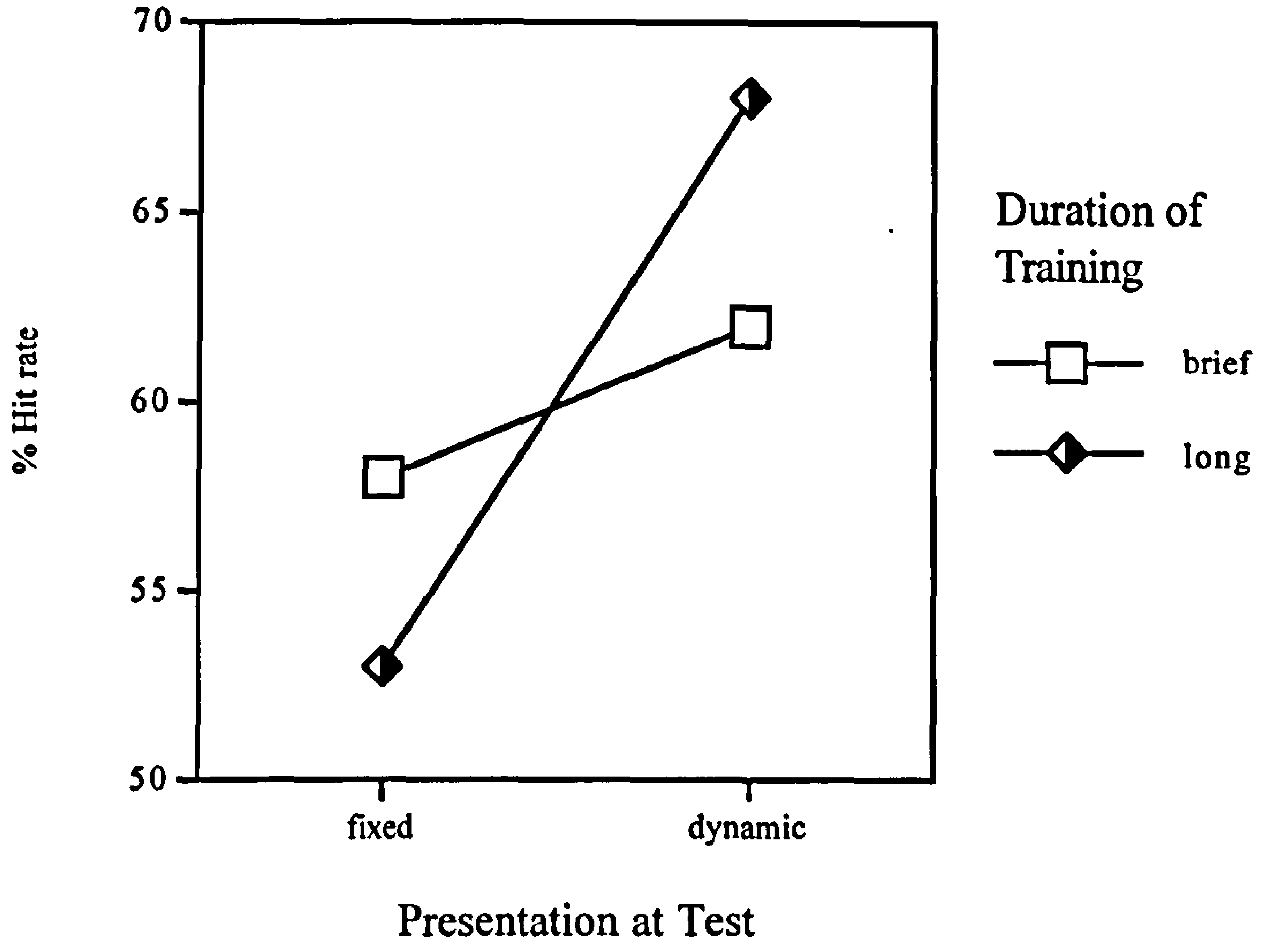
Format at test	*inverted*							
Tr. Duration	*brief*				*long*			
Type	*static*		*moving*		*static*		*moving*	
Presn. at test	*f*	*d*	*f*	*d*	*f*	*d*	*f*	*d*
Hits	54	64	61	67	49	74	50	75
S.D.	18	19	18	16	25	17	14	19
FP's	31	39	36	36	24	42	25	36
S.D.	30	37	26	17	34	29	25	26

Format at test	*negative*							
Tr. Duration	*brief*				*long*			
Type	*static*		*moving*		*static*		*moving*	
Presn. at test	*f*	*d*	*f*	*d*	*f*	*d*	*f*	*d*
Hits	60	54	55	62	60	61	53	64
S.D.	23	27	21	19	18	29	25	26
FP's	53	50	56	50	36	50	41	50
S.D.	39	26	22	30	36	30	27	17

The first interaction was between Duration of training and Presentation at test, which just reached significance, with p = 0.05 (F (1,88) = 3.94); this is illustrated in Figure 5.1 (overleaf). Analysis of the Simple Main Effects showed that where participants had studied the long training films, there was a significant difference between the scores when tested with dynamic faces (68%) and those achieved from fixed images (53%) (F (1,88) = 12.87, p < 0.01).

Figure 5.1

Mean Hit rates as a function of Duration and Presentation in Experiment Ten

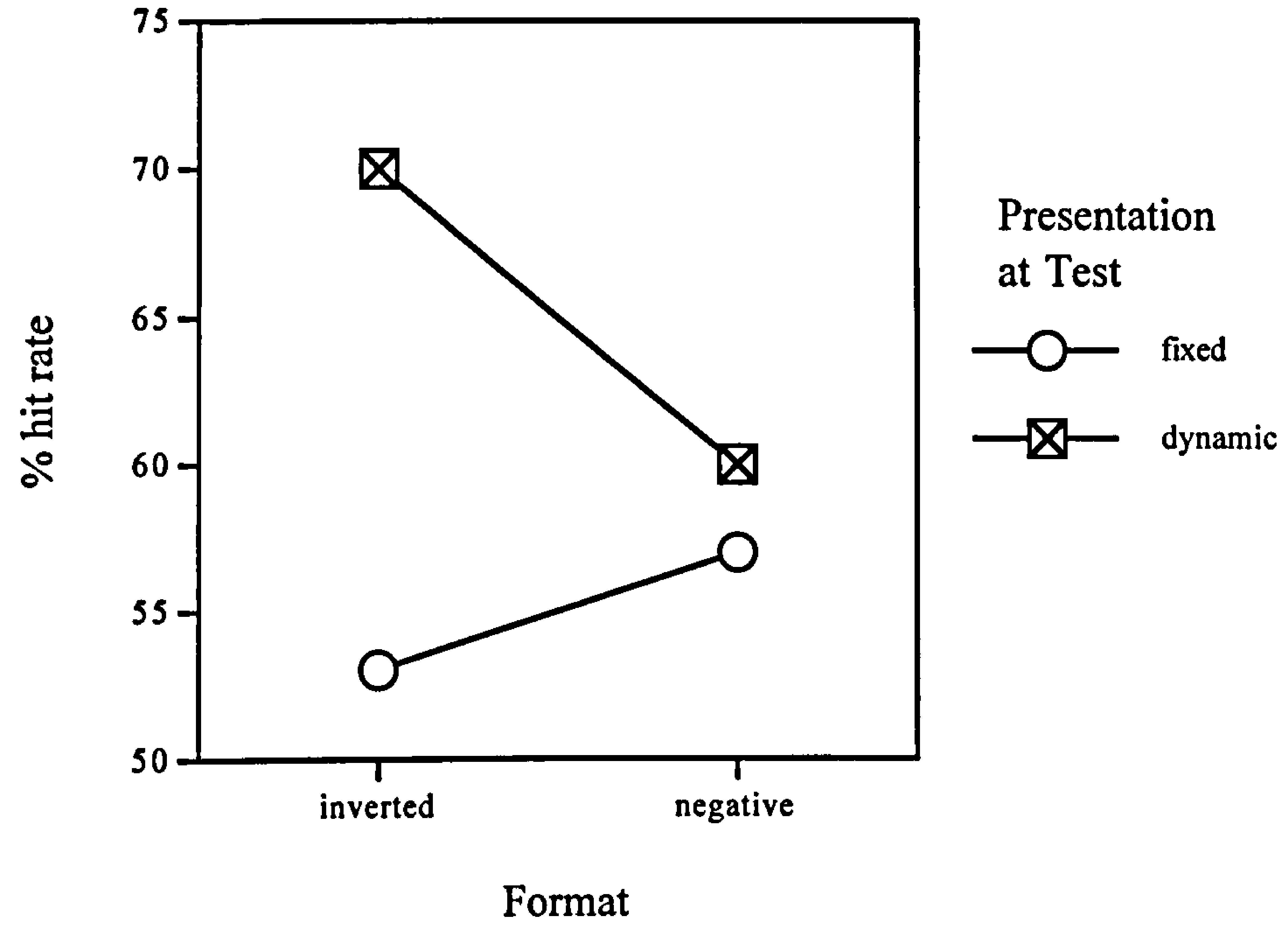


There was no significant advantage as a result of using dynamic test sequences if the faces had been learned in the short Duration training phase; the Hit rates for the dynamic test sequences was 62%, compared with 57% using fixed images (F (1,88) = 0.92, $p > 0.1$).

There was also a significant interaction between Format and Presentation at test in the analysis of Hits (F (1,88) = 4.96, $p < 0.05$). The Simple Main Effects analysis of this interaction showed there was a significant advantage gained in seeing dynamic inverted images, rather than fixed inverted images (70% for moving, compared with 53% for static) (F (1,88) = 14.11, $p < 0.01$). This is shown in Figure 5.2 (overleaf).

Figure 5.2

Mean Hit rates as a function of Format and Presentation in Experiment Ten



There were no other significant main effects in the analysis of Hits by either subjects or items (other F's (1,88) and (1,11) < 0.8, p's > 0.1).

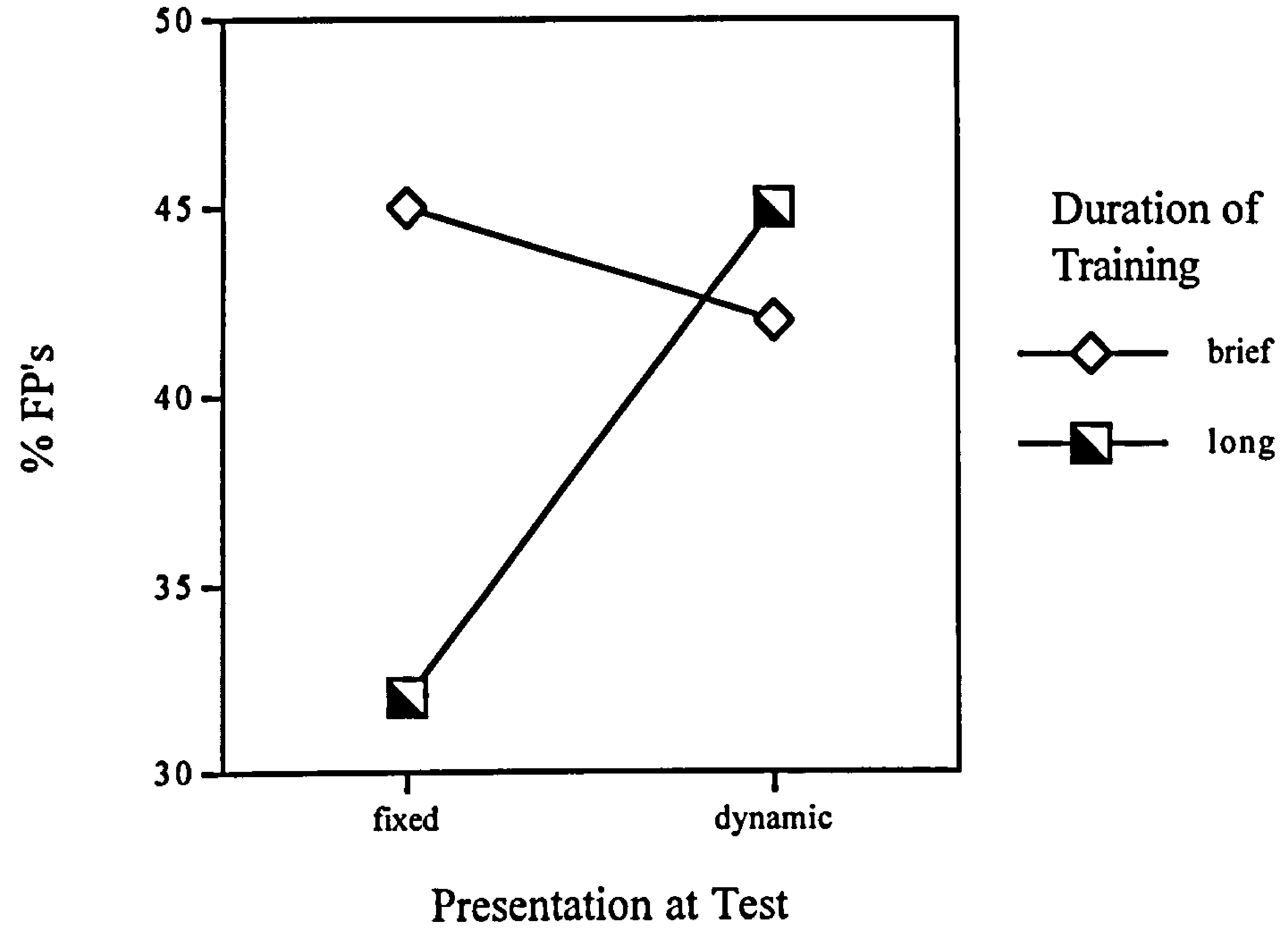
There was a main effect of Format in the analysis of FP's (F (1,88) = 9.57, p < 0.01), with significantly more incorrect decisions being made by participants who were shown negative images at test (48% compared to 34% in the inverted conditions).

There was also a significant interaction between Duration of training and Presentation at test (F (1,88) = 4.32, p < 0.05), shown in Figure 5.3.

Analysis of the Simple Main Effects showed a significant effect of Presentation on the FP's scored in the long training Duration groups (45%

when tested with dynamic sequences, compared with 32% when tested with fixed images) (F (1,88) = 5.9, p < 0.05).

Figure 5.3
Mean % FP rates as a function of Duration and Presentation in Experiment Ten



There was no significant difference between the two types of test if participants studied the faces for a short duration (F (1,88) = 0.26, p > 0.5).

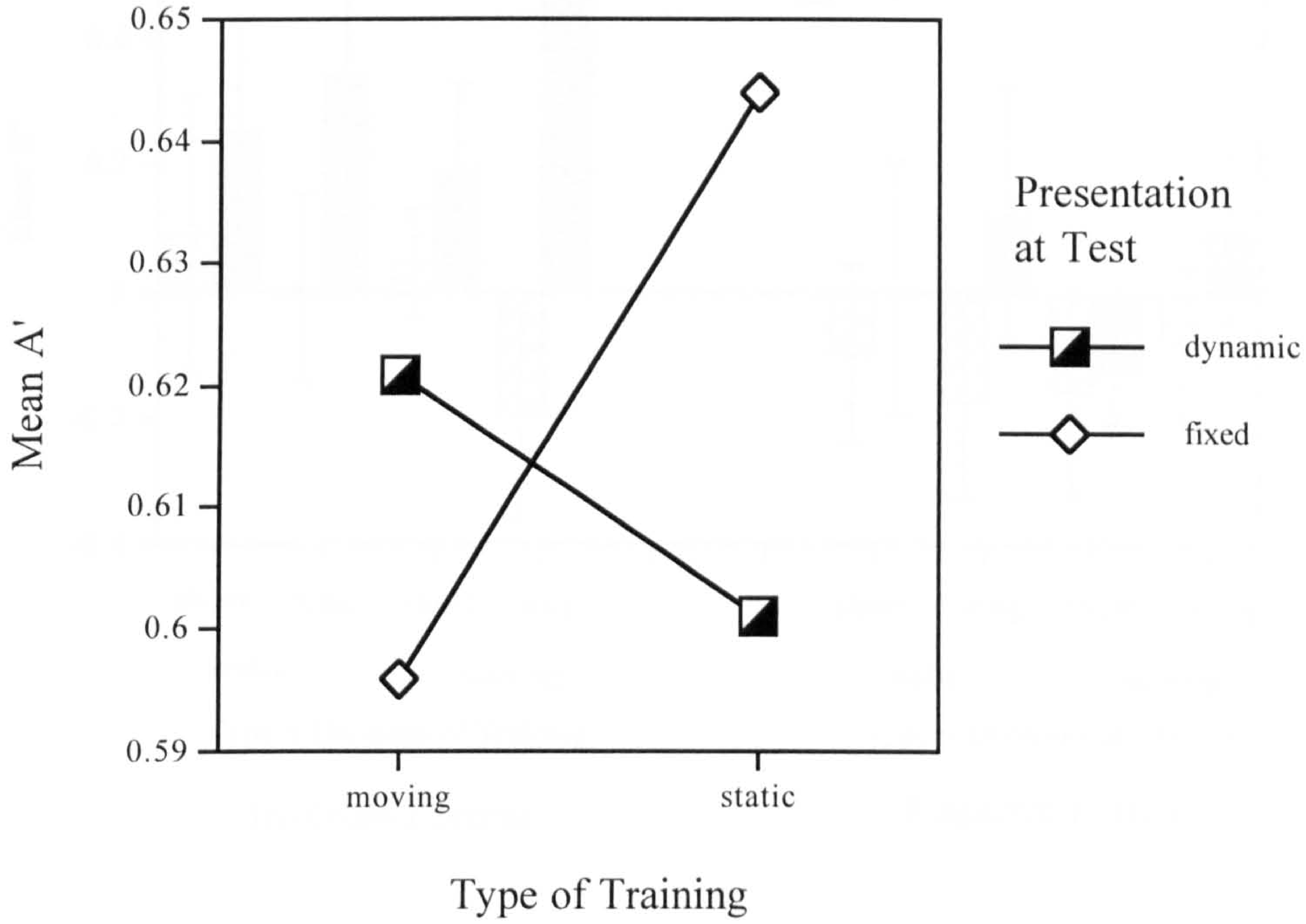
There were no other significant main effects nor interactions in the remaining analyses (all other F's (1,88) and (1,11) < 3.78, p's > 0.05.

Measures of discriminability: Analyses of discrimination indices and bias were carried out using a 2x2x2x2 factorial ANOVA (Duration of training x Type of training x Format at test x Presentation at test): these calculations were based on the Hit and FP data just reported

There were no main effects in the A' analysis (all F's (1,88) < 0.62, p's > 0.1), but there was a significant interaction between the Type of training and Presentation at test variables (F (1,88) = 4.66, p < 0.05), which is shown in Figure 5.4.

Figure 5.4

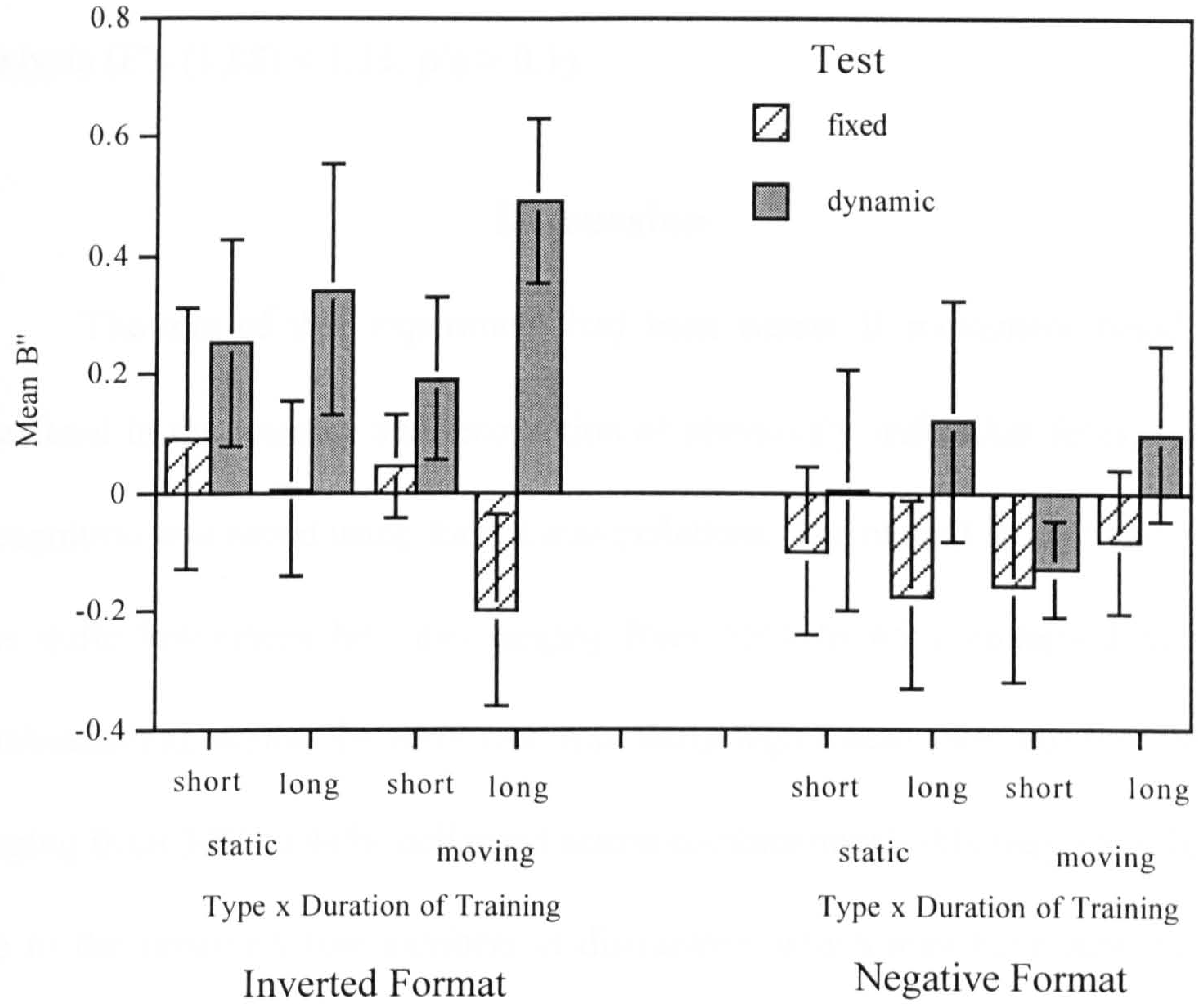
Mean A' as a function of Type of training and Presentation at test in Experiment Ten



There was a significant effect of a fixed test on the Type of training (F (1,88) = 4.08, p < 0.05). There was no significant difference between the levels of discrimination used by participant when test with dynamic sequences following either a moving or a static training phase (F (1,88) = 0.65, p > 0.1), but participants were more discriminating when a fixed test followed a static training phase (A' 0.644) compared to those who had a fixed test following a moving training phase (A' 0.596). There were no other significant interactions in the A' analysis (all F's (1,88) < 2.72, p's > 0.1)

In the bias index, B", there were significant main effects of both Format and Presentation, shown in Figure 5.5.

Figure 5.5
Mean B" in each condition of Experiment Ten. The error bars show the standard errors



Under the variable of Format, participants showed a significantly more conservative bias in the conditions where the test showed the negative images, compared with the more liberal bias shown in the inverted conditions (B" -0.05 negated faces compared to +0.15 for inverted test) (F (1,88) = 5.647, $p < 0.05$). There was also a significant difference between the bias shown by participants when tested with fixed images (-0.07, i.e. more conservative) compared to their bias when tested with dynamic sequences (+0.17, i.e. more liberal) (F (1,88) = 10.89, p < 0.01).

The interaction between the Duration of training and Presentation at test variables just failed to reach significance (F (1,88) = 3.25, p= 0.075), with a trend for a more conservative bias in the trials where a fixed test image was used, irrespective of viewing a long or short duration training episode.

There were no other significant main effects or interactions in the B" analysis (F's (1,88) < 1.51, p's > 0.1)

Discussion

The aim of this experiment had been assess if movement could be beneficial in the learning and recognition of previously unfamiliar faces, when recognition was tested using format manipulations. The overall recognition rate was quite low (mean hit rates ranging from 55% to 65% collapsed across combinations), whilst the error rate was fairly high (mean false positive rates ranging from 34% to 48%, collapsed across combinations); this may have been due to the relatively low numbers of distractors, which may have encouraged participants to incorrectly respond to a higher proportion of items (at no time did they know how many targets there were).

A significant benefit for using dynamic sequences in recognition had earlier been found for familiar faces. It was proposed that this may be due to participants using a slightly unusual strategy, involving the detection of characteristic gestures in a moving display. The recognition of relatively novel faces was similarly aided by the use of dynamic sequences (when compared with recognition from static images). This may mean that they were being processed by analogous methods to those underlying familiar face recognition. Indeed, this *seemed* to be the case, as a significant overall advantage was found for using dynamic sequences in testing previously unfamiliar faces, in both negative *and* inverted formats. This could be interpreted as the ability to detect characteristic gesture patterns from the test sequences was possible even after relatively small amounts of pre-exposure. If the detection of idiosyncratic gesturing was the source of the benefit for motion at test, then there should have been a significant interaction between Presentation and Duration and/or the Type of training. Presumably, studying a face for two minutes would be more conducive to extracting characteristic or likely dynamics than studying a face for ten seconds. Also, studying moving sequences rather than static images should have facilitated the extraction of something characteristic which could possibly be detected at test. As expected, there was an interaction between Duration of study and Presentation at test collapsed across the Type of study phase, where significantly higher Hit rates were found when a dynamic test followed a long study phase; but, this was accompanied by the highest FP's in that same combination of variables.

There was no overall effect of the Duration of study, nor the Type of study phase (the latter was expected from the results of Experiments One to Four). Although there was no main effect of the Type of study phase on Hit rates, there was an interaction in the signal detection measurements involving Presentation at test, which showed that the highest A' was found in conditions where a fixed image was used to test the recognition of faces learned as static. This suggests some sort of pictorial strategy was being used in discriminating the targets.

Nevertheless, with regards to overall Hits, a statistically significant effect was found, where a dynamic test yielded higher recognition rates than did a fixed image test, irrespective of how the faces were learned. It could be argued that this might be due to the extraction of characteristic gesture types, or an overlap between patterns of trajectories. Yet, we cannot simply accept the proposal based on these Hit rates that dynamic test sequences are beneficial, as the analysis of A' measurement showed that the most effective discrimination was found in conditions where a static study phase was tested using a fixed image; in the B" analysis, there was a shift in bias when dynamic test sequences were used. The interaction between the variables of type of study and type of test in the A' results showed that a reinstatement of encoding conditions significantly improved the ability to distinguish between targets and distractors, whereas the B" results pointed to a more liberal criteria applied to any face shown in the dynamic test conditions.

The benefit of a dynamic test phase (vs a fixed image) was more significant after the faces had been studied during a two-minute period than for ten seconds, irrespective of the type of study phase. This evidence came from the significant interaction between the Duration of training and the Presentation at test variables in the analysis of Hits. There was a significant advantage shown by participants in the long training conditions when they were tested with dynamic sequences (68%) rather than those who were tested using a fixed image (53%). This suggested that movement was only beneficial in accessing a (relatively) well established representation in memory, and that study sequences of over ten seconds met this criteria. This may be because dynamic tests produced a description which facilitated recognition by means of an overlap with the representations stored (not a categorical, or exact correspondence), so there was a range of movements within which differences could be accommodated.

Unfortunately, the findings have produced complex interactions, which may not have been completely accounted for. Any arguments become less convincing when aspects other than the Hit rate are considered, such as FP's and signal detection measurements. For example, the significant interaction involving the type of image sequence shown during the training and test phase in the analysis of A' (see Figure 5.4). Rather than illustrating further the advantages for a dynamic test sequence, this showed there was significantly higher discrimination being applied by participants in conditions where the study and test phases comprised the same type of presentation (i.e. static). As stated earlier, this benefit may be due to a replication of study and test conditions, but when the test was of dynamic sequences, there was a higher A' shown by participants who had originally studied the static image (or images). However, the B" measurement shows a tendency for a bias to be involved in decisions made by participants in most of the conditions combining a dynamic test with other variables

The length of the test sequences were determined on the basis that it was long enough to show an expressive gesture, but was possibly not long enough to convey something typical or idiosyncratic, whereas the test phase of the familiar faces was for two and a half seconds. For the unfamiliar faces, it may have been that such individual patterns of change had been extracted, but the test phase of only one and a half seconds was too brief to take advantage of this; i.e. it was not long enough to show anything characteristic at test. This may have in part led to the pattern of results where there was a high FP rate (mostly over 40%, in some cases over 50% in the four-way interaction), and a bias in responding. The trend which was found favoured conditions where a fixed test followed a static training phase.

In reference to the other effects found, again there are some cases where the unfamiliar face results are similar to those for the famous face experiments (Seven to Nine), but these suggestions also have their complications. For example, whereas there were significantly more faces recognised in the inverted format in Experiment Seven, which used a single static frame (as Knight and Johnston had found), an increase in the number of static frames (in Eight and Nine) led to the loss of that effect (in terms of Hits). In Experiment Ten, there is no main effect of the Format manipulation on the Hit rate, but there is a main effect on the FP rate, and B" measurement. There are significantly more FP's made, and a significant difference in bias found when faces are tested using inverted images (B" > 0).

General Discussion

The conclusions to be drawn from this experiment are firstly, that as before, there is no particular benefit to be found as a result of viewing moving images when learning unfamiliar faces (compared to learning based on static displays). Secondly, that there are no significant differences as a result of participants initially studying the faces for either two minutes, or ten seconds, because ten seconds seems to accommodate the same level of recognition of a novel incident as a two minute study duration does. The only significant main effect found reflects the pattern of results from Experiments Seven to Nine, which used famous, familiar faces, in as much as there was a significant advantage in using dynamic sequences at test (even though Experiment Ten had used relatively unfamiliar faces).

It could be said that this advantage was due to an overlap between the (general) description derived from the test sequence, and the stored representation (which might itself contain a description of permissible differences). Alternatively, it may have been as a result of the test sequences somehow capturing idiosyncratic ways of gesturing (either by showing how much the face is transformed, or the way in which the face is transformed). It is argued that the first explanation is more likely, as the concept of an 'overlap' is more likely to be favourable to the possibility of being insensitive to the manner in which the representation was formed. It would be more difficult to understand how idiosyncratic gesturing could be extracted in conditions where the faces were learned as either a single static picture, or using three separate instances, which would be the case if the second option was correct.

Unfortunately, a note of caution is necessary when interpreting these apparent similarities between results of familiar and unfamiliar faces tested under format manipulations; for unfamiliar faces there is a complex pattern of effects on bias, as well as discriminability. Since the variable of Presentation at test was manipulated within-subjects, we cannot attribute the effects on false positives to differences between participant groups. Perhaps the main message is that movement might assist recognition, but we must be careful to qualify that statement by adding there is an increased likelihood of errors and misidentifications in such conditions.

Chapter Six

Discussion: When Motion is Important in Face Processing

The thesis began by questioning the role of dynamic information in face processing, and went on to illustrate cases from previous research where movement helped in the analysis of lip-read speech and emotional expressions; there were also suggestions as to the possible advantages for motion in the processes underlying the task of recognition. Where benefits had been shown in face recognition (e.g. Pike, 1994, Schiff et al, 1987; Knight and Johnston, in press), it was unclear whether these advantages for motion were due to the fact there were more instances normally to be found in dynamic sequences, or if advantages were due a more fundamental property of motion.

There have been discussions of several possible sources for this advantage which might be found either during the study phase, or in the test of recognition. During the learning or study phase, dynamic sequences may build up a representation that is based on 3D or invariant properties, or which might even comprise an abstract description of the characteristic manner of gesturing (of either speech acts, or the production of emotional expression). At test, dynamic sequences might be useful as they may provide a greater overlap with the stored description (by normalising the information presented, so that the particular face viewed at test can be judged as either a legitimate approximation of one of the items stored in memory, or rejected). A dynamic test condition may instead provide access to the 3D or the invariant representation stored, because the test sequence itself comprises the same type of description (i.e. recognition reflects some property of the classification of learning conditions). Finally, motion at test may be beneficial as it captures idiosyncratic patterns of dynamic changes within the configuration, which are compared with specific descriptions of characteristic articulatory movements (rhythm, timing and amounts) of the face of each person we know.

Does Movement Simply Provide More Instances?

In order to assess whether benefits found were due to movement per se, or simply additional instances, the amounts of information in both types of display needed to be equated. The first set of experiments used computer animation to show the same information content (i.e. the numbers of frames) in both the moving and the static learning phases of an incidental learning task. The study sequences lasted three seconds, and showed the (unfamiliar) actors performing either expressive gestures (internal feature changes), or rotations of the whole head in depth (global changes). At test, several factors were manipulated, including a change in viewpoint/plane between study and test phases, and the use of dynamic or fixed displays at test. Variations within the same viewpoint were tolerated (as there was no main effect of changing the expressive gesture between learning and test), but there were consistent detrimental effects on recognition as a result of a change in viewpoint. This suggests that the representation produced during learning was not based on 3D invariants, but rather on more instance-based aspects.

Experiments One to Four also showed that there was no preferential establishment of a representation on the basis of moving sequences (vs. that derived from static instances). However, there seemed to be some advantages in using movement at test, as there was a significant difference between the discriminability (A') measurements for those viewing dynamic test sequences compared with those viewing a single static frame.

Does Movement Help in Matching?

The investigation into possible benefits for motion in face processing then turned to a different type of task, that of matching. Images of unfamiliar faces were divided horizontally, and participants had to match these top and bottom halves on the basis of either identity or expression. It was expected that there would be no advantage for viewing moving sets of images when matching on the basis of identity, as the faces were unknown to the participants, but there were benefits expected for matches made on the expression/s shown.

This was indeed the case, as significantly more correct expression-match decisions were made in the moving trials than in the static conditions. It was suggested that this was due to cues being revealed in each dynamic element of the face during the production of the expressive gestures; such unambiguous classification was only possible by using each element to refer to a stored representation in memory of a complete face showing ‘a sad’ or ‘a disgusted’ expression. The expression shown in the single static image of the apex (end-point) of the gesture would be more questionable.

In addition, the predicted main effect of Task was found, with significantly more correct decisions made by participants in the expression-matching conditions compared to those making identity-matching decisions. There was no overall advantage for the use of moving displays; yet within the groups of participants matching for expression, there were significantly more Hits (correct match detections) scored in those conditions where moving trials were shown than those where static images were used, as predicted.

The level of performance within the participants in the identity-matching conditions was limited, but not at floor, i.e. they were able to carry out sufficient, but rather limited, extrapolation in order to complete the task. Therefore, in Experiment Five, when the faces were positively unknown, motion was only useful in accessing a description for an expression (perhaps by showing what was typical in such a gesture); it was not useful in matching the trials for identity.

In order to increase performance levels, the next experiment provided participants with a learning phase, prior to the matching trials. The full faces of the actors used in the examination were seen for a total of ten seconds in both moving and static displays. In Experiment Six, after this pre-exposure, there was a significant increase in the percentage of correct decisions made to dynamic trials, compared with those shown as static images. This showed that movement is useful in <u>accessing</u> an <u>established</u> representation, whether that was of a <u>person</u>, or of an emotional <u>expression</u>. This reinforced the suggestion from Experiments One to Four that movement might help in tapping a description in memory (where significantly higher A' was found in the dynamic test conditions).

Does Movement Help Familiar Face Identification?

Experiments Seven to Nine were undertaken to assess whether movement could be beneficial in accessing well-established representations, i.e. for highly familiar faces (film and media personalities). Both inversion and negation are known to disrupt the processing of identity, and there was an initial discussion of the sources of the effects these format manipulations. It was proposed that recognition of famous faces tested in such displays could be assisted by using moving sequences, as there may be cues to the underlying structure in these displays, but these advantages might be mediated by different mechanisms. If it was found to be the case that motion only assisted the recovery of configural details, it would reduce the effects of inversion; if motion only assisted the recognition of faces shown as negated images, it may be due to the re-instatement of the 3D information no longer available via shape-from-shading. However, if advantages for motion were found across both types of manipulation, then another type of mechanism would be in operation.

A series of three experiments investigated the effects of motion on the identification of famous faces: the first found a significant overall advantage in favour of a test using dynamic sequences. Although there were significantly fewer faces recognised in the negative format, movement was found to help recognition in both types of manipulation, as there was no interaction (between presentation and the type of format). This contrasted with the findings of Knight and Johnston (in press), who only found advantages for movement in the recognition of negated images. As these reported benefits may have been due to additional sources of information compared with the content in the static test conditions, Experiment Eight in the thesis increased the number of static frames used. The significant advantage for motion persisted, even with additional static information, so the effects do not appear to be due to the extra instances provided by the moving sequences. The same magnitude and significance of the benefit for motion was found in Experiment Nine, which combined negative and inverted image manipulations.

This pattern of results was initially discussed in terms of benefits for motion at test simply providing a more generalised (3D) description, which may be used to access the stored representation; such differences were also discussed in terms of dynamic cues to characteristic movements of the face. In the latter case, the timing, size, and the manner (or order) in which these idiosyncratic variations were produced should be equally recoverable from inverted and negated images.

Consequently, perhaps participants were recognising the idiosyncratic gestures which gave cues to the identity of the person in these format manipulations. This could be an explanation of the principle which makes impersonation successful. Provided the rhythm and timing of the production of such dynamic changes can be replicated, the character portrayed behind that pattern of facial articulation should be revealed. An alternative suggestion was made, that the amounts by which these changes occurred was the important aspect of motion, i.e. that the dynamic trajectories of the configuration assisted in recognition under these difficult conditions.

Several methods of assessing which of these cases might prevail was outlined: a reversal of the direction in which the video footage was played, and rotation of the image sequences in the picture plane. If the cues lie in the manner in which these variations occur, then a reversal of the order in which such changes are articulated should interfere with the extraction of these proposed individual patterns. In such conditions, recognition rates from manipulated images would be lower in trials where the footage is reversed, compare to sequences played as normal. If the image-manipulated footage was shown at an angle, then the way in which these moving changes are produced should be less easy to extract (which might result in more errors, or slower naming or response times). It is predicted that movement might be beneficial at zero and 180 degrees of rotation, but not at stages in between.

If movement is beneficial under format manipulations because the relative amounts of change are preserved in such displays, then a reversal of the direction should not interfere with the extraction of these details of trajectories, and there should be no differences between recognition rates from sequences played forward or reversed when the footage shows format-manipulated images. Such quantitative descriptions should be comparatively unaffected by rotation in the picture plane.

These experiments did highlight that movement was more successful than static instances in accessing an established representation in memory in conditions where the actual task of recognition was more complex than is normally found to be the case. The processing of familiar faces under such format manipulations may have been enhanced by the use of motion, as such sequences capture facial actions which are idiosyncratic and fundamentally dynamic.

Does Movement Help in Familiarisation?

The studies carried out so far had found advantages for motion when testing the recognition of previously unfamiliar faces; when testing the ability to match parts of pre-familiarised (but previously novel) faces for both expression and identity; and finally, in testing the recognition of famous faces shown under format manipulations. The last experiment showed that motion was again beneficial when used to access an established facial representation, in conditions where recognition was tested using the format manipulations of inversion and negation.

Experiment Ten also provided further evidence to support the indication that advantages for motion are not simply a product of more information, as there were no significant differences between the overall recognition rates after viewing moving vs static sequences, or short vs long durations, nor was there a significant interaction between the duration and type of training variables.

It had been proposed that famous people might be recognised more easily on the basis of idiosyncratic dynamics (when tested under format manipulations). However, it was not clear from Experiments Seven to Nine if the important component in such dynamic patterns was the manner of production (rhythm or timing), or the amounts of changes produced within each particular face; yet presumably, such a description in memory could only be achieved or initiated after a substantial period of training. If previously novel faces were sufficiently familiarised, then the same patterns of results should be found across experimental manipulations. Although there was no main effect of the duration of training, there was a (just) significant interaction (with p= 0.05), in favour of long training phases when the test comprised a dynamic sequence. This might be considered as analogous to those results found for highly familiar faces.

The advantages found for testing familiar faces using moving sequences may be due to accessing a pre-existing representation comprising dynamic patterns of characteristic gestures (either articulatory speech or emotional expression); recognition would then be based on cues regarding motion, such as the rhythm and timing of the changes across the face. If the latter was the case, the description of changes may either involve the distances, the actual amounts of change (i.e. the trajectories of various parts of the face, such as the corners of the mouth), or the manner in which these changes occur.

However, it is unlikely that this mediated the advantages for motion found during the test of <u>un</u>familiar faces in Experiment Ten, as this benefit was found across both moving and static learning phases. Therefore we cannot fully accept the proposal concerning idiosyncratic gesture patterns applies to unfamiliar face recognition, as it would be difficult to justify how such qualities could be derived from faces learned as a single static image or as a series of three static images.

Perhaps the way to resolve this complex issue is to accept one of the alternative explanations offered earlier, which proposed that movement during test phases is beneficial as it provides an overlap which can be normalised with respect to the stored description; this overlap at test would be produced for familiar and unfamiliar faces alike. A static test phase of unfamiliar face recognition may rely more on pictorial encoding, but as many viewing occasions are available in memory for familiar faces, the pictorial aspects of processing are less dominant.

However, this advantage for dynamic test presentations is not as straightforward as may seem, as the results illustrate a consistent bias in responding, and also an interaction involving the Presentation at test and Duration of training variables. An examination of the A' interaction between the type of learning sequence, and the presentation at test in Experiment Ten, showed that the poorest levels of discrimination were found for participants in conditions where target faces were learned from moving sequences and were tested with fixed images. This illustrates that although the learning phase provided an opportunity to sample a variety of changes across the face, there was poor generalisation when a novel example was shown in the recognition phase (as the image shown at test was outside the range experienced during the study phase); which is further evidence that motion is not important in establishing a representation in memory. In contrast, the highest A' was found where faces were learned in static and tested with a fixed image, which suggests some element of context specificity.

In conjunction with the results from the famous face experiments, it might now be concluded that recognition may ultimately be a function of the encoding situation, i.e. the manner in which the faces were originally learned (as we will certainly have some experience of famous faces in dynamic sequences). Alternatively, motion may be advantageous in that it provides a general overlap with the specifics of the information stored, and it does not distinguish exactly how that representation was formed. In the case of unfamiliar face recognition, it will therefore be difficult to measure any clear advantage a dynamic test might afford, because of the relatively unusual learning conditions (such as limited exposure to single, or multi-static images).

Overall, these studies have shown that where advantages for motion exist, they do not appear to be products of merely processing more individual images, but rather due to a more fundamental property, by portraying trajectories which provide potential information about likely or legitimate changes that can occur.

These favourable sources of information may be redundant when adequate structural cues are available, which indeed they are in the majority of situations; if the extraction of such a description is not possible, e.g. when recognition is examined under viewing conditions which are less than optimal, movement at test seems to provide cues which help to re-instate them. Other aspects of face processing, such as expression analysis and lip-read speech also seem to be encoded as a patterns of activity. However, the processing of identity only seems to maximise this dynamic information at test by providing an overlap with the stored description (rather than matching it precisely), or by giving cues to a permissible range of activity, by passing through some of the typical, or possible events at the point of access to the stored representation.

Practical Implications

There are a number of possible practical implications as a result of these studies, primarily in the field of eye-witness testimony and face recognition. As it seems that the effects of motion are not simply due to a large collection of static instances, but that important cues can be derived from the way in which those instances are seen dynamically as the face is articulated (either the manner, or the amount of movement). This implies that the use of dynamic test sequences needs to be considered when 'witnesses' are attempting to identify the 'perpetrator' of the crime. This is of particular importance when we consider that the resolution of security cameras is often poor (e.g. Aldridge and Knupfer, 1994), and the provision of movement may help to re-instate some of the impoverished structural details available in such footage.

Work currently in progress aims to assess the effects of image quality on recognition (undertaken at Stirling University by Karen Lander): this research will have implications for the use of CCTV (closed circuit television) surveillance techniques in a criminal setting. A variety of investigations is being carried out: firstly the effects of movement on the recognition of familiar famous faces which are shown at distances of 1.5 and three metres, using moving and static displays of between ten and twenty pixels per face. The results suggest that there are higher recognition rates in conditions where the displays are seen in motion (higher naming rates, or discrimination between famous, i.e. familiar, and unfamiliar faces). Other aspects of this series should consider whether facial movements depicting speech acts are more beneficial than expressive acts in determining identity of a person; also the length time and minimal resolution required to recognise a familiar person by their body movements alone, when the face is replaced by a series of pixels, or is blurred. Such investigations will point to whether movement in general is beneficial, or whether specific types of movement are more useful than others in distinguishing a particular person (e.g. articulatory speech vs expressive gesturing).

Future Research

It is important for future research to ascertain the nature of the gestures which provide important information about idiosyncratic dynamics, whether it lies in the articulatory movements found during speech, or the emotions that pass across the face during our observations. Whichever is the case, we must determine if the important factor is the manner in which the changes occur, or the amounts of change which occur. In order to assess if it is the manner of production which defines these characteristic gesture patterns, the rhythm and the timing of the movements could be interrupted, or interfered with. Lander (work in progress) is investigating the effects on recognition brought about by slowing down the rate at which famous faces are displayed in motion (whilst shown under format manipulations) and also the effects of disruption to the coherent dynamics themselves by repeating only some of the frames which constitute such sequences. The prediction is that recognition will be affected due to the disturbance of the rhythm and timing of production of such gestures, by interrupting the perception that a smooth (and presumably), typical gesture was being produced. Of further interest would be a comparison between recognition rates based on distorted motion patterns showing articulatory gestures and disrupted dynamic expressive acts (again where ceiling rates of recognition were avoided by format manipulations, including the rotation of the images in the picture plane). It was suggested earlier in the thesis that playing the moving footage of manipulated format images in reverse might resolve the question of whether speech gestures or expressive gestures were more useful in identification of familiar faces under unusual conditions, as a reversed moving sequence might distort the 'normal' dynamics of production.

An alternative method might be to use dynamic footage of impressionists, which is subjected to these same image manipulations.

Providing the identity of each character portrayed was possible using normally presented footage, as they are conveying the 'characteristic' gestures adequately, then when these inverted or negated images are shown, we should find rates of identification which begin to approach those found when that actual person is shown. An alternative type of format manipulation could be the use of pixelated or quantized images, i.e. decreasing the number of pixels used to display the sequences; any cues to the underlying identity could only be recovered using the form-from-motion algorithm presumed to be in operation when images are shown in negative.

More generally, if familiarity depends on the coding of internal feature descriptions, then we need to determine if it is the articulatory or the expressive acts alone which are more important, and distinct areas of the face may have differential importance depending on the process being undertaken, such as verbal communication. If we are sensitive to articulatory movements as cues to identity, then the attention we devote to certain areas of the face when listening may be different compared to where we look to on the face when interpreting expressive gestures which might reveal the true emotional state of that particular person.

One way to assess this would be to study patterns of eye-movements under different presentation conditions, such as comparing where attention is focused on in moving and static displays, and possibly attention to 'live' dynamic faces vs areas of interest in dynamic video or format-manipulated images of faces. This might reveal whether advantages for motion are simply a reflection of altered levels of attention (which might result in different mechanisms being used). Alternatively, the benefits might be robust, as any dynamic sequences may facilitate referral to the stored representation using a more abstract process, i.e. an overlap, not an exact match, with the stored representation.

If the role of motion is defined in terms of providing an overlap which helps to identify known category members under difficult circumstances, but not under ideal viewing conditions, it should be beneficial in distinguishing between familiar and unfamiliar distractor faces which are only seen at test. This condition could be applied as an extension to either the famous face experiments or to the matching experiments. If unfamiliar faces were incorrectly identified as being familiar only in the dynamic trials, this may be because the overlap approximates to a description resembling that of a famous person, and where the (presumably low level of) activation of that identity would bias participants to feel as though the face is familiar. A comparison between confidence ratings to correct and incorrect identifications would also illustrate if this was the case.

If the matching experiments were actually successfully achieved by accessing a stored representation in memory for a face (as was proposed), then participants should not be able to match any faces on identity which were not seen in the pre-familiarisation phase (as indeed was shown in Experiment Five). However, because the findings in this thesis point to a bias in responding to dynamic sequences, there is a prediction that a bias in responding to novel faces shown in motion might also be found. An examination of the FP's and signal detection measurements should provide further evidence whether there is simply a tendency to answer positively (but incorrectly) when any test faces are seen moving. The overlap which was proposed as an explanation of the general advantages for motion at test might further complicate the issue, by providing a less than distinct description of permissible candidates; where the faces are relatively unfamiliar, the generally ambiguous nature of their stored differences may need to be tapped more acutely.

The series of findings reported in this thesis have been complex, but perhaps the main message is that unless visually presented image displays are manipulated to show the same numbers of frames in both moving and static presentations, there will be more sources of information embedded in the dynamic presentations; this might lead to an inappropriate account of any advantages found for such sequences. What has been shown is that there are supplementary cues to processing given by the actual movements themselves, e.g. the temporal and spatial relationships. Such information may be useful under some circumstances (e.g. the recognition of familiar faces) but not others (such as building a representation in memory for an unfamiliar face). In particular, this has implications for future research into the exact nature of the stored representation for faces, and the ways that such a description might be maximally activated. Finally, it is hoped that this thesis has highlighted the importance in continuing to investigate the effects of facial movement, particularly as advances in technology allow for increasingly sophisticated manipulation of moving images: this might further clarify the role of dynamic information in face processing.

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Appendix One

Excerpts from the Xrastool reference manual

Name

xrastool - animate rasterfiles in an Xview window

Synopsis

xrastool [generic_options] [other_options] filename ...]

Description

xrastool is an animation package written in Xview. Currently only the 8-bit Sun Rasterfile (RLE or standard) image format is supported, but many other formats can be converted into 8-bit rasterfiles using the PMBplus image utilities, or xv. xrastool provides the used with an Xview panel interface for convenient access to animation, display and colormap functions. There are a number of options to help maximise the display rate. On an unloaded Sparc IPX running twm under X11R5, a display rate of 50 frames/sec can be achieved with 400x400 8-bit images. These speeds are obtained by first loading the rasterfiles into client-resident Ximages then transferring them to the server-resident pixmaps. Consequently, the maximum number of frames displayable (and hence the duration of the animation) is limited only by the core memory available to the server.

Layout

xrastool consists of two panels, a canvas frame for displaying images and a pop-up info window. When invoked without any options or filenames specified, xrastool displays the Main Panel in its default state. If any images were specified and at least one was loaded successfully, the first will be displayed in the Canvas frame, also in the default state. The cursor is moved automatically to point to the More... button (see below) on the Main Panel for convenience. This also ensures that the colormap is displayed correctly fort he first image by forcing the window manager to load xrastool's colormap segment. The Sub Panel and Info window can be called up from the Main Panel. The following two sections describe the control panels in detail.

Section 1: the Main Panel

The Main Panel contains all the controls needed to prepare and run an animation. Features include image loading facilities, sizing controls, timer controls, and cycling buttons. Note that any equivalent command-line options are given in parentheses beside the control name.

Image # (-start)

The current image number is shown here and may be modified, either by using the text field or the incremental buttons. Only numbers in the range 1 to N, where N is the number of images loaded, are accepted as input.

Load

Clicking this button will cause xrastool to load the image shown in the Image field. The image will be assigned the image number shown in the Image # filed, so Load can be used to replace existing images if desired. Note that if there is insufficient server memory to store the image, the functions XCreateImage () or XCreatePixmap () function may abort with an error.

Image

The filename of the current image is displayed in the text field. Typing a new filename and pressing RETURN or clicking on Load instructs xrastool to replace the current image with the contents of the specified rasterfile. A new image can be appended to the existing set by first clicking on New, then supplying the new filename.

Width (-w (width))

This is the image width field. Changing this number either using the text field or the incremental buttons causes the current Sizing option to change to Fixed. Any existing image will have its frame adjusted to accommodate the new size.

H (-h (height))

The height of the Canvas frame can be adjusted with this control, in the same way as the width (W)

Set

This means the frame size can be adjusted by first using the mouse (e.g. dragging the resize corners if the window manager is olwm) and then clicking on Set. This button also causes Fixed to be selected automatically.

Timer Slider (-timervalue (timer))

This slider is used for fine adjustments of the delay timer of animations, The range is 1 to 999 in the units selected on the Timer Scale. The value can be set using the text field or by dragging the slider control. Unit increments or decrements can be performed by clicking either side of the control.

Fast (-fast)

Fast mode can be selected by pressing this button. This sets Fixed sizing, us timer scale, unit timer value, and many of the options of the Sub Panel. In this mode, xrastool will display frames at the fastest possible rate.

Direction (-fwd -rev)

Cycling direction can be toggled between forward (FWD) and reverse (REV) using this control. Blink mode and the Loop Back and One Way cycling options will take over direction control when invoked.

Step

Clicking on this button will display either the next or previous image depending on the Current Direction. The step function is called internally when animating

Blink (+ | -blink)

This button toggles blinking on and off. The current image and the next or previous image are blinked at the current display rate.

Cycle (+ | -cycle)

This button displays the stored images in sequence, subject to the current Direction, Cycling Option and display rate. The animation can be stopped by clicking in Cycle again.

Cycling Option

There are three choices of cycling option:

1) Loop (-loop)

This is the default. When the end of the current sequence of images is reached, cycling continues from the beginning ad infinitum.

2) Loop Back (-loopback)

When the end of the current sequence of images in reached, the current Direction is reversed and cycling continues.

3) One Way (-oneway)

When the end of the current sequence of images is reached, cycling is terminated. Clicking on Cycle again will repeat the sequence, starting with the first or last image, depending on the current Direction.

More ... (+ | -subpanel)

This pops up the Sub Panel.

Refresh

Clicking here redisplays the current image. It is useful if the window manager has corrupted the image display for whatever reason.

Quit

Clicking here terminates the xrastool session.

Section 2: the Sub Panel

When selected using More ... on the Main Panel, or by including the -subpanel option on the command line, the Sub Panel is displayed. The user can perform various fine-tuning operations, e.g.

No Moving (+ | -moving)

When an image is to be displayed, xrastool attempts to reposition the frame so that no part of the image will be off-screen. Selecting No Moving disables this behaviour.

No Updates (+ | --updates)

Normally when cycling, the Image and # Image fields as well as the size fields and Main Panel footer are updated between images. Selecting No Updates disables this behaviour when cycling.

Centering (+ | -centering)

When selected, and if the Sizing is fixed, the current image and all subsequently displayed images will be centred in the display frame, assuming the frame is larger than the image. Any gaps will be filled with the current backdrop.

Cutoff (-cutoff)

With this option, the sliders control the pixel value above which no colours are displayed. Hence, the first color in the colormap can be displayed by setting the slider to 1. All colours are displayed for a setting of 100 (the default). In a future release, the colormap will be sorted in order of usage, so that the most or least 'important' colors can be screened out using the Cutoff option.

Hints

For best results, never exceed the core memory of the server when loading images. Swapping will make the animator painfully slow. Even with more careful use of memory, xrastool may need to perform one or even two cycles through the images before the animation becomes smooth.

History

xrastool replaces its Sunview predecessor rastool, which was never officially released. These tool were designed in partial fulfilment of the authors PhD thesis

Copyright

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Appendix Two

Instructions to actors generating posed expressions in Experiments Five, Six and Ten

Surprise

Raise and curve eyebrows

Eyes open wide

Jaw drops, slight widening

Fear

Raise eyebrows in the middle (opposite to frown gesture)

Narrow eyes

Teeth showing, lips drawn back and corners slightly drawn down

Disgust (2 types)

1) Gustatory

Brows drawn down

Eyes wide

Nostrils flared

Mouth wide, with bottom jaw dropped, and tongue sticking out

2) Olfactory

Brows down

Eyes slightly closed

Nostrils pinched

Mouth slightly open, tongue just visible

Anger

Brows drawn down, and together in the middle

Eyes wide

Nostrils flared

Mouth closed, lips pursed tight

Happiness

Cheeks raised

Raise corners of mouth

Flare nostrils slightly

Sadness

Eyebrows frowning

Eyes slightly closed

Corners of mouth pulled downwards

Bottom lip protruding slightly

Appendix Three

List of targets and distractor names in Experiments Seven, Eight and Nine

Thank you for agreeing to take part in this experiment.

The following people may be presented to you:

Clive Anderson
Rory Bremner
David Attenborough
Anthony Hopkins
Noel Edmonds
David Bellamy
Stephen Fry
Kenneth Brannagh
Bruce Forsyth
Hugh Laurie
Mel Gibson
Tony Slattery
Ronnie Barker
Kevin Kline
Desmond Morris
Pavarotti
Michael Douglas
Spike Milligan

Zsa Zsa Gabor
Gloria Hunniford
Marilyn Monroe
Esther Rantzen
Roseanne Barr
Dawn French
Tracy Ullman
Goldie Hawn
Jodie Foster
Jennifer Saunders
Helena Bonham-Carter
Cher
Josie Lawrence
Joanna Lumley
Michelle Pfeifer
Emma Thomson
Ruby Wax
Demi Moore

Appendix Four

Information given to participants during training phases Experiment Ten

Name:	Age:	Faculty	Favourite Sport	Favourite Band:
1 Donald	23	Science	Football	Rolling Stones
2 Richard.	26	Arts	Badminton	Alanis Morrisett
3 Fiona	24	Science	Swimming	Rod Stewart
4 Kevin	25	Arts	Cycling	Levellers
5 Rachael	26	Science	Swimming	George Michael
6 Martin	25	Arts	Cycling	Beatles
7 Graeme	25	Science	Squash	Del Amitri
8 Frances	24	Arts	Hockey	M People
9 Paula	23	Arts	Badminton	Madonna
10 Sharron	23	Science	Squash	Oasis
11 Marion	24	Science	Swimming	Lightning Seeds
12 Howard	26	Arts	Hockey	The Who

Appendix Five: ANOVA tables

Experiment One: Hit rates

```
SOURCE: grand mean
view   expre  presn        N    MEAN      SD       SE
                           80   64.5000   22.9419  2.5650

SOURCE: view
view   expre  presn        N    MEAN      SD       SE
FF                         40   73.0000   21.5073  3.4006
PROF                       40   56.0000   21.3397  3.3741

SOURCE: expression
view   expre  presn        N    MEAN      SD       SE
        same               40   67.0000   23.3370  3.6899
        diff               40   62.0000   22.5548  3.5662

SOURCE: view expression
view   expre  presn        N    MEAN      SD       SE
FF      same               20   76.0000   20.1050  4.4956
FF     diff                20   70.0000   22.9416  5.1299
PROF   same                20   58.0000   23.3057  5.2113
PROF   diff                20   54.0000   19.5744  4.3770

SOURCE: presnt
view   expre  presn        N    MEAN      SD       SE
              move         40   63.0000   23.7724  3.7588
               static      40   66.0000   22.2803  3.5228

SOURCE: view presnt
view   expre  presn        N    MEAN      SD       SE
FF            move         20   73.0000   22.7342  5.0835
FF            static       20   73.0000   20.7998  4.6510
PROF          move         20   53.0000   20.7998  4.6510
PROF          static       20   59.0000   21.9809  4.9151

SOURCE: expression presnt
view   expre  presn        N    MEAN      SD       SE
       same   move         20   70.0000   22.9416  5.1299
       same   static       20   64.0000   23.9297  5.3508
       diff   move         20   56.0000   23.0332  5.1504
       diff   static       20   68.0000   20.9259  4.6792
```

```
SOURCE: view expression presnt
view   expre  presn       N    MEAN      SD       SE
FF     same   move        10   82.0000   17.5119  5.5377
FF     same   static      10   70.0000   21.6025  6.8313
FF     diff   move        10   64.0000   24.5855  7.7746
FF     diff   static      10   76.0000   20.6559  6.5320
PROF   same   move        10   58.0000   22.0101  6.9602
PROF   same   static      10   58.0000   25.7337  8.1377
PROF   diff   move        10   48.0000   19.3218  6.1101
PROF   diff   static      10   60.0000   18.8562  5.9628

FACTOR:   subj     view       expression  presnt    score
LEVELS:    40       2             2          2      80
TYPE  :RANDOM  BETWEEN  BETWEEN  WITHIN  DATA
SOURCE            SS         df        MS          F         p
===============================================================
view         5780.0000    1    5780.0000     12.626    0.001 **
s/ve         16480.0000   36    457.7778

express     500.0000      1     500.0000     1.092     0.303
s/ve       16480.0000     36     457.7778

ve          20.0000       1      20.0000     0.044     0.836
s/ve       16480.0000     36     457.7778

presnt      180.0000      1     180.0000     0.389     0.537
ps/ve      16640.0000     36     462.2222

vp          180.0000      1     180.0000     0.389     0.537
ps/ve      16640.0000     36     462.2222

ep          1620.0000     1     1620.0000    3.505     0.069
ps/ve      16640.0000     36     462.2222

vep         180.0000      1     180.0000     0.389     0.537
ps/ve      16640.0000     36     462.2222
```

Experiment One: False Positives

```
SOURCE: grand mean
view        expression   N    MEAN      SD       SE
                         40  28.5000  12.9199  2.0428

SOURCE: view
view        expression   N    MEAN      SD       SE
FF                       20  25.0000  12.7733  2.8562
PROF                     20  32.0000  12.3969  2.7720

SOURCE: expression
view        expression   N    MEAN      SD       SE
               same      20  26.0000  10.9545  2.4495
               diff      20  31.0000  14.4732  3.2363

SOURCE: view expression
view        expression   N    MEAN      SD       SE
FF             same      10  23.0000   9.4868  3.0000
FF             diff      10  27.0000  15.6702  4.9554
PROF           same      10  29.0000  11.9722  3.7859
PROF           diff      10  35.0000  12.6930  4.0139

FACTOR:     subj      view      expression    rate
LEVELS:     40        2           2           40
TYPE :   RANDOM    BETWEEN     BETWEEN       DATA

SOURCE          SS        df       MS        F        p
=========================================================
view         490.0000     1    490.0000    3.062    0.089
s/ve        5760.0000    36    160.0000

expression   250.0000     1    250.0000    1.562    0.219
s/ve        5760.0000    36    160.0000

ve            10.0000     1     10.0000    0.062    0.804
s/ve        5760.0000    36    160.0000
```

Experiment One: Items analysis

```
SOURCE: grand mean
view  expression    presn   N   MEAN      SD       SE
                           80  64.5000  23.5947  2.6380

SOURCE: view
view  expression    presn   N   MEAN      SD       SE
FF                         40  73.0000  17.2760  2.7316
PROF                       40  56.0000  26.0965  4.1262

SOURCE: expression
view  expression    presn   N   MEAN      SD       SE
      same                 40  67.0000  25.0333  3.9581
      diff                 40  62.0000  22.0954  3.4936

SOURCE: view expression
view  expression    presn   N   MEAN      SD       SE
FF    same                 20  76.0000  16.6702  3.7276
FF    diff                 20  70.0000  17.7705  3.9736
PROF  same                 20  58.0000  28.9464  6.4726
PROF  diff                 20  54.0000  23.4857  5.2516

SOURCE: presn
view  expression    presn   N   MEAN      SD       SE
                    move   40  63.0000  24.6202  3.8928
                    static   40  66.0000  22.7359  3.5949

SOURCE: view presn
view  expression    presn   N   MEAN      SD       SE
FF                  move   20  73.0000  17.5019  3.9135
FF                  static   20  73.0000  17.5019  3.9135
PROF                move   20  53.0000  26.9698  6.0306
PROF                static   20  59.0000  25.5260  5.7078

SOURCE: expression presn
view  expression    presn   N   MEAN      SD       SE
      same          move   20  70.0000  28.6540  6.4072
      same          static   20  64.0000  21.1262  4.7240
      diff          move   20  56.0000  17.8885  4.0000
      diff          static   20  68.0000  24.6235  5.5060
```

```
SOURCE: view expression presn
view   expression   presn    N   MEAN      SD       SE
FF     same         move    10   82.0000   14.7573   4.6667
FF     same         static  10   70.0000   16.9967   5.3748
FF     diff         move    10   64.0000   15.7762   4.9889
FF     diff         static  10   76.0000   18.3787   5.8119
PROF   same         move    10   58.0000   34.5768  10.9341
PROF   same         static  10   58.0000   23.9444   7.5719
PROF   diff         move    10   48.0000   16.8655   5.3333
PROF   diff         static  10   60.0000   28.2843   8.9443

FACTOR:     face     view      express   presn    hits
LEVELS:      10        2          2        2       80
TYPE  : RANDOM    WITHIN    WITHIN    WITHIN    DATA

SOURCE          SS        df      MS         F        p
===============================================================
view         5780.0000    1   5780.0000   14.370   0.004 **
vf/          3620.0000    9    402.2222

expression    500.0000    1    500.0000    0.918   0.363
ef/          4900.0000    9    544.4444

ve             20.0000    1     20.0000    0.023   0.882
vef/         7780.0000    9    864.4444

presn         180.0000    1    180.0000    0.618   0.452
pf/          2620.0000    9    291.1111

vp            180.0000    1    180.0000    0.384   0.551
vpf/         4220.0000    9    468.8889

ep           1620.0000    1   1620.0000    4.585   0.061
epf/         3180.0000    9    353.3333

vep           180.0000    1    180.0000    0.384   0.551
vppf/        4220.0000    9    468.8889
```

Experiment One: A'

```
SOURCE: grand mean
view   expre  presn    N     MEAN      SD       SE
                       80   0.5842   0.0947   0.0106

SOURCE: view
view   expre  presn    N     MEAN      SD       SE
FF                     40   0.6235   0.1004   0.0159
PROF                   40   0.5450   0.0703   0.0111

SOUCE: expression
view   expre  presn    N     MEAN      SD       SE
       same            40   0.6027   0.1040   0.0165
       diff            40   0.5657   0.0816   0.0129

SOURCE: view expression
view   expre  presn    N     MEAN      SD       SE
FF     same            20   0.6425   0.1025   0.0229
FF     diff            20   0.6045   0.0970   0.0217
PROF   same            20   0.5630   0.0916   0.0205
PROF   diff            20   0.5270   0.0328   0.0073

SOURCE: presentation
view   expre  presn    N     MEAN      SD       SE
              move     40   0.5810   0.0929   0.0147
              static     40   0.5875   0.0976   0.0154

SOURCE: view presentation
view   expre  presn    N     MEAN      SD       SE
FF            move     20   0.6260   0.1029   0.0230
FF            static     20   0.6210   0.1004   0.0224
PROF          move     20   0.5360   0.0534   0.0119
PROF          static     20   0.5540   0.0844   0.0189

SOURCE: expression presentation
view   expre  presn    N     MEAN      SD       SE
       same   move     20   0.6140   0.1062   0.0237
       same   static     20   0.5915   0.1033   0.0231
       diff   move     20   0.5480   0.0643   0.0144
       diff   static     20   0.5835   0.0941   0.0210

SOURCE: view expression presentation
view          expre  presn    N     MEAN      SD       SE
FF            same   move     10   0.6700   0.1105   0.0349
FF            same   static     10   0.6150   0.0911   0.0288
```

```
FF        diff   move    10   0.5820   0.0766   0.0242
FF        diff   static   10   0.6270   0.1135   0.0359
PROF      same   move    10   0.5580   0.0681   0.0215
PROF      same   static   10   0.5680   0.1141   0.0361
PROF      diff   move    10   0.5140   0.0171   0.0054
PROF      diff   static   10   0.5400   0.0400   0.0126

FACTOR:   subj        view   expression   presentation   score
LEVELS:   40          2           2          2            80
TYPE :  RANDOM   BETWEEN   BETWEEN   WITHIN   DATA
SOURCE        SS   df       MS          F              p
===========================================================
view      0.1232   1     0.1232      15.891         0.000 ***
s/ve      0.2792   36     0.0078

express   0.0274   1     0.0274      3.530          0.068
s/ve      0.2792   36     0.0078

ve        0.0000   1     0.0000      0.003          0.960
s/ve      0.2792   36     0.0078

presnti   0.0008   1     0.0008      0.122          0.729
ps/ve     0.2500   36     0.0069

vp        0.0026   1     0.0026       0.381         0.541
ps/ve     0.2500   36     0.0069

ep        0.0168   1     0.0168      2.422          0.128
ps/ve     0.2500   36     0.0069

vep       0.0088   1     0.0088      1.270          0.267
ps/ve     0.2500   36     0.0069
```

Experiment One: B"

SOURCE: grand mean

view	expre	presn	N	MEAN	SD	SE
			80	-0.0742	0.3850	0.0430

SOURCE: view

view	expre	presn	N	MEAN	SD	SE
FF			40	-0.1425	0.4697	0.0743
PROF			40	-0.0060	0.2647	0.0419

SOURCE: expression

view	expre	presn	N	MEAN	SD	SE
	same		40	-0.1275	0.4324	0.0684
	diff		40	-0.0210	0.3279	0.0518

SOURCE: view expression

view	expre	presn	N	MEAN	SD	SE
FF	same		20	-0.2020	0.5121	0.1145
FF	diff		20	-0.0830	0.4280	0.0957
PROF	same		20	-0.0530	0.3314	0.0741
PROF	diff		20	0.0410	0.1712	0.0383

SOURCE: presentation

view	expre	presn	N	MEAN	SD	SE
		move	40	-0.0710	0.4032	0.0638
		static	40	-0.0775	0.3710	0.0587

SOURCE: view presentation

view	expre	presn	N	MEAN	SD	SE
FF		move	20	-0.1565	0.4946	0.1106
FF		static	20	-0.1285	0.4559	0.1020
PROF		move	20	0.0145	0.2716	0.0607
PROF		static	20	-0.0265	0.2630	0.0588

SOURCE: expression presentation

view	expre	presn	N	MEAN	SD	SE
	same	move	20	-0.1675	0.4747	0.1061
	same	static	20	-0.0875	0.3938	0.0881
	diff	move	20	0.0255	0.2980	0.0666
	diff	static	20	-0.0675	0.3568	0.0798

```
SOURCE: view expression presentation
view    expre presn   N    MEAN      SD      SE
FF      same  move    10  -0.3200  0.5367  0.1697
FF      same  static  10  -0.0840  0.4844  0.1532
FF      diff  move    10   0.0070  0.4111  0.1300
FF      diff  static  10  -0.1730  0.4470  0.1414
PROF    same  move    10  -0.0150  0.3688  0.1166
PROF    same  static  10  -0.0910  0.3045  0.0963
PROF    diff  move    10   0.0440  0.1333  0.0421
PROF    diff  static  10   0.0380  0.2101  0.0664

FACTOR:      subj    view      expression    presentation   score
LEVELS:       40       2            2              2          80
TYPE  :RANDOM  BETWEEN  BETWEEN    WITHIN DATA

SOURCE           SS    df        MS        F        p
=================================================================
view           0.3726   1     0.3726    2.499            0.123
s/ve           5.3683  36     0.1491

express        0.2268   1     0.2268    1.521            0.225
s/ve           5.3683  36     0.1491

ve             0.0031   1     0.0031    0.021            0.886
s/ve           5.3683  36     0.1491

presnti        0.0008   1     0.0008    0.006            0.940
ps/ve          5.2705  36     0.1464

vp             0.0238   1     0.0238    0.163            0.689
ps/ve          5.2705  36     0.1464

ep             0.1496   1     0.1496    1.022            0.319
ps/ve          5.2705  36     0.1464

vep            0.2952   1     0.2952    2.017            0.164
ps/ve                5.2705   36        0.1464
```

Experiment Two: Hits

```
SOURCE: grand mean
view   expre   condi   N    MEAN      SD        SE
                       64   64.3750   23.2225   2.9028

SOURCE: view
view   expre   condi   N    MEAN      SD        SE
FF                     32   78.1250   18.5677   3.2823
PROF                   32   50.6250   18.9970   3.3582

SOURCE: express
view   expre   condi   N    MEAN      SD        SE
       same            32   65.6250   24.4867   4.3287
       diff            32   63.1250   22.2069   3.9257

SOURCE: view express
view   expre   condi   N    MEAN      SD        SE
FF     same            16   81.2500   18.5742   4.6435
FF     diff            16   75.0000   18.6190   4.6547
PROF   same            16   50.0000   19.3218   4.8305
PROF   diff            16   51.2500   19.2787   4.8197

SOURCE: condition
view   expre   condi   N    MEAN      SD        SE
               move    32   65.6250   22.8512   4.0396
               still   32   63.1250   23.8865   4.2226

SOURCE: view condition
view   expre   condi   N    MEAN      SD        SE
FF             move    16   80.0000   16.3299   4.0825
FF             still   16   76.2500   20.9364   5.2341
PROF           move    16   51.2500   19.2787   4.8197
PROF           still   16   50.0000   19.3218   4.8305

SOURCE: express condition
view   expre   condi   N    MEAN      SD        SE
       same    move    16   67.5000   24.0832   6.0208
       same    still   16   63.7500   25.5278   6.3819
       diff    move    16   63.7500   22.1736   5.5434
       diff    still   16   62.5000   22.9492   5.7373
```

```
SOURCE: view express condition
view   expre  condi  N    MEAN       SD        SE
FF     same   move   8  85.0000   14.1421   5.0000
FF     same   still  8  77.5000   22.5198   7.9620
FF     diff   move   8  75.0000   17.7281   6.2678
FF     diff   still  8  75.0000   20.7020   7.3193
PROF   same   move   8  50.0000   18.5164   6.5465
PROF   same   still  8  50.0000   21.3809   7.5593
PROF   diff   move   8  52.5000   21.2132   7.5000
PROF   diff   still  8  50.0000   18.5164   6.5465

FACTOR:     subj     view      express    condition   score
LEVELS:      32       2           2          2          64
TYPE  :  RANDOM   BETWEEN   BETWEEN    WITHIN      DATA

SOURCE          SS          df       MS              F          p
=====================================================================
view        12100.0000      1   12100.0000      25.764   0.000 ***
s/ve        13150.0000     28     469.6429

express       100.0000      1     100.0000       0.213   0.648
s/ve        13150.0000     28     469.6429

ve          225.0000        1     225.0000       0.479   0.495
s/ve       13150.0000      28     469.6429

conditi     100.0000        1     100.0000       0.344   0.562
cs/ve      8150.0000       28     291.0714

vc           25.0000        1      25.0000       0.086   0.772
cs/ve      8150.0000       28     291.0714

ec           25.0000        1      25.0000       0.086   0.772
cs/ve      8150.0000       28     291.0714

vec         100.0000        1     100.0000       0.344   0.562
cs/ve      8150.0000       28     291.0714
```

Experiment Two: Items analysis

```
SOURCE: grand mean
view   expre  presn   N     MEAN       SD        SE
                     80   64.3750   29.1697   3.2613

SOURCE: view
view   expre  presn   N     MEAN       SD        SE
FF                   40   78.1250   24.7989   3.9210
PROF                 40   50.6250   26.8468   4.2449

SOURCE: express
view   expre  presn   N     MEAN       SD        SE
       same          40   65.6250   30.8468   4.8773
       diff          40   63.1250   27.7278   4.3841

SOURCE: view express
view   expre  presn   N     MEAN       SD        SE
FF     same          20   81.2500   24.1636   5.4032
FF     diff          20   75.0000   25.6495   5.7354
PROF   same          20   50.0000   29.2449   6.5394
PROF   diff          20   51.2500   24.9671   5.5828

SOURCE: presentation
view   expre  presn   N     MEAN       SD        SE
              move   40   65.6250   28.6935   4.5368
              static 40   63.1250   29.9505   4.7356

SOURCE: view presentation
view   expre  presn   N     MEAN       SD        SE
FF            move   20   80.0000   25.1312   5.6195
FF            static 20   76.2500   24.9671   5.5828
PROF          move   20   51.2500   24.9671   5.5828
PROF          static 20   50.0000   29.2449   6.5394

SOURCE: express presentation
view   expre  presn   N     MEAN       SD        SE
       same   move   20   67.5000   30.4570   6.8104
       same   static 20   63.7500   31.9076   7.1347
       diff   move   20   63.7500   27.4761   6.1438
       diff   static 20   62.5000   28.6770   6.4124
```

```
SOURCE: view express presentation
view   expre  presn   N    MEAN      SD       SE
FF     same   move    10   85.0000   21.0819  6.6667
FF     same   static  10   77.5000   27.5126  8.7003
FF     diff   move    10   75.0000   28.8675  9.1287
FF     diff   static  10   75.0000   23.5702  7.4536
PROF   same   move    10   50.0000   28.8675  9.1287
PROF   same   static  10   50.0000   31.1805  9.8601
PROF   diff   move    10   52.5000   21.8899  6.9222
PROF   diff   static  10   50.0000   28.8675  9.1287

FACTOR:     subj    view    express  presn    score
LEVELS:     10      2       2        2        80
TYPE  :  RANDOM  WITHIN  WITHIN  WITHIN   DATA

SOURCE        SS           df    MS           F        p
=====================================================================
view          15125.0000   1     15125.0000   22.806   0.001 **
vs/           5968.7500    9     663.1944

express       125.0000     1     125.0000     0.188    0.674
es/           5968.7500    9     663.1944

ve            281.2500     1     281.2500     0.698    0.425
ves/          3625.0000    9     402.7778

presn         125.0000     1     125.0000     0.298    0.599
ps/           3781.2500    9     420.1389

vp            31.2500      1     31.2500      0.167    0.693
vps/          1687.5000    9     187.5000

ep            31.2500      1     31.2500      0.096    0.764
eps/          2937.5000    9     326.3889

vep           125.0000     1     125.0000     0.128    0.729
veps/         8781.2500    9     975.6944
```

Experiment Two: False Positives

```
SOURCE: grand mean
view          exp    N    MEAN      SD       SE
                     32   28.1250   16.9320  2.9932

SOURCE: view
view          exp    N    MEAN      SD       SE
FF                   16   25.0000   17.8885  4.4721
PROF                 16   31.2500   15.8640  3.9660

SOURCE: exp
view          exp    N    MEAN      SD       SE
              same   16   24.3750   18.6078  4.6519
              diff   16   31.8750   14.7054  3.6764

SOURCE: view exp
view          exp    N    MEAN      SD       SE
FF            same   8    20.0000   23.2993  8.2375
FF            diff   8    30.0000   9.2582   3.2733
PROF          same   8    28.7500   12.4642  4.4068
PROF          diff   8    33.7500   19.2261  6.7975

FACTOR:    subj        view      exp        rate
LEVELS:    32          2         2          32
TYPE  :  RANDOM  BETWEEN  BETWEEN    DATA

SOURCE         SS         df       MS          F          p
===============================================================
view        312.5000      1     312.5000     1.084      0.307
s/ve       8075.0000     28     288.3929

exp         450.0000      1     450.0000     1.560      0.222
s/ve       8075.0000     28     288.3929

ve         50.0000        1      50.0000     0.173      0.680
s/ve       8075.0000     28     288.3929
```

Experiment Two: A'

```
SOURCE: grand mean
view  expre  presn   N    MEAN     SD      SE
                     64   0.5923   0.1124  0.0141

SOURCE: view
view  expre  presn   N    MEAN     SD      SE
FF                   32   0.6534   0.1271  0.0225
PROF                 32   0.5312   0.0429  0.0076

SOURCE: expression
view  expre  presn   N    MEAN     SD      SE
      same           32   0.6162   0.1369  0.0242
      diff           32   0.5684   0.0759  0.0134

SOURCE: view expression
view  expre  presn   N    MEAN     SD      SE
FF    same           16   0.6987   0.1501  0.0375
FF    diff           16   0.6081   0.0804  0.0201
PROF  same           16   0.5337   0.0413  0.0103
PROF  diff           16   0.5288   0.0456  0.0114

SOURCE: presentation
view  expre  presn   N    MEAN     SD      SE
             move    32   0.5953   0.1143  0.0202
             static  32   0.5894   0.1123  0.0199

SOURCE: view presntion
view  expre  presn   N    MEAN     SD      SE
FF           move    16   0.6600   0.1282  0.0321
FF           static  16   0.6469   0.1298  0.0324
PROF         move    16   0.5306   0.0402  0.0101
PROF         static  16   0.5319   0.0467  0.0117

SOURCE: expression presentation
view  expre  presn   N    MEAN     SD      SE
      same   move    16   0.6269   0.1452  0.0363
      same   static  16   0.6056   0.1321  0.0330
      diff   move    16   0.5637   0.0615  0.0154
      diff   static  16   0.5731   0.0898  0.0224
```

```
SOURCE: view expression presentation
view   expre  presn   N    MEAN     SD      SE
FF     same   move    8   0.7187  0.1529  0.0541
FF     same   static  8   0.6787  0.1549  0.0548
FF     diff   move    8   0.6012  0.0629  0.0222
FF     diff   static  8   0.6150  0.0989  0.0349
PROF   same   move    8   0.5350  0.0499  0.0176
PROF   same   static  8   0.5325  0.0341  0.0121
PROF   diff   move    8   0.5262  0.0307  0.0108
PROF   diff   static  8   0.5313  0.0591  0.0209

FACTOR:    subj       view     expression   presn     score
LEVELS:     32          2          2          2          64
TYPE :   RANDOM    BETWEEN    BETWEEN     WITHIN     DATA

SOURCE        SS      df     MS          F          p
=========================================================
view        0.2389    1    0.2389     16.881      0.000 ***
s/ve        0.3962   28     0.0142

express     0.0366    1    0.0366      2.585      0.119
s/ve        0.3962   28     0.0142

ve          0.0293    1    0.0293      2.072      0.161
s/ve        0.3962   28     0.0142

presn       0.0006    1    0.0006      0.179      0.675
ps/ve       0.0881   28     0.0031

vp          0.0008    1    0.0008      0.263      0.612
ps/ve       0.0881   28     0.0031

ep          0.0038    1    0.0038   1.193  0.284
ps/ve       0.0881   28    0.0031

vep         0.0021    1    0.0021   0.680  0.417
ps/ve       0.0881   28    0.0031
```

Experiment Two: B"

```
SOURCE: grand mean
view   expre  presn   N    MEAN      SD      SE
                      64  -0.0352   0.3897  0.0487

SOURCE: view
view   expre  presn   N    MEAN      SD      SE
FF                    32  -0.1469   0.5137  0.0908
PROF                  32   0.0766   0.1379  0.0244

SOURCE: expression
view   expre  presn   N    MEAN      SD      SE
       same           32  -0.0003   0.4563  0.0807
       diff           32  -0.0700   0.3128  0.0553

SOURCE: view expression
view   expre  presn   N    MEAN      SD      SE
FF      same          16  -0.0875   0.6274  0.1569
FF      diff          16  -0.2062   0.3796  0.0949
PROF   same           16   0.0869   0.1433  0.0358
PROF   diff           16   0.0663   0.1361  0.0340

SOURCE: presentation
view   expre  presn   N    MEAN      SD      SE
              move    32  -0.0266   0.3411  0.0603
              static  32  -0.0437   0.4383  0.0775

SOURCE: view presentation
view   expre  presn   N    MEAN      SD      SE
FF            move    16  -0.1262   0.4431  0.1108
FF            static  16  -0.1675   0.5899  0.1475
PROF          move    16   0.0731   0.1512  0.0378
PROF          static  16   0.0800   0.1280  0.0320

SOURCE: expression presentation
view   expre  presn   N    MEAN      SD      SE
       same   move    16  -0.0044   0.3974  0.0994
       same   static  16   0.0038   0.5219  0.1305
       diff   move    16  -0.0487   0.2854  0.0713
       diff   static  16  -0.0912   0.3462  0.0865
```

```
SOURCE: view expression presentation
view   expre  presn   N    MEAN      SD      SE
FF     same   move    8  -0.0925  0.5467  0.1933
FF     same   static  8  -0.0825  0.7379  0.2609
FF     diff   move    8  -0.1600  0.3453  0.1221
FF     diff   static  8  -0.2525  0.4298  0.1519
PROF   same   move    8   0.0837  0.1476  0.0522
PROF   same   static  8   0.0900  0.1489  0.0526
PROF   diff   move    8   0.0625  0.1642  0.0581
PROF   diff   static  8   0.0700  0.1126  0.0398

FACTOR:    subj     view      expression    presn    score
LEVELS:    32        2        2              2         64
TYPE  : RANDOM   BETWEEN   BETWEEN       WITHIN   DATA

SOURCE          SS    df       MS        F           p
=====================================================
view         0.7988    1    0.7988    4.126       0.052
s/ve         5.4212   28     0.1936

express     0.0777    1    0.0777     0.401       0.532
s/ve         5.4212   28     0.1936

ve           0.0385    1    0.0385    0.199       0.659
s/ve         5.4212   28     0.1936

presnti      0.0047    1    0.0047    0.041       0.840
ps/ve        3.1957   28     0.1141

vp           0.0093    1    0.0093     0.081      0.778
ps/ve        3.1957   28     0.1141

ep           0.0103    1    0.0103    0.090       0.767
ps/ve       3.1957   28    0.1141

vep         0.0108    1    0.0108     0.094       0.761
ps/ve       3.1957   28    0.1141
```

Experiment Three: Hits

```
SOURCE: grand mean
plane  t.ges   presn   N    MEAN      SD       SE
                       64   58.4375   25.0218  3.1277

SOURCE: plane
plane  t.ges   presn   N    MEAN      SD       SE
same                   32   66.2500   21.8130  3.8560
diff                   32   50.6250   25.8953  4.5777

SOURCE: t.gesture
plane  t.ges   presn   N    MEAN      SD       SE
       shake           32   56.2500   25.1126  4.4393
       nod             32   60.6250   25.1367  4.4436

SOURCE: plane t.gesture
plane  t.ges   presn   N    MEAN      SD       SE
same   shake           16   63.7500   22.1736  5.5434
same   nod             16   68.7500   21.8708  5.4677
diff   shake           16   48.7500   26.2996  6.5749
diff   nod             16   52.5000   26.2043  6.5511

SOURCE: presentation
plane  t.ges   presn   N    MEAN      SD       SE
               move    32   51.2500   24.8544  4.3937
               static  32   65.6250   23.4091  4.1382

SOURCE: plane presentation
plane  t.ges   presn   N    MEAN      SD       SE
same           move    16   60.0000   24.2212  6.0553
same           static  16   72.5000   17.7012  4.4253
diff           move    16   42.5000   22.9492  5.7373
diff           static  16   58.7500   26.8017  6.7004

SOURCE: t.gesture presentation
plane  t.ges   presn   N    MEAN      SD       SE
       shake   move    16   46.2500   25.0000  6.2500
       shake   static  16   66.2500   21.5639  5.3910
       nod     move    16   56.2500   24.4609  6.1152
       nod     static  16   65.0000   25.8199  6.4550
```

```
SOURCE: plane t.gesture presentation
plane  t.ges  presn  N   MEAN     SD       SE
same   shake  move   8  55.0000  25.6348   9.0633
same   shake  static 8  72.5000  14.8805   5.2610
same   nod    move   8  65.0000  23.2993   8.2375
same   nod    static 8  72.5000  21.2132   7.5000
diff   shake  move   8  37.5000  22.5198   7.9620
diff   shake  static 8  60.0000  26.1861   9.2582
diff   nod    move   8  47.5000  23.7547   8.3986
diff   nod    static 8  57.5000  29.1548  10.3078

FACTOR:    subj    plane    t.gesture   presn   score
LEVELS:     32      2          2          2       64
TYPE  : RANDOM  BETWEEN BETWEEN  WITHIN   DATA

SOURCE            SS     df      MS         F          p
===============================================================
plane     3906.2500   1   3906.2500    5.408      0.028 *
s/pt     20225.0000  28    722.3214

t.gestu    306.2500   1    306.2500    0.424      0.520
s/pt     20225.0000  28    722.3214

pt           6.2500   1      6.2500    0.009      0.927
s/pt     20225.0000  28    722.3214

presn     3306.2500   1   3306.2500    8.321      0.007 **
ps/pt    11125.0000  28    397.3214

pp          56.2500   1     56.2500    0.142      0.710
ps/pt    11125.0000  28    397.3214

tp         506.2500   1    506.2500    1.274      0.269
ps/pt    11125.0000  28    397.3214

ptp          6.2500   1      6.2500    0.016      0.901
ps/pt    11125.0000  28    397.3214
```

Experiment Three: Items analysis

```
SOURCE: grand mean
plane  t.ges   presn   N     MEAN       SD        SE
                       80   58.4375   25.4528    2.8457

SOURCE: plane
plane  t.ges   presn   N     MEAN       SD        SE
same                   40   66.2500   22.3248    3.5299
diff                   40   50.6250   26.2431    4.1494

SOURCE: t.gest
plane  t.ges   presn   N     MEAN       SD        SE
       shake           40   56.2500   27.0031    4.2696
       nod             40   60.6250   23.9440    3.7859

SOURCE: plane t.gest
plane  t.ges  presn   N     MEAN       SD        SE
same   shake          20   63.7500   22.1760    4.9587
same   nod            20   68.7500   22.7616    5.0897
diff   shake          20   48.7500   29.7744    6.6578
diff   nod            20   52.5000   22.7977    5.0977

SOURCE: presentation
plane  t.ges   presn   N     MEAN       SD        SE
               move    40   51.2500   25.9128    4.0972
               static  40   65.6250   23.1269    3.6567

SOURCE: plane presentation
plane  t.ges   presn   N     MEAN       SD        SE
same           move    20   60.0000   23.5081    5.2566
same           static  20   72.5000   19.7017    4.4054
diff           move    20   42.5000   25.7774    5.7640
diff           static  20   58.7500   24.7022    5.5236

SOURCE: t.gest presentation
plane  t.ges   presn   N     MEAN       SD        SE
       shake   move    20   46.2500   24.7022    5.5236
       shake   static  20   66.2500   25.9997    5.8137
       nod     move    20   56.2500   26.7481    5.9811
       nod     static  20   65.0000   20.5196    4.5883
```

```
SOURCE: plane t.gest presentation
plane  t.ges  presn   N    MEAN      SD       SE
same   shake  move    10   55.0000   19.7203   6.2361
same   shake  static  10   72.5000   21.8899   6.9222
same   nod    move    10   65.0000   26.8742   8.4984
same   nod    static  10   72.5000   18.4466   5.8333
diff   shake  move    10   37.5000   27.0031   8.5391
diff   shake  static  10   60.0000   29.3447   9.2796
diff   nod    move    10   47.5000   24.8607   7.8617
diff   nod    static  10   57.5000   20.5818   6.5085

FACTOR:    face     plane   t.gest    presn    score
LEVELS:    10       2       2         2        80
TYPE : RANDOM  WITHIN  WITHIN  WITHIN  DATA

SOURCE         SS          df      MS          F         p
===============================================================
plane          4882.8125    1    4882.8125    4.310     0.068
pf/            10195.3125   9    1132.8125

t.gest         382.8125     1    382.8125     1.100     0.322
tf/            3132.8125    9    348.0903

pt             7.8125       1    7.8125       0.010     0.924
ptf/           7257.8125    9    806.4236

presn          4132.8125    1    4132.8125    39.347    0.000 ***
pf/            945.3125     9    105.0347

pp             70.3125      1    70.3125      0.144     0.713
ppf/           4382.8125    9    486.9792

tp             632.8125     1    632.8125     0.948     0.356
tpf/           6007.8125    9    667.5347

ptp            7.8125       1    7.8125       0.031     0.864
ptpf/          2257.8125    9    250.8681
```

Experiment Three: False Positives

```
SOURCE: grand mean
plane        t.ges   N    MEAN       SD       SE
                     32   25.6250   13.1830   2.3304

SOURCE: expt
plane        t.ges   N    MEAN       SD       SE
same                 16   24.3750   13.1498   3.2874
diff                 16   26.8750   13.5247   3.3812

SOURCE: t.gest
plane        t.ges   N    MEAN       SD       SE
             shake   16   25.6250   14.5917   3.6479
             nod     16   25.6250   12.0934   3.0233

SOURCE: expt t.gest
plane        t.ges   N    MEAN       SD       SE
same         shake   8    28.7500   16.4208   5.8056
same         nod     8    20.0000   7.5593    2.6726
diff         shake   8    22.5000   12.8174   4.5316
diff         nod     8    31.2500   13.5620   4.7949

FACTOR:      subj        plane        t.gest    score
LEVELS:      32            2            2         32
TYPE  :  RANDOM     BETWEEN     BETWEEN   DATA

SOURCE          SS           df        MS          F          p
===============================================================
plane           50.0000       1     50.0000       0.296      0.591
s/et            4725.0000    28     168.7500

t.gest          0.0000        1     0.0000        0.000      1.000
s/et            4725.0000    28     168.7500

et              612.5000      1     612.5000      3.630      0.067
s/et            4725.0000    28     168.7500
```

Experiment Three: A'

```
SOURCE: grand mean
plane  t.ges    presn   N     MEAN      SD       SE
                        64    0.5723   0.0801   0.0100

SOURCE: plane
plane  t.ges  presn     N     MEAN      SD       SE
same                    32    0.5987   0.0852   0.0151
diff                    32    0.5459   0.0658   0.0116

SOURCE: t.gesture
plane  t.ges    presn   N     MEAN      SD       SE
       shake            32    0.5656   0.0711   0.0126
       nod              32    0.5791   0.0888   0.0157

SOURCE: plane t.gesture
plane  t.ges    presn   N     MEAN      SD       SE
same   shake            16    0.5763   0.0735   0.0184
same   nod              16    0.6212   0.0924   0.0231
diff   shake            16    0.5550   0.0694   0.0173
diff   nod              16    0.5369   0.0629   0.0157

SOURCE: presentation
plane  t.ges    presn   N     MEAN      SD       SE
                move    32    0.5544   0.0758   0.0134
                static  32    0.5903   0.0813   0.0144

SOURCE: plane presentation
plane  t.ges    presn   N     MEAN      SD       SE
same            move    16    0.5831   0.0860   0.0215
same            static  16    0.6144   0.0842   0.0211
diff            move    16    0.5256   0.0521   0.0130
diff            static  16    0.5662   0.0731   0.0183

SOURCE: t.gesture presntion
plane  t.ges    presn   N     MEAN      SD       SE
       shake    move    16    0.5412   0.0611   0.0153
       shake    static  16    0.5900   0.0738   0.0185
       nod      move    16    0.5675   0.0882   0.0221
       nod      static  16    0.5906   0.0907   0.0227
```

```
SOURCE: plane t.gesture presentation
plane  t.ges  presn   N    MEAN     SD      SE
same   shake  move    8   0.5575  0.0694  0.0245
same   shake  static  8   0.5950  0.0771  0.0273
same   nod    move    8   0.6087  0.0976  0.0345
same   nod    static  8  0.6337  0.0916  0.0324
diff   shake  move    8   0.5250  0.0507  0.0179
diff   shake  static  8  0.5850  0.0754  0.0267
diff   nod    move    8   0.5262  0.0571  0.0202
diff   nod    static  8  0.5475  0.0705  0.0249

FACTOR:      subj    plane       t.gesture      presn      score
LEVELS:      32      2             2             2           64
TYPE  :  RANDOM BETWEEN   BETWEEN     WITHIN DATA
SOURCE            SS    df         MS       F              p
=============================================================
plane          0.0446    1      0.0446     5.986          0.021 *
s/pt           0.2087   28       0.0075

t.gestu         0.0029    1      0.0029     0.388          0.539
s/pt           0.2087   28       0.0075

pt             0.0159    1      0.0159     2.138          0.155
s/pt           0.2087   28       0.0075

presn          0.0207    1      0.0207     5.386          0.028 *
ps/pt          0.1074   28      0.0038

pp             0.0004    1      0.0004     0.092          0.764
ps/pt          0.1074   28       0.0038

tp             0.0026    1      0.0026     0.685          0.415
ps/pt          0.1074   28       0.0038

ptp            0.0007    1      0.0007     0.180          0.675
ps/pt          0.1074   28       0.0038
```

Experiment Three: B"

```
SOURCE: grand mean
plane  t.ges  presn   N    MEAN     SD      SE
                      64   0.0847   0.4601  0.0575

SOURCE: plane
plane  t.ges  presn   N    MEAN     SD      SE
same                  32  -0.0131   0.4904  0.0867
diff                  32   0.1825   0.4123  0.0729

SOURCE: t.gesture
plane  t.ges  presn   N    MEAN     SD      SE
       shake          32   0.1047   0.5012  0.0886
       nod            32   0.0647   0.4222  0.0746

SOURCE: plane t.gesture
plane  t.ges  presn   N    MEAN     SD      SE
same   shake          16   0.0112   0.5208  0.1302
same   nod            16  -0.0375   0.4738  0.1184
diff   shake          16   0.1981   0.4788  0.1197
diff   nod            16   0.1669   0.3487  0.0872

SOURCE: presentation
plane  t.ges  presn   N    MEAN     SD      SE
              move    32   0.1391   0.4320  0.0764
              static  32   0.0303   0.4873  0.0861

SOURCE: plane presentation
plane  t.ges  presn   N    MEAN     SD      SE
same          move    16   0.0175   0.4709  0.1177
same          static  16  -0.0437   0.5227  0.1307
diff          move    16   0.2606   0.3639  0.0910
diff          static  16   0.1044   0.4537  0.1134

SOURCE: t.gesture presentation
plane  t.ges  presn   N    MEAN     SD      SE
       shake  move    16   0.1681   0.4882  0.1220
       shake  static  16   0.0412   0.5217  0.1304
       nod    move    16   0.1100   0.3817  0.0954
       nod    static  16   0.0194   0.4672  0.1168
```

```
SOURCE: plane t.gesture presentation
plane  t.ges  presn   N    MEAN     SD      SE
same   shake  move    8   0.0212  0.5446  0.1926
same   shake  static  8   0.0013  0.5333  0.1886
same   nod    move    8   0.0138  0.4226  0.1494
same   nod    static  8  -0.0887  0.5444  0.1925
diff   shake  move    8   0.3150  0.4059  0.1435
diff   shake  static  8   0.0812  0.5434  0.1921
diff   nod    move    8   0.2062  0.3352  0.1185
diff   nod    static  8   0.1275  0.3803  0.1345

FACTOR:     subj    plane      t.gesture    presn     score
LEVELS:     32      2              2            2      64
TYPE  : RANDOM  BETWEEN   BETWEEN    WITHIN    DATA

SOURCE              SS    df        MS         F           p
===============================================================
plane         0.6123    1     0.6123      1.680        0.205
s/pt          10.2026   28      0.3644

t.gestu       0.0256    1     0.0256      0.070        0.793
s/pt          10.2026   28      0.3644

pt            0.0012    1     0.0012      0.003        0.954
s/pt          10.2026   28      0.3644

presn         0.1892    1     0.1892      2.399        0.133
ps/pt         2.2083   28     0.0789

pp            0.0361    1     0.0361      0.458        0.504
ps/pt         2.2083   28     0.0789

tp            0.0053    1     0.0053      0.067        0.798
ps/pt         2.2083   28     0.0789

ptp           0.0564    1     0.0564      0.715        0.405
ps/pt         2.2083   28     0.0789
```

Experiment Four: Hits

```
SOURCE: grand mean
t.ges   plane   presn   N     MEAN       SD        SE
                        64   75.0000   21.9668   2.7458

SOURCE: t.gesture
t.ges   plane   presn   N     MEAN       SD        SE
nod                     32   77.5000   20.7908   3.6753
shake                   32   72.5000   23.1405   4.0907

SOURCE: plane
t.ges   plane   presn   N     MEAN       SD        SE
        same            32   81.8750   18.5677   3.2823
        diff            32   68.1250   23.2014   4.1015

SOURCE: t.gesture plane
t.ges   plane   presn   N     MEAN       SD        SE
nod     same            16   78.7500   21.2525   5.3131
nod     diff            16   76.2500   20.9364   5.2341
shake   same            16   85.0000   15.4919   3.8730
shake   diff            16   60.0000   23.0940   5.7735

SOURCE: presentation
t.ges   plane   presn   N     MEAN       SD        SE
                move    32   70.6250   23.8189   4.2106
                still   32   79.3750   19.3337   3.4177

SOURCE: t.gesture presentation
t.ges   plane   presn   N     MEAN       SD        SE
nod             move    16   75.0000   22.5093   5.6273
nod             still   16   80.0000   19.3218   4.8305
shake           move    16   66.2500   25.0000   6.2500
shake           still   16   78.7500   19.9583   4.9896

SOURCE: plane presentation
t.ges   plane   presn   N     MEAN       SD        SE
        same    move    16   80.0000   19.3218   4.8305
        same    still   16   83.7500   18.2117   4.5529
        diff    move    16   61.2500   24.7319   6.1830
        diff    still   16   75.0000   20.0000   5.0000
```

```
SOURCE: t.gesture plane presentation
t.ges   plane  presn   N    MEAN       SD        SE
nod     same   move    8   77.5000   22.5198   7.9620
nod     same   still   8   80.0000   21.3809   7.5593
nod     diff   move    8   72.5000   23.7547   8.3986
nod     diff   still   8   80.0000   18.5164   6.5465
shake   same   move    8   82.5000   16.6905   5.9010
shake   same   still   8   87.5000   14.8805   5.2610
shake   diff   move    8   50.0000   21.3809   7.5593
shake   diff   still   8   70.0000   21.3809   7.5593

FACTOR:    subj     t.gesture    plane     presn    score
LEVELS:     32         2           2          2       64
TYPE  : RANDOM  BETWEEN  BETWEEN   WITHIN  DATA

SOURCE            SS          df         MS            F       p
===============================================================

t.gestu        400.0000       1      400.0000       0.770   0.388
s/tp         14550.0000      28      519.6429

plane         3025.0000       1     3025.0000       5.821   0.023 *
s/tp         14550.0000      28      519.6429

tp            2025.0000       1     2025.0000       3.897   0.058
s/tp         14550.0000      28      519.6429

presn         1225.0000       1     1225.0000       4.059   0.054
ps/tp         8450.0000      28      301.7857

tp             225.0000       1      225.0000       0.746   0.395
ps/tp         8450.0000      28      301.7857

pp             400.0000       1      400.0000       1.325   0.259
ps/tp         8450.0000      28      301.7857

tpp            100.0000       1      100.0000       0.331   0.569
ps/tp         8450.0000      28      301.7857
```

Experiment Four: Items analysis

```
SOURCE: grand mean
plane  t.ges   presn    N     MEAN       SD        SE
                        80   75.0000   26.6838   2.9833

SOURCE: plane
plane  t.ges   presn    N     MEAN       SD        SE
same                    40   81.8750   21.9173   3.4654
diff                    40   68.1250   29.4106   4.6502

SOURCE: t.gest
plane  t.ges   presn    N     MEAN       SD        SE
       shake            40   72.5000   27.0327   4.2743
        nod             40   77.5000   26.4333   4.1795

SOURCE: plane t.gest
plane  t.ges   presn    N     MEAN       SD        SE
same   shake            20   85.0000   18.8484   4.2146
same   nod              20   78.7500   24.7022   5.5236
diff   shake            20   60.0000   28.5620   6.3867
diff   nod              20   76.2500   28.6483   6.4059

SOURCE: presentation
plane  t.ges   presn    N     MEAN       SD        SE
               move     40   70.6250   28.2432   4.4656
               still    40   79.3750   24.6042   3.8903

SOURCE: plane presentation
plane  t.ges   presn    N     MEAN       SD        SE
same           move     20   80.0000   22.3607   5.0000
same           still    20   83.7500   21.8773   4.8919
diff           move     20   61.2500   30.8594   6.9004
diff           still    20   75.0000   26.9014   6.0153

SOURCE: t.gest presentation
plane  t.ges   presn    N     MEAN       SD        SE
       shake   move     20   66.2500   29.5526   6.6082
       shake   still    20   78.7500   23.3326   5.2173
       nod     move     20   75.0000   26.9014   6.0153
       nod     still    20   80.0000   26.4077   5.9049
```

```
SOURCE: plane t.gest presentation
plane  t.ges  presn   N    MEAN      SD       SE
same   shake  move    10   82.5000   20.5818   6.5085
same   shake  still   10   87.5000   17.6777   5.5902
same   nod    move    10   77.5000   24.8607   7.8617
same   nod    still   10   80.0000   25.8199   8.1650
diff   shake  move    10   50.0000   28.8675   9.1287
diff   shake  still   10   70.0000   25.8199   8.1650
diff   nod    move    10   72.5000   29.9305   9.4648
diff   nod    still   10   80.0000   28.3823   8.9753

FACTOR:   face    plane    t.gest   presn    score
LEVELS:    10      2        2        2        80
TYPE  : RANDOM  WITHIN  WITHIN  WITHIN     DATA

SOURCE          SS      df       MS          F          p
===============================================================
plane        3781.2500   1    3781.2500   6.444      0.032 *
pf/          5281.2500   9     586.8056

t.gest        500.0000   1     500.0000   1.263      0.290
tf/          3562.5000   9     395.8333

pt           2531.2500   1    2531.2500   10.565     0.010 **
ptf/         2156.2500   9     239.5833

presn        1531.2500   1    1531.2500   2.921      0.122
pf/          4718.7500   9     524.3056

pp            500.0000   1     500.0000   2.250      0.168
ppf/         2000.0000   9     222.2222

tp            281.2500   1     281.2500   0.218      0.651
tpf/        11593.7500   9    1288.1944

ptp           125.0000   1     125.0000   0.141      0.716
ptpf/        8000.0000   9     888.8889
```

Experiment Four: False Positives

```
SOURCE: grand mean
plane        t.ges   N    MEAN      SD       SE
                     32   23.1250   15.1205   2.6729

SOURCE: expt
plane        t.ges   N    MEAN      SD       SE
same                 16   23.7500   17.8419   4.4605
diff                 16   22.5000   12.3828   3.0957

SOURCE: t.gest
plane        t.ges   N    MEAN      SD       SE
             nod     16   25.0000   16.3299   4.0825
             shake   16   21.2500   14.0831   3.5208

SOURCE: expt t.gest
plane        t.ges   N    MEAN      SD       SE
same         nod     8    25.0000   20.0000   7.0711
same         shake   8    22.5000   16.6905   5.9010
diff         nod     8    25.0000   13.0931   4.6291
diff         shake   8    20.0000   11.9523   4.2258

FACTOR:      subj     plane       t.gest      score
LEVELS:      32       2           2           32
TYPE   :  RANDOM    BETWEEN     BETWEEN     DATA

SOURCE          SS          df        MS          F         p
===============================================================
plane           12.5000      1        12.5000     0.050     0.824
s/et          6950.0000     28       248.2143

t.gest         112.5000      1       112.5000     0.453     0.506
s/et          6950.0000     28       248.2143

et              12.5000      1        12.5000     0.050     0.824
s/et          6950.0000     28       248.2143
```

Experiment Four: A'

```
SOURCE: grand mean
t.ges   plane   presn   N     MEAN      SD       SE
                        64   0.6587   0.1488   0.0186

SOURCE: t.gesture
t.ges   plane   presn   N     MEAN      SD       SE
nod                     32   0.6347   0.1513   0.0267
shake                   32   0.6828   0.1445   0.0255

SOURCE: plane
t.ges   plane  presn    N     MEAN      SD       SE
        same            32   0.6900   0.1576   0.0279
        diff            32   0.6275   0.1346   0.0238

SOURCE: t.gesture plane
t.ges   plane  presn    N     MEAN      SD       SE
nod     same            16   0.6781   0.1620   0.0405
nod     diff            16   0.5912   0.1306   0.0326
shake   same            16   0.7019   0.1574   0.0394
shake   diff            16   0.6638   0.1327   0.0332

SOURCE: presentation
t.ges  plane    presn   N     MEAN      SD       SE
                move    32   0.6425   0.1439   0.0254
                still   32   0.6750   0.1540   0.0272

SOURCE: t.gesture presentation
t.ges   plane   presn   N     MEAN      SD       SE
nod             move    16   0.6119   0.1362   0.0341
nod             still   16   0.6575   0.1663   0.0416
shake           move    16   0.6731   0.1491   0.0373
shake           still   16   0.6925   0.1440   0.0360

SOURCE: plane presentation
t.ges   plane   presn   N     MEAN      SD       SE
        same    move    16   0.6806   0.1601   0.0400
        same    still   16   0.6994   0.1596   0.0399
        diff    move    16   0.6044   0.1185   0.0296
        diff    still   16   0.6506   0.1492   0.0373
```

```
SOURCE: t.gesture plane presentation
t.ges   plane  presn   N    MEAN     SD       SE
nod     same   move    8   0.6637   0.1569   0.0555
nod     same   still   8   0.6925   0.1765   0.0624
nod     diff   move    8   0.5600   0.0949   0.0335
nod     diff   still   8   0.6225   0.1591   0.0562
shake   same   move    8   0.6975   0.1723   0.0609
shake   same   still   8   0.7062   0.1529   0.0540
shake   diff   move    8   0.6487   0.1289   0.0456
shake   diff   still   8   0.6788   0.1436   0.0508

FACTOR:      subj    t.gesture    plane  presentation     score
LEVELS:      32      2            2      2          64
TYPE  : RANDOM   BETWEEN   BETWEEN    WITHIN DATA

SOURCE            SS     df        MS       F             p
==================================================================
t.gestu         0.0371    1     0.0371     0.976         0.332
s/tp            1.0628   28      0.0380

plane           0.0625    1     0.0625     1.647         0.210
s/tp            1.0628   28      0.0380

tp              0.0095    1     0.0095     0.250         0.621
s/tp            1.0628   28      0.0380

presnti         0.0169    1     0.0169     2.371         0.135
ps/tp           0.1996   28      0.0071

tp              0.0028    1     0.0028     0.387         0.539
ps/tp           0.1996   28      0.0071

pp              0.0030    1     0.0030     0.424         0.520
ps/tp           0.1996   28      0.0071

tpp             0.0002    1     0.0002     0.022         0.883
ps/tp           0.1996   28      0.0071
```

Experiment Four: B"

```
SOURCE: grand mean
t.ges   plane  presn   N     MEAN       SD       SE
                       64   -0.1053   0.5145   0.0643

SOURCE: t.gesture
t.ges   plane  presn   N     MEAN       SD       SE
        nod            32   -0.0528   0.4421   0.0781
        shake          32   -0.1578   0.5804   0.1026

SOURCE: plane
t.ges   plane  presn   N     MEAN       SD       SE
        same           32   -0.1884   0.5454   0.0964
        diff           32   -0.0222   0.4757   0.0841

SOURCE: t.gesture plane
t.ges   plane  presn   N     MEAN       SD       SE
nod     same           16   -0.1556   0.4953   0.1238
nod     diff           16    0.0500   0.3689   0.0922
shake   same           16   -0.2212   0.6060   0.1515
shake   diff           16   -0.0944   0.5661   0.1415

SOURCE: presentation
t.ges   plane  presn   N     MEAN       SD       SE
               move    32   -0.0406   0.5283   0.0934
               still   32   -0.1700   0.5003   0.0884

SOURCE: t.gesture presentation
t.ges   plane  presn   N     MEAN       SD       SE
nod            move    16    0.0206   0.4597   0.1149
nod            still   16   -0.1262   0.4255   0.1064
shake          move    16   -0.1019   0.5978   0.1494
shake          still   16   -0.2137   0.5764   0.1441

SOURCE: plane presentation
t.ges   plane  presn   N     MEAN       SD       SE
        same   move    16   -0.1325   0.5502   0.1376
        same   still   16   -0.2444   0.5526   0.1382
        diff   move    16    0.0513   0.5059   0.1265
        diff   still   16   -0.0956   0.4474   0.1118
```

```
SOURCE: t.gesture plane presentation
t.ges  plane  presn   N    MEAN      SD       SE
nod    same   move    8   -0.1187   0.5413   0.1914
nod    same   still   8   -0.1925   0.4790   0.1694
nod    diff   move    8    0.1600   0.3399   0.1202
nod    diff   still   8   -0.0600   0.3852   0.1362
shake  same   move    8   -0.1462   0.5960   0.2107
shake  same   still   8   -0.2962   0.6471   0.2288
shake  diff   move    8   -0.0575   0.6372   0.2253
shake  diff   still   8   -0.1312   0.5269   0.1863

FACTOR:   subj    t.gesture     plane     presentation   score
LEVELS:    32       2 ·           2             2          64
TYPE  : RANDOM  BETWEEN    BETWEEN  WITHIN  DATA

SOURCE          SS      df      MS        F            p
===============================================================
t.gestu       0.1764    1     0.1764    0.453        0.507
s/tp         10.9094   28       0.3896

plane         0.4422    1     0.4422    1.135        0.296
s/tp         10.9094   28       0.3896

tp            0.0248    1     0.0248    0.064        0.803
s/tp         10.9094   28       0.3896

presnti       0.2678    1     0.2678    1.563        0.222
ps/tp         4.7989   28     0.1714

tp            0.0049    1     0.0049    0.029        0.867
ps/tp         4.7989   28     0.1714

pp            0.0049    1     0.0049    0.029        0.867
ps/tp         4.7989   28     0.1714

tpp           0.0495    1     0.0495    0.289        0.595
ps/tp         4.7989   28     0.1714
```

Pilot study: Hits

```
SOURCE: grand mean
view   N    MEAN      SD      SE
       28  58.9286  23.6069   4.4613

SOURCE: view
view   N    MEAN      SD      SE
diff   14  51.4286  15.5670   4.1605
same   14  66.4286  28.1772   7.5307

FACTOR:     subj     view    score
LEVELS:      14        2       28
TYPE  :   RANDOM    WITHIN     DATA

SOURCE            SS    df        MS        F     p
===============================================================
view       1575.0000    1    1575.0000   2.755  0.121
vs/        7431.0442   13     571.6188
```

Pilot study FP's

```
SOURCE: grand mean
view   N    MEAN      SD      SE
       28  37.7976  26.3993   4.9890

SOURCE: view
view   N    MEAN      SD      SE
diff   14  42.2619  24.5612   6.5642
same   14  33.3333  28.3069   7.5653

FACTOR:     subj     view      fp
LEVELS:      14        2       28
TYPE  :   RANDOM    WITHIN     DATA

SOURCE            SS    df        MS        F     p
===============================================================
view        558.0357    1     558.0357   1.883  0.193
vs/        3851.6865   13     296.2836
```

Reaction Times Experiment One

```
SOURCE: grand mean
view  expre  condi   N     MEAN       SD        SE
                    64  2270.6613  906.7035  115.1515

SOURCE: view
view  expre  condi   N     MEAN       SD        SE
FF                  32   2042.1333  811.0569  148.0780
PROF                32   2484.9062  951.0033  168.1152

SOURCE: expression
view  expre  condi   N     MEAN       SD        SE
      same          32   2142.6562  910.0174  160.8699
      diff          32   2407.2000  898.1416  163.9775

SOURCE: view expression
view  expre  condi   N     MEAN       SD        SE
FF    same          16   1747.9375  583.0640  145.7660
FF     diff         16   2378.3571  920.2700  245.9525
PROF  same          16   2537.3750 1019.3767  254.8442
PROF  diff          16   2432.4375  907.8030  226.9507

SOURCE: condition (presentation)
view  expre  condi   N     MEAN       SD        SE
             still  32   2172.7742  824.6883  148.1184
             move   32   2368.5484  985.7549  177.0468

SOURCE: view condition
view  expre  condi   N     MEAN       SD        SE
FF           still  16   1941.3333  647.9807  167.3079
FF           move   16   2142.9333  959.6673  247.7850
PROF         still  16   2389.7500  929.8133  232.4533
PROF         move   16   2580.0625  992.5919  248.1480

SOURCE: expression condition
view  expre  condi   N     MEAN       SD        SE
      same  still   16   2086.6875  771.8450  192.9613
      same  move    16   2198.6250 1053.1119  263.2780
      diff  still   16   2264.6000  895.3092  231.1678
      diff  move    16   2549.8000  908.7255  234.6319
```

```
SOURCE: view expression condition
view  expre  condi   N    MEAN       SD         SE
FF     same  still   8    1756.0000  563.6503   199.2805
FF     same  move    8    1739.8750  640.8145   226.5622
FF     diff  still   8    2153.1429  714.7917   270.1659
FF     diff  move    8    2603.5714  1098.0282  415.0157
PROF   same  still   8    2417.3750  841.9868   297.6873
PROF   same  move    8    2657.3750  1218.5437  430.8203
PROF   diff  still   8    2362.1250  1068.6098  377.8106
PROF   diff  move    8    2502.7500  782.7610   276.7478

FACTOR:      subj     view expression  condition
LEVELS:       31        2       2        2       62
TYPE :   RANDOM   BETWEEN   BETWEEN    WITHIN      DATA

SOURCE            SS          df          MS          F      p
==================================================================
view      3035579.7017     1   3035579.7017     3.138  0.088
s/ve     26121862.3393    27    967476.3829

express   1083613.8683     1   1083613.8683     1.120  0.299
s/ve     26121862.3393    27    967476.3829

ve        1971950.4778     1   1971950.4778     2.038  0.165
s/ve     26121862.3393    27    967476.3829

conditi    594076.7903     1    594076.7903     0.948  0.339
cs/ve    16915137.2321    27    626486.5642

vc            493.1909     1        493.1909    0.001  0.978
cs/ve    16915137.2321    27    626486.5642

ec         116206.0409     1    116206.0409     0.185  0.670
cs/ve    16915137.2321    27    626486.5642

vec        309866.2457     1    309866.2457     0.495  0.488
cs/ve    16915137.2321    27    626486.5642
```

RT's Experiment Three

```
SOURCE: grand mean
view  expre  condi    N     MEAN       SD        SE
                      80  2430.6375  1325.4707  148.1921

SOURCE: view
view  expre  condi    N     MEAN       SD        SE
FF                    40   1994.0500  796.3785  125.9185
PROF                   40   2867.2250 1591.7232  251.6735

SOURCE: expression
view  expre  condi    N     MEAN       SD        SE
      same            40    2097.0000  884.0786  139.7851
      diff            40    2764.2750 1596.5156  252.4313

SOURCE: view expression
view  expre  condi    N     MEAN       SD        SE
FF    same            20  1695.2000  540.7649  120.9187
FF    diff            20  2292.9000  906.2928  202.6532
PROF  same            20  2498.8000  985.9104  220.4563
PROF  diff            20  3235.6500 1985.6310  444.0006

SOURCE: condit
view  expre  condi    N     MEAN       SD        SE
             still   40  2362.0750  1426.6108  225.5670
             move    40  2499.2000  1230.4196  194.5464

SOURCE: view condit
view  expre  condi    N     MEAN       SD        SE
FF           still   20  1934.3000  693.2955  155.0256
FF           move    20  2053.8000  902.0214  201.6981
PROF         still   20  2789.8500  1819.7938  406.9183
PROF         move    20  2944.6000  1369.7657  306.2889

SOURCE: expression condit
view  expre  condi    N     MEAN       SD        SE
      same  still    20  1986.7500  763.7289  170.7750
      same  move     20  2207.2500  997.7249  223.0981
      diff  still    20  2737.4000  1815.9586  406.0607
      diff  move     20  2791.1500  1390.1973  310.8576
```

```
SOURCE: view expression condit
view   expre  condi   N     MEAN        SD         SE
FF     same   still   10  1687.7000   517.9112   163.7779
FF     same   move    10  1702.7000   590.7523   186.8123
FF     diff   still   10  2180.9000   781.8919   247.2559
FF     diff   move    10  2404.9000  1046.3106   330.8725
PROF   same   still   10  2285.8000   874.3027   276.4788
PROF   same   move    10  2711.8000  1089.4105   344.5019
PROF   diff   still   10  3293.9000  2379.5510   752.4801
PROF   diff   move    10  3177.4000  1629.0300   515.1445

FACTOR:     subj       view expression    condit
LEVELS:      40         2        2          2        80
TYPE :   RANDOM    BETWEEN    BETWEEN    WITHIN      DATA

SOURCE            SS          df          MS          F           p
===============================================================
view     15248691.6125     1  15248691.6125   5.975     0.020 *
s/ve     91868083.2500    36   2551891.2014

express   8905118.5125     1   8905118.5125   3.490     0.070
s/ve     91868083.2500    36   2551891.2014

ve          96813.6125     1     96813.6125   0.038     0.847
s/ve     91868083.2500    36   2551891.2014

condit     376065.3125     1    376065.3125   0.631     0.432
cs/ve    21446987.2500    36    595749.6458

vc           6212.8125     1      6212.8125   0.010     0.919
cs/ve    21446987.2500    36    595749.6458

ec         139027.8125     1    139027.8125   0.233     0.632
cs/ve    21446987.2500    36    595749.6458

vec        705940.3125     1    705940.3125   1.185     0.284
cs/ve    21446987.2500    36    595749.6458
```

Meta analysis A': Experiments One to Four

```
SOURCE: grand mean
presn test  viewp gestu   N     MEAN      SD       SE
                         272   0.6009   0.1152   0.0070

SOURCE: presn
presn test  viewp gestu   N     MEAN      SD       SE
move                     136   0.5926   0.1120   0.0096
still                    136   0.6092   0.1182   0.0101

SOURCE: test
presn test  viewp gestu   N     MEAN      SD       SE
      fixed              144   0.5790   0.0884   0.0074
      dynam              128   0.6255   0.1355   0.0120

SOURCE: presn test
presn test  viewp gestu   N     MEAN      SD       SE
move  fixed               72   0.5692   0.0862   0.0102
move  dynam               64   0.6189   0.1311   0.0164
still fixed               72   0.5887   0.0901   0.0106
still dynam               64   0.6322   0.1405   0.0176

SOURCE: viewpoint
presn test  viewp gestu   N     MEAN      SD       SE
            same         136   0.6404   0.1229   0.0105
            diff         136   0.5614   0.0916   0.0079

SOURCE: presn viewpoint
presn test  viewp gestu   N     MEAN      SD       SE
move        same          68   0.6368   0.1241   0.0150
move        diff          68   0.5484   0.0769   0.0093
still       same          68   0.6440   0.1226   0.0149
still       diff          68   0.5744   0.1032   0.0125

SOURCE: test viewpoint
presn test  viewp gestu   N     MEAN      SD       SE
      fixed same          72   0.6125   0.0941   0.0111
      fixed diff          72   0.5454   0.0679   0.0080
      dynam same          64   0.6717   0.1432   0.0179
      dynam diff          64   0.5794   0.1104   0.0138
```

```
SOURCE: presn test viewpoint
presn test  viewp gestu   N    MEAN     SD      SE
move  fixed  same         36  0.6069  0.0969  0.0161
move  fixed  diff         36  0.5314  0.0523  0.0087
move  dynam  same         32  0.6703  0.1431  0.0253
move  dynam  diff         32  0.5675  0.0948  0.0168
still fixed  same         36  0.6181  0.0923  0.0154
still fixed  diff         36  0.5594  0.0787  0.0131
still dynam  same         32  0.6731  0.1456  0.0257
still dynam  diff         32  0.5912  0.1244  0.0220

SOURCE: gesture
presn test  viewp gestu   N    MEAN     SD      SE
                  inter  144  0.5878  0.1027  0.0086
                  globa  128  0.6155  0.1267  0.0112

SOURCE: presn gesture
presn test  viewp gestu   N    MEAN     SD      SE
move              inter   72  0.5874  0.1024  0.0121
move              globa   64  0.5984  0.1224  0.0153
still             inter   72  0.5883  0.1037  0.0122
still             globa   64  0.6327  0.1294  0.0162

SOURCE: test gesture
presn test  viewp gestu   N    MEAN     SD      SE
      fixed       inter   80  0.5842  0.0947  0.0106
      fixed       globa   64  0.5723  0.0801  0.0100
      dynam       inter   64  0.5923  0.1124  0.0141
      dynam       globa   64  0.6587  0.1488  0.0186

SOURCE: presn test gesture
presn test  viewp gestu   N    MEAN     SD      SE
move  fixed       inter   40  0.5810  0.0929  0.0147
move  fixed       globa   32  0.5544  0.0758  0.0134
move  dynam       inter   32  0.5953  0.1143  0.0202
move  dynam       globa   32  0.6425  0.1439  0.0254
still fixed       inter   40  0.5875  0.0976  0.0154
still fixed       globa   32  0.5903  0.0813  0.0144
still dynam       inter   32  0.5894  0.1123  0.0199
still dynam       globa   32  0.6750  0.1540  0.0272
```

```
SOURCE: viewpoint gesture
presn  test   viewp  gestu   N     MEAN      SD       SE
              same   inter   72   0.6368   0.1132   0.0133
              same   globa   64   0.6444   0.1338   0.0167
              diff   inter   72   0.5389   0.0597   0.0070
              diff   globa   64   0.5867   0.1129   0.0141
```

```
SOURCE: presn viewpoint gesture
presn  test   viewp  gestu   N     MEAN      SD       SE
move          same   inter   36   0.6411   0.1144   0.0191
move          same   globa   32   0.6319   0.1358   0.0240
move          diff   inter   36   0.5336   0.0474   0.0079
move          diff   globa   32   0.5650   0.0986   0.0174
still         same   inter   36   0.6325   0.1134   0.0189
still         same   globa   32   0.6569   0.1328   0.0235
still         diff   inter   36   0.5442   0.0702   0.0117
still         diff   globa   32   0.6084   0.1233   0.0218
```

```
SOURCE: test viewpoint gesture
presn  test   viewp  gestu   N     MEAN      SD       SE
       fixed  same   inter   40   0.6235   0.1004   0.0159
       fixed  same   globa   32   0.5987   0.0852   0.0151
       fixed  diff   inter   40   0.5450   0.0703   0.0111
       fixed  diff   globa   32   0.5459   0.0658   0.0116
       dynam  same   inter   32   0.6534   0.1271   0.0225
       dynam  same   globa   32   0.6900   0.1576   0.0279
       dynam  diff   inter   32   0.5312   0.0429   0.0076
       dynam  diff   globa   32   0.6275   0.1346   0.0238
```

```
SOURCE: presn test viewpoint gesture
presn  test  viewp gestu   N    MEAN      SD       SE
move   fixed same  inter   20   0.6260   0.1029   0.0230
move   fixed same  globa   16   0.5831   0.0860   0.0215
move   fixed diff  inter   20   0.5360   0.0534   0.0119
move   fixed diff  globa   16   0.5256   0.0521   0.0130
move   dynam same  inter   16   0.6600   0.1282   0.0321
move   dynam same  globa   16   0.6806   0.1601   0.0400
move   dynam diff  inter   16   0.5306   0.0402   0.0101
move   dynam diff  globa   16   0.6044   0.1185   0.0296
still  fixed same  inter   20   0.6210   0.1004   0.0224
still  fixed same  globa   16   0.6144   0.0842   0.0211
still  fixed diff  inter   20   0.5540   0.0844   0.0189
still  fixed diff  globa   16   0.5662   0.0731   0.0183
still  dynam same  inter   16   0.6469   0.1298   0.0324
still  dynam same  globa   16   0.6994   0.1596   0.0399
still  dynam diff  inter   16   0.5319   0.0467   0.0117
still  dynam diff  globa   16   0.6506   0.1492   0.0373

FACTOR:     subj     presn    'test viewpoint  gesture    DATA
LEVELS:     136        2        2      2          2     272
TYPE  :  RANDOM    WITH  BETW  BETW  BETW   DATA

SOURCE           SS    df        MS       F        p
===============================================================
presn         0.0188    1     0.0188   3.520     0.063
ps/tvg        0.6828  128      0.0053

test          0.1471    1     0.1471   8.941     0.003 **
s/tvg         2.1057  128      0.0165

pt            0.0007    1     0.0007   0.126     0.723
ps/tvg        0.6828  128      0.0053

viewpoi       0.4241    1     0.4241  25.778     0.000 ***
s/tvg         2.1057  128      0.0165

pv            0.0060    1     0.0060   1.129     0.290
ps/tvg        0.6828  128      0.0053

tv            0.0108    1     0.0108   0.657     0.419
s/tvg         2.1057  128      0.0165

ptv           0.0001    1     0.0001   0.013     0.911
ps/tvg        0.6828  128      0.0053
```

gesture	0.0520	1	0.0520	3.161	0.078
s/tvg	2.1057	128	0.0165		
pg	0.0187	1	0.0187	3.510	0.063
ps/tvg	0.6828	128	0.0053		
tg	0.0942	1	0.0942	5.724	0.018 *
s/tvg	2.1057	128	0.0165		
ptg	0.0008	1	0.0008	0.149	0.700
ps/tvg	0.6828	128	0.0053		
vg	0.0275	1	0.0275	1.669	0.199
s/tvg	2.1057	128	0.0165		
pvg	0.0000	1	0.0000	0.000	0.984
ps/tvg	0.6828	128	0.0053		
tvg	0.0069	1	0.0069	0.420	0.518
s/tvg	2.1057	128	0.0165		
ptvg	0.0008	1	0.0008	0.142	0.707
ps/tvg	0.6828	128	0.0053		

Meta "B

```
SOURCE: grand mean
presn  test  viewp  gestu    N      MEAN       SD       SE
                            272   -0.0350   0.4408   0.0267

SOURCE: presn
presn  test  viewp  gestu    N      MEAN       SD       SE
move                        136   -0.0040   0.4327   0.0371
still                       136   -0.0660   0.4481   0.0384

SOURCE: test
presn  test  viewp  gestu    N      MEAN       SD       SE
       fixed                144   -0.0036   0.4260   0.0355
       dynam                128   -0.0702   0.4560   0.0403

SOURCE: presn test
presn  test  viewp  gestu    N      MEAN       SD       SE
move   fixed                 72    0.0224   0.4265   0.0503
move   dynam                 64   -0.0336   0.4411   0.0551
still  fixed                 72   -0.0296   0.4269   0.0503
still  dynam                 64   -0.1069   0.4709   0.0589

SOURCE: viewpoint
presn  test  viewp  gestu    N      MEAN       SD       SE
             same           136   -0.1239   0.5020   0.0430
             diff           136    0.0540   0.3494   0.0300

SOURCE: presn viewpoint
presn  test  viewp  gestu    N      MEAN       SD       SE
move         same            68   -0.1028   0.4852   0.0588
move         diff            68    0.0949   0.3494   0.0424
still        same            68   -0.1450   0.5210   0.0632
still        diff            68    0.0131   0.3472   0.0421

SOURCE: test viewpoint
presn  test  viewp  gestu    N      MEAN       SD       SE
       fixed same            72   -0.0850   0.4800   0.0566
       fixed diff            72    0.0778   0.3487   0.0411
       dynam same            64   -0.1677   0.5260   0.0657
       dynam diff            64    0.0272   0.3510   0.0439
```

```
SOURCE: presn test viewpoint
presn test   viewp gestu   N    MEAN      SD      SE
move  fixed  same          36  -0.0792  0.4853  0.0809
move  fixed  diff          36   0.1239  0.3349  0.0558
move  dynam  same          32  -0.1294  0.4914  0.0869
move  dynam  diff          32   0.0622  0.3675  0.0650
still fixed  same          36  -0.0908  0.4814  0.0802
still fixed  diff          36   0.0317  0.3607  0.0601
still dynam  same          32  -0.2059  0.5636  0.0996
still dynam  diff          32  -0.0078  0.3358  0.0594

SOURCE: gesture
presn test viewp   gestu   N    MEAN      SD      SE
                   inter 144  -0.0569  0.3862  0.0322
                   globa 128  -0.0103  0.4954  0.0438

SOURCE: presn gesture
presn test viewp gestu     N    MEAN      SD      SE
move             inter    72  -0.0512  0.3750  0.0442
move             globa    64   0.0492  0.4872  0.0609
still            inter    72  -0.0625  0.3997  0.0471
still            globa    64  -0.0698  0.5002  0.0625

SOURCE: test gesture
presn  test  viewp gestu   N    MEAN      SD      SE
       fixed       inter  80  -0.0742  0.3850  0.0430
       fixed       globa  64   0.0847  0.4601  0.0575
       dynam       inter  64  -0.0352  0.3897  0.0487
       dynam       globa  64  -0.1053  0.5145  0.0643

SOURCE: presn test gesture
presn test  viewp gestu    N    MEAN      SD      SE
move  fixed       inter   40  -0.0710  0.4032  0.0638
move  fixed       globa   32   0.1391  0.4320  0.0764
move  dynam       inter   32  -0.0266  0.3411  0.0603
move  dynam       globa   32  -0.0406  0.5283  0.0934
still fixed       inter   40  -0.0775  0.3710  0.0587
still fixed       globa   32   0.0303  0.4873  0.0861
still dynam       inter   32  -0.0437  0.4383  0.0775
still dynam       globa   32  -0.1700  0.5003  0.0884
```

```
SOURCE: viewpoint gesture
presn test  viewp  gestu   N    MEAN      SD      SE
            same   inter  72  -0.1444  0.4862  0.0573
            same   globa  64  -0.1008  0.5220  0.0653
            diff   inter  72   0.0307  0.2202  0.0260
            diff   globa  64   0.0802  0.4535  0.0567
```

```
SOURCE: presn viewpoint gesture
presn test  viewp  gestu   N    MEAN      SD      SE
move        same   inter  36  -0.1431  0.4660  0.0777
move        same   globa  32  -0.0575  0.5095  0.0901
move        diff   inter  36   0.0406  0.2252  0.0375
move        diff   globa  32   0.1559  0.4464  0.0789
still       same   inter  36  -0.1458  0.5122  0.0854
still       same   globa  32  -0.1441  0.5388  0.0953
still       diff   inter  36   0.0208  0.2179  0.0363
still       diff   globa  32   0.0044  0.4547  0.0804
```

```
SOURCE: test viewpoint gesture
presn test  viewp  gestu   N    MEAN      SD      SE
      fixed same   inter  40  -0.1425  0.4697  0.0743
      fixed same   globa  32  -0.0131  0.4904  0.0867
      fixed diff   inter  40  -0.0060  0.2647  0.0419
      fixed diff   globa  32   0.1825  0.4123  0.0729
      dynam same   inter  32  -0.1469  0.5137  0.0908
      dynam same   globa  32  -0.1884  0.5454  0.0964
      dynam diff   inter  32   0.0766  0.1379  0.0244
      dynam diff   globa  32  -0.0222  0.4757  0.0841
```

```
SOURCE: presn test viewpoint gesture
presn    test  viewp gestu  N    MEAN      SD      SE
move     fixed same   inter  20  -0.1565  0.4946  0.1106
move     fixed same   globa  16   0.0175  0.4709  0.1177
move     fixed diff   inter  20   0.0145  0.2716  0.0607
move     fixed diff   globa  16   0.2606  0.3639  0.0910
move   dynam same   inter  16  -0.1262  0.4431  0.1108
move   dynam same   globa  16  -0.1325  0.5502  0.1376
move   dynam diff   inter  16   0.0731  0.1512  0.0378
move   dynam diff   globa  16   0.0513  0.5059  0.1265
still    fixed same   inter  20  -0.1285  0.4559  0.1020
still    fixed same   globa  16  -0.0437  0.5227  0.1307
still    fixed diff   inter  20  -0.0265  0.2630  0.0588
still    fixed diff   globa  16   0.1044  0.4537  0.1134
still  dynam same   inter  16  -0.1675  0.5899  0.1475
still  dynam same   globa  16  -0.2444  0.5526  0.1382
still  dynam  diff   inter  16   0.0800  0.1280  0.0320
still  dynam  diff   globa  16  -0.0956  0.4474  0.1118

FACTOR:    subj    presn    test  viewpoint  gesture   DATA
LEVELS:     136      2         2      2          2      272
TYPE :  RANDOM   WITH     BET   BET    BET     DATA
SOURCE           SS    df        MS       F        p
===============================================================
presn        0.2613    1     0.2613   2.083      0.151
ps/tvg      16.0554   128     0.1254

test         0.3008    1     0.3008   1.186      0.278
s/tvg       32.4757   128     0.2537

pt           0.0077    1     0.0077   0.061      0.805
ps/tvg      16.0554   128     0.1254

viewpoi      2.1513    1     2.1513   8.479      0.004 **
s/tvg       32.4757   128     0.2537

pv           0.0266    1     0.0266   0.212      0.646
ps/tvg      16.0554   128     0.1254

tv           0.0174    1     0.0174   0.069      0.794
s/tvg       32.4757   128     0.2537

ptv          0.0321    1     0.0321   0.256      0.614
ps/tvg      16.0554   128     0.1254
```

gesture	0.1469	1	0.1469	0.579	0.448
s/tvg	32.4757	128	0.2537		
pg	0.1969	1	0.1969	1.570	0.213
ps/tvg	16.0554	128	0.1254		
tg	0.9088	1	0.9088	3.582	0.061
s/tvg	32.4757	128	0.2537		
ptg	0.0000	1	0.0000	0.000	1.000
ps/tvg	16.0554	128	0.1254		
vg	0.0006	1	0.0006	0.002	0.962
s/tvg	32.4757	128	0.2537		
pvg	0.0098	1	0.0098	0.078	0.781
ps/tvg	16.0554	128	0.1254		
tvg	0.0567	1	0.0567	0.223	0.637
s/tvg	32.4757	128	0.2537		
ptvg	0.0055	1	0.0055	0.044	0.834
ps/tvg	16.0554	128	0.1254		

Experiment Five: correct decisions

```
SOURCE: grand mean
task  presn   N    MEAN      SD      SE
              48  58.3854   9.8592  1.4231

SOURCE: task
task  presn   N    MEAN      SD      SE
expm          24  61.9792   8.0750  1.6483
idm           24  54.7917  10.3187  2.1063

SOURCE: presn
task   presn   N    MEAN      SD      SE
       movin  24  60.2083  11.6076  2.3694
       stati  24  56.5625   7.5474  1.5406

SOURCE: task presn
task   presn   N    MEAN      SD      SE
expm   movin  12  65.8333   7.4874  2.1614
expm   stati  12  58.1250   6.9188  1.9973
idm    movin  12  54.5833  12.5151  3.6128
idm    stati  12  55.0000   8.1184  2.3436

FACTOR:     subj        task        presn       score
LEVELS:     48          2           2           48
TYPE :   RANDOM     BETWEEN     BETWEEN     DATA

SOURCE          SS        df      MS        F         p
===============================================================
task        619.9219       1   619.9219   7.596     0.008 **
s/tp       3591.1458      44    81.6170

presn       159.5052       1   159.5052   1.954     0.169
s/tp       3591.1458      44    81.6170

tp          198.0469       1   198.0469   2.427     0.126
s/tp       3591.1458      44    81.6170
```

Experiment Five: Hits

```
SOURCE: grand mean
task   prese   N    MEAN       SD       SE
               48   54.4792   13.8855   2.0042

SOURCE: task
task   prese   N    MEAN       SD       SE
expm           24   57.7083   12.9362   2.6406
idm            24   51.2500   14.3140   2.9218

SOURCE: presentation
task   prese   N    MEAN       SD       SE
       movin   24   57.2917   16.4171   3.3511
       stati   24   51.6667   10.3909   2.1210

SOURCE: task presentation
task   prese   N    MEAN       SD       SE
expm   movin   12   62.9167   12.1465   3.5064
expm   stati   12   52.5000   11.9659   3.4542
idm    movin   12   51.6667   18.6271   5.3772
idm    stati   12   50.8333    9.0034   2.5990

FACTOR:     subj       task      presentati   score
LEVELS:     48         2                  2   48
TYPE :    RANDOM     BETWEEN   BETWEEN        DATA

SOURCE          SS      df        MS       F       p
=====================================================
task        500.5208     1   500.5208   2.786   0.102
s/tp       7906.2500    44    179.6875

present     379.6875     1   379.6875   2.113   0.153
s/tp       7906.2500    44    179.6875

tp          275.5208     1   275.5208   1.533   0.222
s/tp       7906.2500    44    179.6875
```

Experiment Five: FP’s

```
SOURCE: grand mean
task   condi   N     MEAN       SD       SE
              48   37.7083   12.2456   1.7675

SOURCE: task
task   condi   N     MEAN       SD       SE
expm          24   33.7500    9.9181   2.0245
idm           24   41.6667   13.2424   2.7031

SOURCE: condit
task   condi   N     MEAN       SD       SE
       movin  24   36.8750   15.3093   3.1250
       stati  24   38.5417    8.4028   1.7152

SOURCE: task condit
task   condi   N     MEAN       SD       SE
expm   movin  12   31.2500   12.0840   3.4883
expm   stati  12   36.2500    6.7840   1.9584
idm    movin  12   42.5000   16.5831   4.7871
idm    stati  12   40.8333    9.4948   2.7409

FACTOR:      subj        task        condit       score
LEVELS:      48          2           2            48
TYPE  :    RANDOM     BETWEEN     BETWEEN       DATA

SOURCE            SS         df        MS        F          p
===============================================================
task          752.0833       1    752.0833    5.399      0.025 *
s/tc         6129.1667      44     139.2992

condit         33.3333       1     33.3333    0.239      0.627
s/tc         6129.1667      44     139.2992

tc            133.3333       1    133.3333    0.957      0.333
s/tc         6129.1667      44     139.2992
```

Experiment Five: A'

```
SOURCE: grand mean
task    presn    N     MEAN      SD       SE
                48   0.5631   0.0584   0.0084

SOURCE: task
task    presn    N     MEAN      SD       SE
idm             24   0.5448   0.0410   0.0084
expm            24   0.5815   0.0677   0.0138

SOURCE: presn
task    presn    N     MEAN      SD       SE
        movin   24   0.5788   0.0690   0.0141
        stati   24   0.5475   0.0412   0.0084

SOURCE: task presn
task    presn    N     MEAN      SD       SE
idm     movin   12   0.5571   0.0518   0.0150
idm     stati   12   0.5325   0.0225   0.0065
expm    movin   12   0.6004   0.0790   0.0228
expm    stati   12   0.5625   0.0505   0.0146

FACTOR:     subj        task        presn       score
LEVELS:     48          2           2           48
TYPE  :   RANDOM     BETWEEN     BETWEEN      DATA

SOURCE          SS        df       MS       F          p
===============================================================
task          0.0161      1     0.0161   5.388      0.025 *
s/tp          0.1317     44      0.0030

presn         0.0117      1     0.0117   3.914      0.054
s/tp          0.1317     44      0.0030

tp            0.0005      1     0.0005   0.178       0.675
s/tp          0.1317     44      0.0030
```

Experiment Five: B"

```
SOURCE: grand mean
task   presn   N    MEAN     SD       SE
               48   0.0248   0.1113   0.0161

SOURCE: task
task   presn   N    MEAN     SD       SE
idm            24   0.0369   0.1043   0.0213
expm           24   0.0127   0.1189   0.0243

SOURCE: presn
task   presn   N    MEAN     SD       SE
       movin   24   0.0188   0.1430   0.0292
       stati   24   0.0308   0.0693   0.0142

SOURCE: task presn
task   presn   N    MEAN     SD       SE
idm    movin   12   0.0508   0.1263   0.0365
idm    stati   12   0.0229   0.0797   0.0230
expm   movin   12   -0.0133  0.1567   0.0452
expm   stati   12   0.0387   0.0597   0.0172

FACTOR:    subj       task       presn      score
LEVELS:    48         2          2
TYPE :   RANDOM    BETWEEN    BETWEEN     DATA

SOURCE           SS    df        MS            F      p
===============================================================
task          0.0070       1    0.0070       0.556  0.460
s/tp          0.5545      44     0.0126

presn         0.0018       1    0.0018       0.139  0.711
s/tp          0.5545      44     0.0126

tp            0.0192       1    0.0192       1.524  0.224
s/tp          0.5545      44     0.0126
```

Experiment Five: EXPM hits

```
SOURCE: grand mean
presn  perso   N    MEAN      SD       SE
              48  57.7083  15.7426   2.2722

SOURCE: presentation
presn  perso   N    MEAN      SD       SE
movin         24  62.9167  14.2887   2.9167
stati         24  52.5000  15.6733   3.1993

SOURCE: person
presn  perso   N    MEAN      SD       SE
       ps     24  61.6667  13.4056   2.7364
       pd     24  53.7500  17.1471   3.5001

SOURCE: presentation person
presn  perso   N    MEAN      SD       SE
movin  ps     12  64.1667  11.6450   3.3616
movin  pd     12  61.6667  16.9670   4.8979
stati  ps     12  59.1667  15.0504   4.3447
stati  pd     12  45.8333  13.7895   3.9807

FACTOR:     subj        presentation   person    score
LEVELS:     24          2              2          48
TYPE :   RANDOM     BETWEEN        WITHIN     DATA

SOURCE           SS         df         MS         F          p
==================================================================
presnti       1302.0833     1     1302.0833    4.479      0.046 *
s/p           6395.8333    22      290.7197

person      752.0833        1      752.0833    5.814      0.025 *
ps/p       2845.8333       22      129.3561

pp          352.0833        1      352.0833    2.722      0.113
ps/p       2845.8333       22      129.3561
```

Experiment Five: EXPM FP's

```
SOURCE: grand mean
condi  perso   N     MEAN       SD        SE
              48   33.7500   13.4678   1.9439

SOURCE: condition
condi  perso   N     MEAN       SD        SE
movin         24   31.2500   15.4110   3.1458
stati         24   36.2500   10.9594   2.2371

SOURCE: person
condi  perso   N     MEAN       SD        SE
       ps     24   34.1667   15.2990   3.1229
       pd     24   33.3333   11.6718   2.3825

SOURCE: condition person
condi  perso   N     MEAN       SD        SE
movin  ps     12   30.8333   17.8164   5.1432
movin  pd     12   31.6667   13.3712   3.8599
stati  ps     12   37.5000   12.1543   3.5086
stati  pd     12   35.0000   10.0000   2.8868

FACTOR:      subj      condition     person    score
LEVELS:       24           2            2        48
TYPE :     RANDOM     BETWEEN       WITHIN     DATA

SOURCE           SS          df        MS         F          p
===============================================================
conditi      300.0000        1     300.0000    1.562      0.224
s/c          4225.0000      22     192.0455

person        8.3333         1      8.3333    0.046      0.832
ps/c        3958.3333       22     179.9242

cp           33.3333         1     33.3333    0.185      0.671
ps/c        3958.3333       22     179.9242
```

Experiment Five: EXPM A'

```
SOURCE: grand mean
condi  perso   N     MEAN       SD        SE
               48   0.5448    0.0471    0.0068

SOURCE: condition
condi  perso   N     MEAN       SD        SE
movin          24   0.5571    0.0548    0.0112
stati          24   0.5325    0.0348    0.0071

SOURCE: person
condi  perso   N     MEAN       SD        SE
       ps     24   0.5454    0.0458    0.0093
       pd     24   0.5442    0.0493    0.0101

SOURCE: condition person
condi  perso   N     MEAN       SD        SE
movin  ps     12   0.5592    0.0543    0.0157
movin  pd     12   0.5550    0.0576    0.0166
stati  ps     12   0.5317    0.0319    0.0092
stati  pd     12   0.5333    0.0389    0.0112

FACTOR:      subj       condition      person     score
LEVELS:      24            2             2          48
TYPE :     RANDOM     BETWEEN       WITHIN       DATA

SOURCE            SS          df          MS           F        p
=================================================================
conditi        0.0073          1        0.0073        2.273  0.146
s/c            0.0702         22         0.0032

person         0.0000          1        0.0000        0.015  0.902
ps/c           0.0266         22         0.0012

cp             0.0001          1        0.0001        0.084  0.774
ps/c           0.0266         22         0.0012
```

Experiment Five: EXPM B"

```
SOURCE: grand mean
condi  perso   N     MEAN      SD       SE
               48   0.0369   0.1507   0.0218

SOURCE: condition
condi  perso   N     MEAN      SD       SE
stati          24   0.0508   0.1826   0.0373
movin          24   0.0229   0.1125   0.0230

SOURCE: person
condi  perso   N     MEAN      SD       SE
       ps     24   0.0479   0.1819   0.0371
       pd     24   0.0258   0.1144   0.0234

SOURCE: condition person
condi  perso   N     MEAN      SD       SE
stati  ps     12   0.0875   0.2048   0.0591
stati  pd     12   0.0142   0.1577   0.0455
movin  ps     12   0.0083   0.1543   0.0445
movin  pd     12   0.0375   0.0467   0.0135

FACTOR:      subj      condition      person    score
LEVELS:       24           2             2        48
TYPE  :    RANDOM    BETWEEN       WITHIN      DATA

SOURCE           SS          df          MS        F           p
===============================================================
conditi       0.0094          1      0.0094    0.419        0.524
s/c           0.4907         22       0.0223

person        0.0059          1      0.0059    0.243        0.627
ps/c          0.5302         22       0.0241

cp            0.0315          1      0.0315    1.308        0.265
ps/c          0.5302         22       0.0241
```

Experiment Five: IDM Hits

```
SOURCE: grand mean
condi  gestu   N     MEAN       SD        SE
               48   51.2500   19.3099   2.7871

SOURCE: condition
condi  gestu   N     MEAN       SD        SE
stati          24   50.8333   15.8572   3.2368
movin          24   51.6667   22.5864   4.6104

SOURCE: gesture
condi  gestu   N     MEAN       SD        SE
       gs     24   55.4167   18.4106   3.7580
       gd     24   47.0833   19.6666   4.0144

SOURCE: condition gesture
condi  gestu   N     MEAN       SD        SE
stati  gs     12   55.0000   17.3205   5.0000
stati  gd     12   46.6667   13.7069   3.9568
movin  gs     12   55.8333   20.2073   5.8333
movin  gd     12   47.5000   24.9089   7.1906

FACTOR:      subj      condition   gesture    score
LEVELS:       24           2          2         48
TYPE  :    RANDOM    BETWEEN     WITHIN     DATA

SOURCE            SS          df         MS         F           p
===============================================================
conditi       8.3333          1      8.3333     0.019       0.890
s/c        9416.6667         22    428.0303

gesture     833.3333          1    833.3333     2.523       0.126
gs/c       7266.6667         22    330.3030

cg            0.0000          1      0.0000     0.000       1.000
gs/c       7266.6667         22    330.3030
```

Experiment Five: IDM FP's

```
SOURCE: grand mean
condi  gestu   N     MEAN       SD       SE
              48   41.6667   16.5457   2.3882

SOURCE: condition
condi  gestu   N     MEAN       SD       SE
movin         24   40.8333   13.4864   2.7529
stati         24   42.5000   19.3930   3.9586

SOURCE: gesture
condi  gestu   N     MEAN       SD       SE
       gd     24   38.3333   16.0615   3.2785
       gs     24   45.0000   16.6812   3.4050

SOURCE: condition gesture
condi  gestu   N     MEAN       SD       SE
movin  gd     12   40.0000   13.4840   3.8925
movin  gs     12   41.6667   14.0346   4.0514
stati  gd     12   36.6667   18.7487   5.4123
stati  gs     12   48.3333   18.9896   5.4818

FACTOR:      subj      condition     gesture          score
LEVELS:      24           2             2             48
TYPE :     RANDOM     BETWEEN       WITHIN           DATA

SOURCE          SS         df        MS        F          p
===============================================================
conditi      33.3333        1     33.3333    0.091      0.765
s/c        8033.3333       22    365.1515

gesture     533.3333        1    533.3333    2.958      0.099
gs/c       3966.6667       22    180.3030

cg          300.0000        1    300.0000    1.664      0.210
gs/c       3966.6667       22    180.3030
```

Experiment Five: IDM A'

```
SOURCE: grand mean
condi  gestu   N     MEAN      SD       SE
              48    0.5815   0.0943   0.0136

SOURCE: condition
condi  gestu   N     MEAN      SD       SE
stati         24    0.5625   0.0747   0.0153
movin         24    0.6004   0.1087   0.0222

SOURCE: gesture
condi  gestu   N     MEAN      SD       SE
       gs     24    0.5671   0.0667   0.0136
       gd     24    0.5958   0.1152   0.0235

SOURCE: condition gesture
condi  gestu   N     MEAN      SD       SE
stati  gs     12    0.5617   0.0587   0.0170
stati  gd     12    0.5633   0.0907   0.0262
movin  gs     12    0.5725   0.0761   0.0220
movin  gd     12    0.6283   0.1313   0.0379

FACTOR:     subj        condition  gesture         score
LEVELS:     24          2          2               48
TYPE :    RANDOM     BETWEEN     WITHIN            DATA

SOURCE            SS         df       MS       F          p
===============================================================
conditi       0.0173         1     0.0173   1.964      0.175
s/c           0.1933        22      0.0088

gesture       0.0099         1     0.0099   1.159      0.293
gs/c          0.1883        22      0.0086

cg            0.0088         1     0.0088   1.028      0.322
gs/c          0.1883        22      0.0086
```

Experiment Five: IDM B"

```
SOURCE: grand mean
condi  gestu   N     MEAN      SD       SE
               48   0.0127   0.1729   0.0250

SOURCE: condition
condi  gestu   N     MEAN      SD       SE
stati          24   0.0387   0.1121   0.0229
movin          24  -0.0133   0.2171   0.0443

SOURCE: gesture
condi  gestu   N     MEAN      SD       SE
       gs     24   0.0258   0.1366   0.0279
       gd     24  -0.0004   0.2051   0.0419

SOURCE: condition gesture
condi  gestu   N     MEAN      SD       SE
stati  gs     12   0.0292   0.1448   0.0418
stati  gd     12   0.0483   0.0716   0.0207
movin  gs     12   0.0225   0.1344   0.0388
movin  gd     12  -0.0492   0.2787   0.0805

FACTOR:      subj      condition    gesture       score
LEVELS:      24        2            2             48
TYPE :    RANDOM    BETWEEN      WITHIN         DATA

SOURCE          SS         df        MS        F          p
===============================================================
conditi      0.0326        1      0.0326    1.158      0.293
s/c          0.6182        22       0.0281

gesture      0.0083        1      0.0083    0.252      0.621
gs/c         0.7217        22       0.0328

cg           0.0248        1      0.0248    0.755      0.394
gs/c         0.7217        22       0.0328
```

Experiment Six: Correct decisions

```
SOURCE: grand mean
task   presentation   N    MEAN      SD       SE
                     48  62.8646   7.0142   1.0124

SOURCE: task
task   presentation   N    MEAN      SD       SE
EXPM                 24  62.0833   5.8359   1.1913
IDM                  24  63.6458   8.0750   1.6483

SOURCE: presentation
task   presentation   N    MEAN      SD       SE
       stati         24  60.8333   6.4550   1.3176
       move          24  64.8958   7.0895   1.4471

SOURCE: task presentation
task   presentation   N    MEAN      SD       SE
EXPM   stati         12  60.2083   6.0733   1.7532
EXPM   move          12  63.9583   5.1631   1.4904
IDM    stati         12  61.4583   7.0274   2.0286
IDM    move          12  65.8333   8.7473   2.5251

FACTOR:    subj       task      presentation   score
LEVELS:    48         2            2           48
TYPE :   RANDOM    BETWEEN     BETWEEN        DATA

SOURCE          SS          df        MS        F          p
==================================================================
task         29.2969         1     29.2969    0.619       0.436
s/tp       2083.8542        44     47.3603

presn       198.0469         1    198.0469    4.182       0.047 *
s/tp       2083.8542        44     47.3603

tp            1.1719         1      1.1719    0.025       0.876
s/tp       2083.8542        44     47.3603
```

Experiment Six: Hits

```
SOURCE: grand mean
task    presn   N     MEAN       SD        SE
               48   54.5833   12.1091    1.7478

SOURCE: task
task    presn   N     MEAN       SD        SE
EXPM           24   55.6250   12.2752    2.5057
IDM            24   53.5417   12.1117    2.4723

SOURCE: presentation
task    presn   N     MEAN       SD        SE
        stati  24   53.5417   10.1595    2.0738
        move   24   55.6250   13.9340    2.8443

SOURCE: task presentation
task    presn    N     MEAN       SD        SE
EXPM   stati    12   54.5833    9.4046    2.7149
EXPM   move     12   56.6667   14.9747    4.3228
IDM     stati   12   52.5000   11.1803    3.2275
IDM     move    12   54.5833   13.3924    3.8660

FACTOR:     subj         task       presentation    score
LEVELS:      48            2              2            48
TYPE :   RANDOM    BETWEEN    BETWEEN        DATA

SOURCE            SS          df          MS        F          p
===============================================================
task          52.0833         1      52.0833    0.338        0.564
s/tp        6787.5000        44      154.2614

present       52.0833         1      52.0833    0.338        0.564
s/tp        6787.5000        44      154.2614

tp             0.0000         1       0.0000    0.000        1.000
s/tp        6787.5000        44      154.2614
```

Experiment Six: FP's

```
SOURCE: grand mean
task   presn   N    MEAN      SD       SE
               48  28.8542  10.1184   1.4605

SOURCE: task
task   presn   N    MEAN      SD       SE
EXPM          24  31.4583   8.5312   1.7414
IDM           24  26.2500  11.0581   2.2572

SOURCE: presn
task   presn   N    MEAN      SD       SE
       static  24  31.8750   9.7593   1.9921
       move    24  25.8333   9.7431   1.9888

SOURCE: task presn
task   presn   N    MEAN      SD       SE
EXPM   static  12  34.1667   6.6856   1.9300
EXPM   move    12  28.7500   9.5644   2.7610
IDM    static  12  29.5833  11.9579   3.4520
IDM    move    12  22.9167   9.4046   2.7149

FACTOR:    subj      task      presn    score
LEVELS:    48        2         2        48
TYPE :   RANDOM   BETWEEN   BETWEEN    DATA

SOURCE          SS        df       MS       F          p
===============================================================
task        325.5208       1   325.5208   3.542      0.066
s/tp       4043.7500      44    91.9034

presn       438.0208       1   438.0208   4.766      0.034 *
s/tp       4043.7500      44    91.9034

tp            4.6875       1     4.6875   0.051      0.822
s/tp       4043.7500      44    91.9034
```

Experiment Six: A'

```
SOURCE: grand mean
task    presn   N     MEAN      SD       SE
                48    0.5569    0.0394   0.0057

SOURCE: task
task    presn   N     MEAN      SD       SE
EXPM            24    0.5488    0.0347   0.0071
IDM             24    0.5650    0.0429   0.0088

SOURCE: presn
task    presn   N     MEAN      SD       SE
        static  24    0.5465    0.0335   0.0068
        move    24    0.5673    0.0428   0.0087

SOURCE: task presn
task      presn   N     MEAN      SD       SE
EXPM    static    12    0.5387    0.0225   0.0065
EXPM    move      12    0.5588    0.0423   0.0122
IDM     static    12    0.5542    0.0413   0.0119
IDM     move      12    0.5758    0.0434   0.0125

FACTOR:     subj       task       presn     score
LEVELS:     48         2          2         48
TYPE :    RANDOM     BETWEEN    BETWEEN     DATA

SOURCE          SS          df        MS        F          p
===============================================================
task          0.0032        1       0.0032    2.153      0.149
s/tp          0.0647        44      0.0015

presn         0.0052        1       0.0052    3.539      0.067
s/tp          0.0647        44      0.0015

tp            0.0000        1       0.0000    0.006      0.940
s/tp          0.0647        44      0.0015
```

Experiment Six: B"

```
SOURCE: grand mean
task   presn   N    MEAN     SD       SE
               48   0.1040   0.1751   0.0253

SOURCE: task
task   presn   N    MEAN     SD       SE
IDNM           24   0.0321   0.1512   0.0309
EXPM           24   0.1758   0.1704   0.0348

SOURCE: presn
task   presn   N    MEAN     SD       SE
       move    24   0.0765   0.0939   0.0192
       stati   24   0.1315   0.2287   0.0467

SOURCE: task presn
task    presn   N    MEAN     SD       SE
IDNM    move    12   0.0354   0.0635   0.0183
IDNM    stati   12   0.0288   0.2091   0.0604
EXPM    move    12   0.1175   0.1037   0.0299
EXPM    stati   12   0.2342   0.2063   0.0596

FACTOR:    subj      task      presn      score
LEVELS:    48        2         2          48
TYPE  :  RANDOM   BETWEEN   BETWEEN     DATA

SOURCE          SS        df      MS       F          p
===============================================================
task         0.2480       1    0.2480   9.813      0.003 **
s/tp         1.1119      44     0.0253

presn        0.0363       1    0.0363   1.436      0.237
s/tp         1.1119      44     0.0253

tp           0.0456       1    0.0456   1.806      0.186
s/tp         1.1119      44     0.0253
```

Experiment Six: EXPM Hits

```
SOURCE: grand mean
condi  person   N     MEAN       SD       SE
               48   55.6250   17.9723   2.5941

SOURCE: condition
condi  person   N     MEAN       SD       SE
stati          24   54.5833   15.5980   3.1839
move           24   56.6667   20.3591   4.1558

SOURCE: person
condi  person   N     MEAN       SD       SE
       ps      24   59.1667   17.9169   3.6573
       pd      24   52.0833   17.6879   3.6105

SOURCE: condition person
condi  person   N     MEAN       SD       SE
stati  ps      12   55.8333   16.2135   4.6804
stati  pd      12   53.3333   15.5700   4.4947
move   ps      12   62.5000   19.5982   5.6575
move   pd      12   50.8333   20.2073   5.8333

FACTOR:     subj       condition   person        score
LEVELS:     24         2           2             48
TYPE  :   RANDOM     BETWEEN     WITHIN          DATA

SOURCE          SS          df        MS        F           p
===============================================================
conditi       52.0833        1      52.0833   0.167       0.687
s/c         6879.1667       22     312.6894

person       602.0833        1     602.0833   1.791       0.194
ps/c        7395.8333       22     336.1742

cp           252.0833        1     252.0833   0.750       0.396
ps/c        7395.8333       22     336.1742
```

Experiment Six: EXPM FP's

```
SOURCE: grand mean
condi  perso   N     MEAN      SD       SE
              48   31.4583   12.2021   1.7612

SOURCE: condition
condi  person   N     MEAN      SD       SE
stati          24   34.1667   11.7646   2.4014
move           24   28.7500   12.2696   2.5045

SOURCE: person
condi  person   N     MEAN      SD       SE
       ps      24   30.8333   13.4864   2.7529
       pd      24   32.0833   11.0253   2.2505

SOURCE: condition person
condi  person   N     MEAN      SD       SE
stati  ps      12   36.6667   13.0268   3.7605
stati  pd      12   31.6667   10.2986   2.9729
move   ps      12   25.0000   11.6775   3.3710
move   pd      12   32.5000   12.1543   3.5086

FACTOR:      subj        condition    person    score
LEVELS:      24          2            2         48
TYPE :    RANDOM      BETWEEN      WITHIN     DATA

SOURCE          SS           df        MS         F          p
===============================================================
conditi     352.0833         1     352.0833    2.586      0.122
s/c        2995.8333        22     136.1742

person       18.7500         1      18.7500    0.130      0.721
ps/c       3162.5000        22     143.7500

cp          468.7500         1     468.7500    3.261      0.085
ps/c       3162.5000        22     143.7500
```

Experiment Six: EXPM A'

```
SOURCE: grand mean
condi  person   N     MEAN      SD       SE
               48   0.5487   0.0513   0.0074

SOURCE: condition
condi  person   N     MEAN      SD       SE
stati          24   0.5387   0.0330   0.0067
move           24   0.5588   0.0638   0.0130

SOURCE: person
condi  person   N     MEAN      SD       SE
       ps      24   0.5538   0.0572   0.0117
       pd      24   0.5437   0.0452   0.0092

SOURCE: condition person
condi  person   N     MEAN      SD       SE
stati  ps      12   0.5350   0.0288   0.0083
stati  pd      12   0.5425   0.0377   0.0109
move   ps      12   0.5725   0.0725   0.0209
move   pd      12   0.5450   0.0533   0.0154

FACTOR:      subj        condition   person        score
LEVELS:      24          2           2             48
TYPE :     RANDOM      BETWEEN     WITHIN          DATA

SOURCE            SS        df        MS       F          p
=====================================================================
conditi        0.0048        1     0.0048   2.090      0.162
s/c            0.0505       22      0.0023

person         0.0012        1     0.0012   0.417      0.525
ps/c           0.0633       22      0.0029

cp             0.0037        1     0.0037   1.277      0.271
ps/c           0.0633       22      0.0029
```

```
Experiment Six: EXPM B"
SOURCE: grand mean
condi  person   N     MEAN      SD       SE
               48   0.0321   0.1964   0.0283

SOURCE: condition
condi  person   N     MEAN      SD       SE
stati          24   0.0354   0.1040   0.0212
move           24   0.0288   0.2608   0.0532

SOURCE: person
condi  person   N     MEAN      SD       SE
       ps      24   0.0221   0.2665   0.0544
       pd      24   0.0421   0.0873   0.0178

SOURCE: condition person
condi  person   N     MEAN      SD       SE
stati  ps      12   0.0183   0.1208   0.0349
stati  pd      12   0.0525   0.0859   0.0248
move   ps      12   0.0258   0.3658   0.1056
move   pd      12   0.0317   0.0911   0.0263

FACTOR:      subj        condition   person    score
LEVELS:      24          2             2       48
TYPE :    RANDOM    BETWEEN     WITHIN     DATA

SOURCE           SS          df        MS       F          p
===============================================================
conditi        0.0005         1      0.0005   0.011       0.917
s/c            1.0508        22        0.0478

person         0.0048         1      0.0048   0.140       0.712
ps/c           0.7547        22        0.0343

cp             0.0024         1      0.0024   0.070       0.794
ps/c           0.7547        22        0.0343
```

Experiment Six: IDM Hits

```
SOURCE: grand mean
condi  gesture   N     MEAN      SD       SE
                48  53.5417  15.7763   2.2771

SOURCE: condition
condi  gesture   N     MEAN      SD       SE
stati           24  52.5000  15.1083   3.0840
move            24  54.5833  16.6757   3.4039

SOURCE: gesture
condi  gesture   N     MEAN      SD       SE
        gs      24  57.0833   8.5867   1.7528
        gd      24  50.0000  20.2162   4.1266

SOURCE: condition gesture
condi  gesture   N     MEAN      SD       SE
stati   gs      12  54.1667   6.6856   1.9300
stati   gd      12  50.8333  20.6522   5.9618
move    gs      12  60.0000   9.5346   2.7524
move    gd      12  49.1667  20.6522   5.9618

FACTOR:    subj      condition  gesture   score
LEVELS:    24        2          2         48
TYPE :     RANDOM    BETWEEN    WITHIN    DATA

SOURCE         SS          df       MS        F        p
===============================================================
conditi     52.0833        1     52.0833   0.171    0.683
s/c       6695.8333       22    304.3561

gesture    602.0833        1    602.0833   3.169    0.089
gs/c      4179.1667       22    189.9621

cg         168.7500        1    168.7500   0.888    0.356
gs/c      4179.1667       22    189.9621
```

Experiment Six: IDM FP's

```
SOURCE: grand mean
condi  gesture   N    MEAN       SD       SE
                 48   26.2500   14.0856   2.0331

SOURCE: condition
condi  gesture   N    MEAN       SD       SE
stati            24   29.5833   15.4580   3.1553
move             24   22.9167   11.9707   2.4435

SOURCE: gesture
condi  gesture   N    MEAN       SD       SE
       gd        24   31.2500   14.8361   3.0284
       gs        24   21.2500   11.5392   2.3554

SOURCE: condition gesture
condi  gesture   N    MEAN       SD       SE
stati  gd        12   36.6667   17.7525   5.1247
stati  gs        12   22.5000    8.6603   2.5000
move   gd        12   25.8333    9.0034   2.5990
move   gs        12   20.0000   14.1421   4.0825

FACTOR:     subj      condition    gesture     score
LEVELS:     24           2            2         48
TYPE :    RANDOM     BETWEEN      WITHIN      DATA

SOURCE          SS          df        MS         F          p
==================================================================
conditi      533.3333        1     533.3333    2.304      0.143
s/c         5091.6667       22     231.4394

gesture     1200.0000        1    1200.0000   11.520      0.003 **
gs/c        2291.6667       22     104.1667

cg           208.3333        1     208.3333    2.000      0.171
gs/c        2291.6667       22     104.1667
```

Experiment Six: IDM A'

```
SOURCE: grand mean
condi  gesture   N     MEAN      SD       SE
                48   0.5650   0.0637   0.0092

SOURCE: condition
condi  gesture   N     MEAN      SD       SE
stati           24   0.5542   0.0643   0.0131
move            24   0.5758   0.0627   0.0128

SOURCE: gesture
condi  gesture   N     MEAN      SD       SE
       gs       24   0.5471   0.0392   0.0080
       gd       24   0.5829   0.0781   0.0159

SOURCE: condition gesture
condi  gesture   N     MEAN      SD       SE
stati  gs       12   0.5400   0.0467   0.0135
stati  gd       12   0.5683   0.0776   0.0224
move   gs       12   0.5542   0.0303   0.0087
move   gd       12   0.5975   0.0792   0.0229

FACTOR:    subj      condition    gesture     score
LEVELS:    24          2            2          48
TYPE :   RANDOM    BETWEEN      WITHIN      DATA

SOURCE          SS        df        MS       F          p
==============================================================
conditi     0.0056        1     0.0056   1.569      0.223
s/c         0.0790       22      0.0036

gesture     0.0154        1     0.0154   3.753      0.066
gs/c        0.0903       22      0.0041

cg          0.0007        1     0.0007   0.164      0.689
gs/c        0.0903       22      0.0041
```

Experiment Six: IDM B"

```
SOURCE: grand mean
condi  gesture   N    MEAN      SD      SE
                48   0.1758   0.2205   0.0318

SOURCE: condition
condi  gesture   N    MEAN      SD      SE
move            24   0.1175   0.1410   0.0288
still           24   0.2342   0.2691   0.0549

SOURCE: gesture
condi  gesture   N    MEAN      SD      SE
       gs      24   0.1029   0.1472   0.0300
       gd      24   0.2488   0.2581   0.0527

SOURCE: condition gesture
condi  gesture   N    MEAN      SD      SE
move   gs       12   0.0867   0.1476   0.0426
move   gd       12   0.1483   0.1330   0.0384
still  gs       12   0.1192   0.1514   0.0437
still  gd       12   0.3492   0.3156   0.0911

FACTOR:     subj      condition    gesture     score
LEVELS:      24           2            2          48
TYPE :   RANDOM    BETWEEN      WITHIN      DATA

SOURCE           SS          df         MS        F           p
===============================================================
conditi       0.1633         1       0.1633    3.063        0.094
s/c           1.1730        22        0.0533

gesture       0.2552         1       0.2552    9.220        0.006 **
gs/c          0.6090        22        0.0277

cg            0.0850         1       0.0850    3.071        0.094
gs/c          0.6090        22        0.0277
```

Experiment Seven (single static): Hits

```
SOURCE: grand mean
format       presn   N     MEAN       SD        SE
                     96   56.1625   19.8047   2.0213

SOURCE: format
format       presn   N     MEAN       SD        SE
inv                  48   62.1542   18.1098   2.6139
neg                  48   50.1708   19.7866   2.8559

SOURCE: presentation
format       presn   N     MEAN       SD        SE
             move    48   59.8896   19.5041   2.8152
             static  48   52.4354   19.5963   2.8285

SOURCE: format presn
format       presn   N     MEAN       SD        SE
inv          move    24   64.5792   19.2384   3.9270
inv          static  24   59.7292   16.9646   3.4629
neg          move    24   55.2000   19.0092   3.8802
neg          static  24   45.1417   19.6444   4.0099

FACTOR:   subj       format      presentation  score
LEVELS:     48          2             2          96
TYPE  :  RANDOM    BETWEEN      WITHIN       DATA

SOURCE          SS          df        MS          F        p
===============================================================
format      3446.4066       1    3446.4066     6.128   0.017 *
s/f        25870.6783      46     562.4060

presn       1333.5504       1    1333.5504     9.513   0.003 **
ps/f        6448.1693      46     140.1776

fp           162.7604       1     162.7604     1.161    0.287
ps/f        6448.1693      46     140.1776
```

Experiment Seven: Items analysis

```
SOURCE: grand mean
format      condi   N    MEAN      SD        SE
                    96   56.1635   24.5792   2.5086

SOURCE: format
format      cond    N    MEAN      SD        SE
inv                 48   62.1521   23.8878   3.4479
neg                 48   50.1750   24.0260   3.4679

SOURCE: condition
format      cond    N    MEAN      SD        SE
            move    48   59.8958   25.1236   3.6263
            static  48   52.4312   23.6956   3.4202

SOURCE: format condition
format      cond    N    MEAN      SD        SE
inv         move    24   64.5833   22.5594   4.6049
inv         static  24   59.7208   25.3930   5.1833
neg         move    24   55.2083   27.1118   5.5342
neg         static  24   45.1417   19.7908   4.0398

FACTOR:     face      format     condition   score
LEVELS:     48        2          2           96
TYPE  : RANDOM   BETWEEN    WITHIN      DATA

SOURCE      SS           df    MS          F       p
===============================================================
format      3442.8122    1     3442.8122   4.381   0.042 *
f/f         36147.7547   46    785.8208

conditi     1337.2802    1     1337.2802   3.773   0.058
cf/f        16302.7547   46    354.4077

fc          162.5001     1     162.5001    0.459   0.502
cf/f        16302.7547   46    354.4077
```

Experiment Eight (multi-static): Hits

```
SOURCE: grand mean
format      presn   N    MEAN       SD        SE
                    96   52.6062   18.9779   1.9369

SOURCE: format
format      presn   N    MEAN       SD        SE
inv                 48   54.3375   19.2902   2.7843
neg                 48   50.8750   18.7016   2.6993

SOURCE: presentation
format      presn   N    MEAN       SD        SE
            move    48   58.8521   18.7905   2.7122
            static  48   46.3604   17.1820   2.4800

SOURCE: format presentation
format      presn   N    MEAN       SD        SE
inv         move    24   61.1042   17.1399   3.4987
inv         static  24   47.5708   19.2631   3.9321
neg         move    24   56.6000   20.4244   4.1691
neg         static  24   45.1500   15.1377   3.0900

FACTOR:   subj      format     presn    score
LEVELS:    48         2          2       96
TYPE  :  RANDOM  BETWEEN  WITHIN  DATA

SOURCE         SS          df       MS          F         p
===========================================================
format      287.7338       1    287.7338      0.700     0.407
s/f         18920.7720     46   411.3211

presn       3745.0014      1    3745.0014     15.332    0.000 ***
ps/f        11235.6662     46   244.2536

fp          26.0417        1    26.0417       0.107     0.746
ps/f        11235.6662     46   244.2536
```

Experiment Eight (multi static): Items analysis

```
SOURCE: grand mean
format  condition   N     MEAN       SD        SE
                    96   52.6010   28.3452   2.8930

SOURCE: format
format        cond   N     MEAN       SD        SE
inv                  48   54.3354   28.9262   4.1751
neg                  48   50.8667   27.9486   4.0340

SOURCE: condition
format        cond    N     MEAN       SD        SE
              move    48   58.8521   28.3769   4.0958
              static  48   46.3500   27.1834   3.9236

SOURCE: format condition
format        cond    N     MEAN       SD        SE
inv           move    24   61.1083   29.1537   5.9510
inv           static  24   47.5625   27.6435   5.6427
neg           move    24   56.5958   28.0168   5.7189
neg           static  24   45.1375   27.2538   5.5632

FACTOR:      face      format      condition    score
LEVELS:      48             2             2     96
TYPE  :  RANDOM  BETWEEN  WITHIN  DATA

SOURCE              SS     df          MS               F        p
=====================================================================
format        288.7734      1     288.7734         0.214    0.645
f/f         61935.3906     46    1346.4215

condit       3751.2500      1    3751.2500        16.711    0.000 ***
cf/f        10326.2486     46     224.4837

fc             26.1459      1      26.1459         0.116    0.734
cf/f        10326.2486     46     224.4837
```

Experiment Nine (combined formats): Hits

```
SOURCE: grand mean
presentation         N     MEAN       SD       SE
                    48   18.5750   11.1784   1.6135

SOURCE: presnt
presentation         N     MEAN       SD       SE
move                24   22.2208   11.7084   2.3900
static              24   14.9292    9.5143   1.9421

FACTOR:             subj    presentation         score
LEVELS:              24          2                 48
TYPE :          RANDOM      WITHIN              DATA

SOURCE          SS          df        MS           F       p
===============================================================
presnt      638.0208         1      638.0208      6.330   0.019 *
ps/        2318.1091        23      100.7874
```

Experiment Nine: combined formats: Items analysis

```
SOURCE: grand mean
presentation         N     MEAN       SD       SE
                    48   18.5688   19.1607   2.7656

SOURCE: presentation
presentation         N     MEAN       SD       SE
move                24   22.2125   19.1418   3.9073
static              24   14.9250   18.8709   3.8520

FACTOR:             face    presentation     score
LEVELS:              24        2               48
TYPE :          RANDOM      WITHIN          DATA

SOURCE          SS          df        MS           F       p
===============================================================
presnt        637.2919      1      637.2919    6.738     0.016 *
pf/          2175.2231     23       94.5749
```

Experiment Ten: Hits

```
SOURCE: grand mean
duration  type  format  presn     N     MEAN       SD       SE
                                192   60.1556   21.7644   1.5707

SOURCE: duration
duration  type  format  presn     N     MEAN       SD       SE
sh.tr                            96   59.7208   20.0394   2.0453
l.tr                             96   60.5903   23.4608   2.3945

SOURCE: type
duration  type  format  presn     N     MEAN       SD       SE
          st                     96   59.3747   22.6608   2.3128
          mt                     96   60.9365   20.9195   2.1351

SOURCE: duration type
duration  type  format  presn     N     MEAN       SD       SE
sh.tr     st                     48   57.9854   21.7406   3.1380
sh.tr     mt                     48   61.4562   18.2453   2.6335
l.tr      st                     48   60.7640   23.6928   3.4198
l.tr      mt                     48   60.4167   23.4759   3.3885

SOURCE: format
duration  type  format  presn     N     MEAN       SD       SE
                inv              96   61.6341   20.1047   2.0519
                neg              96   58.6771   23.3184   2.3799

SOURCE: duration format
duration  type  format  presn     N     MEAN       SD       SE
sh.tr           inv              48   61.4625   17.5827   2.5378
sh.tr           neg              48   57.9792   22.2789   3.2157
l.tr            inv              48   61.8056   22.5342   3.2525
l.tr            neg              48   59.3750   24.5300   3.5406

SOURCE: type format
duration  type  format  presn     N     MEAN       SD       SE
          st    inv              48   60.0723   21.3987   3.0886
          st    neg              48   58.6771   24.0635   3.4733
          mt    inv              48   63.1958   18.8180   2.7161
          mt    neg              48   58.6771   22.8039   3.2915
```

```
SOURCE: duration type format
durn  type  format  presn      N   MEAN     SD       SE
sh.tr  st    inv               24  59.0333  18.3754  3.7509
sh.tr  st    neg               24  56.9375  25.0183  5.1068
sh.tr  mt    inv               24  63.8917  16.7861  3.4264
sh.tr  mt    neg               24  59.0208  19.6495  4.0109
l.tr   st    inv               24  61.1113  24.4092  4.9825
l.tr   st    neg               24  60.4167  23.4744  4.7917
l.tr   mt    inv               24  62.5000  20.9963  4.2859
l.tr   mt    neg               24  58.3333  26.0057  5.3084

SOURCE: presentation
duration type  format presn      N   MEAN     SD       SE
                      dynamic   96  65.1044  22.1743  2.2632
                      fixed     96  55.2068  20.2774  2.0696

SOURCE: duration presentation
durn  type  format    presn      N   MEAN     SD       SE
sh.tr                 dynamic    48  61.8062  20.6178  2.9759
sh.tr                 fixed      48  57.6354  19.4350  2.8052
l.tr                  dynamic    48  68.4025  23.3783  3.3744
l.tr                  fixed      48  52.7781  21.0078  3.0322

SOURCE: type presentation
duration type  format presn      N   MEAN     SD       SE
         st           dynamic    48  63.1929  23.8109  3.4368
         st           fixed      48  55.5565  21.0050  3.0318
         mt           dynamic    48  67.0158  20.4801  2.9560
         mt           fixed      48  54.8571  19.7392  2.8491

SOURCE: duration type presentation
durn  type  format    presn      N   MEAN     SD       SE
sh.tr  st             dynamic    24  59.0250  23.5627  4.8097
sh.tr  st             fixed      24  56.9458  20.2090  4.1251
sh.tr  mt             dynamic    24  64.5875  17.2431  3.5197
sh.tr  mt             fixed      24  58.3250  19.0385  3.8862
l.tr   st             dynamic    24  67.3608  23.8142  4.8611
l.tr   st             fixed      24  54.1671  22.1172  4.5147
l.tr   mt             dynamic    24  69.4442  23.3981  4.7761
l.tr   mt             fixed      24  51.3892  20.2150  4.1264
```

SOURCE: format presentation

duration	type	format	presn	N	MEAN	SD	SE
		inv	dynamic	48	69.7944	17.7484	2.5618
		inv	fixed	48	53.4737	19.1306	2.7613
		neg	dynamic	48	60.4144	25.1778	3.6341
		neg	fixed	48	56.9398	21.4238	3.0923

SOURCE: duration format presentation

durn	type	format	presn	N	MEAN	SD	SE
sh.tr		inv	dynamic	24	65.2833	16.9636	3.4627
sh.tr		inv	fixed	24	57.6417	17.7062	3.6143
sh.tr		neg	dynamic	24	58.3292	23.5728	4.8118
sh.tr		neg	fixed	24	57.6292	21.4091	4.3701
l.tr		inv	dynamic	24	74.3054	17.7054	3.6141
l.tr		inv	fixed	24	49.3058	19.9526	4.0728
l.tr		neg	dynamic	24	62.4996	27.0306	5.5176
l.tr		neg	fixed	24	56.2504	21.8764	4.4655

SOURCE: type format presentation

durn	type	format	presn	N	MEAN	SD	SE
	st	inv	dynamic	24	68.7512	17.9315	3.6603
	st	inv	fixed	24	51.3933	21.3771	4.3636
	st	neg	dynamic	24	57.6346	27.7949	5.6736
	st	neg	fixed	24	59.7196	20.2102	4.1254
	mt	inv	dynamic	24	70.8375	17.8858	3.6509
	mt	inv	fixed	24	55.5542	16.7886	3.4270
	mt	neg	dynamic	24	63.1942	22.5105	4.5949
	mt	neg	fixed	24	54.1600	22.6570	4.6248

```
SOURCE: duration type format presentation
durn  type  format   presn      N   MEAN     SD       SE
sh.tr  st    inv    dynamic    12  63.8917  18.5778  5.3630
sh.tr  st    inv    fixed      12  54.1750  17.5889  5.0775
sh.tr  st    neg    dynamic    12  54.1583  27.6417  7.9795
sh.tr  st    neg    fixed      12  59.7167  22.9742  6.6321
sh.tr  mt    inv    dynamic    12  66.6750  15.8847  4.5855
sh.tr  mt    inv    fixed      12  61.1083  17.8867  5.1634
sh.tr  mt    neg    dynamic    12  62.5000  18.9697  5.4761
sh.tr  mt    neg    fixed      12  55.5417  20.5194  5.9234
l.tr   st    inv    dynamic    12  73.6108  16.6026  4.7928
l.tr   st    inv    fixed      12  48.6117  25.0849  7.2414
l.tr   st    neg    dynamic    12  61.1108  28.7213  8.2911
l.tr   st    neg     fixed     12  59.7225  18.0616  5.2139
l.tr   mt    inv    dynamic    12  75.0000  19.4617  5.6181
l.tr   mt    inv    fixed      12  50.0000  14.2162  4.1039
l.tr   mt    neg    dynamic    12  63.8883  26.4312  7.6300
l.tr   mt    neg  f ixed       12  52.7783  25.4585  7.3492

FACTOR:     subj      duration  type   format   presn    score
LEVELS:      96          2        2       2        2      192
TYPE :   RANDOM  BETW    BETW    BETW  WITHIN   DATA

SOURCE          SS         df        MS        F          p
================================================================
duration     36.2877       1     36.2877    0.071       0.791
s/dtf      45014.7046     88      511.5307

type        117.0782       1    117.0782    0.229       0.634
s/dtf      45014.7046     88      511.5307

dt          174.9369       1    174.9369    0.342       0.560
s/dtf      45014.7046     88      511.5307

format      419.6988       1    419.6988    0.820       0.368
s/dtf      45014.7046     88      511.5307

df           13.2983       1     13.2983    0.026       0.872
s/dtf      45014.7046     88      511.5307

tf          117.0782       1    117.0782    0.229       0.634
s/dtf      45014.7046     88      511.5307

dtf           1.4578       1      1.4578    0.003       0.958
s/dtf      45014.7046     88      511.5307
```

presn	4702.2033	1	4702.2033	11.789	0.001 ***
ps/dtf	35100.1757	88	398.8656		
dp	1574.2035	1	1574.2035	3.947	0.050
ps/dtf	35100.1757	88	398.8656		
tp	245.4134	1	245.4134	0.615	0.435
ps/dtf	35100.1757	88	398.8656		
dtp	1.3787	1	1.3787	0.003	0.953
ps/dtf	35100.1757	88	398.8656		
fp	1980.2494	1	1980.2494	4.965	0.028 *
ps/dtf	35100.1757	88	398.8656		
dfp	418.3397	1	418.3397	1.049	0.309
ps/dtf	35100.1757	88	398.8656		
tfp	522.2251	1	522.2251	1.309	0.256
ps/dtf	35100.1757	88	398.8656		
dtfp	36.1835	1	36.1835	0.091	0.764
ps/dtf	35100.1757	88	398.8656		

Experiment Ten: Items analysis

```
SOURCE: grand mean
durat  learn   forma  condi       N    MEAN      SD       SE
                                  192  60.0690   23.6293  1.7053

SOURCE: duration
durat  learn   forma  condi       N    MEAN      SD       SE
short                             96   59.5484   24.1516  2.4650
long                              96   60.5895   23.2103  2.3689

SOURCE: learning
durat  learn   forma  condi       N    MEAN      SD       SE
       static                     96   59.3745   22.4013  2.2863
       moving                     96   60.7634   24.8953  2.5409

SOURCE: duration learning
durat  learn   forma  condi       N    MEAN      SD       SE
short  static                     48   57.9858   22.0114  3.1771
short  moving                     48   61.1110   26.2587  3.7901
long   static                     48   60.7631   22.9319  3.3099
long   moving                     48   60.4158   23.7269  3.4247

SOURCE: format
durat  learn   forma  condi       N    MEAN      SD       SE
               inv                96   61.4576   25.2832  2.5805
               neg                96   58.6803   21.8959  2.2347

SOURCE: duration format
durat  learn   forma  condi       N    MEAN      SD       SE
short          inv                48   61.1108   26.2583  3.7901
short          neg                48   57.9860   22.0119  3.1772
long           inv                48   61.8044   24.5426  3.5424
long           neg                48   59.3746   21.9898  3.1739

SOURCE: learning format
durat  learn   forma  condi       N    MEAN      SD       SE
       static  inv                48   60.0690   24.2469  3.4997
       static  neg                48   58.6800   20.6256  2.9770
       moving  inv                48   62.8463   26.4618  3.8194
       moving  neg                48   58.6806   23.3162  3.3654
```

```
SOURCE: duration learning format
durat  learn   forma  condi        N    MEAN      SD       SE
short  static  inv                 24   59.0275   24.0663  4.9125
short  static  neg                 24   56.9442   20.2142  4.1262
short  moving  inv                 24   63.1942   28.6483  5.8478
short  moving  neg                 24   59.0279   24.0674  4.9127
long   static  inv                 24   61.1104   24.8985  5.0824
long   static  neg                 24   60.4158   21.3172  4.3513
long   moving  inv                 24   62.4983   24.6966  5.0412
long   moving  neg                 24   58.3333   23.0530  4.7057

SOURCE: condition
durat  learn   forma  condi        N    MEAN      SD       SE
                      dyn          96   63.8883   23.7760  2.4266
                      fixed        96   56.2496   22.9736  2.3447

SOURCE: duration condition
durat  learn   forma  condi        N    MEAN      SD       SE
short                 dyn          48   61.4581   23.3576  3.3714
short                 fixed        48   57.6388   25.0197  3.6113
long                  dyn          48   66.3185   24.1865  3.4910
long                  fixed        48   54.8604   20.9015  3.0169

SOURCE: learning condition
durat  learn   forma  condi        N    MEAN      SD       SE
       static         dyn          48   61.1106   23.1481  3.3411
       static         fixed        48   57.6383   21.7330  3.1369
       moving         dyn          48   66.6660   24.3112  3.5090
       moving         fixed        48   54.8608   24.3010  3.5075

SOURCE: duration learning condition
durat  learn   forma  condi        N    MEAN      SD       SE
short  static         dyn          24   59.0275   23.0407  4.7032
short  static         fixed        24   56.9442   21.3759  4.3633
short  moving         dyn          24   63.8888   23.9096  4.8805
short  moving         fixed        24   58.3333   28.6575  5.8497
long   static         dyn          24   63.1938   23.5591  4.8090
long   static         fixed        24   58.3325   22.5221  4.5973
long   moving         dyn          24   69.4433   24.8998  5.0826
long   moving         fixed        24   51.3883   18.9825  3.8748
```

SOURCE: format condition

durat	learn	forma	condi	N	MEAN	SD	SE
		inv	dyn	48	67.3604	24.5421	3.5423
		inv	fixed	48	55.5548	24.8716	3.5899
		neg	dyn	48	60.4163	22.7088	3.2777
		neg	fixed	48	56.9444	21.1475	3.0524

SOURCE: duration format condition

durat	learn	forma	condi	N	MEAN	SD	SE
short		inv	dyn	24	64.5833	23.7291	4.8437
short		inv	fixed	24	57.6383	28.6485	5.8479
short		neg	dyn	24	58.3329	23.0525	4.7056
short		neg	fixed	24	57.6392	21.4114	4.3706
long		inv	dyn	24	70.1375	25.5275	5.2108
long		inv	fixed	24	53.4713	20.8397	4.2539
long		neg	dyn	24	62.4996	22.6566	4.6248
long		neg	fixed	24	56.2496	21.3172	4.3514

SOURCE: learning format condition

durat	learn	forma	condi	N	MEAN	SD	SE
	static	inv	dyn	24	64.5829	24.7259	5.0471
	static	inv	fixed	24	55.5550	23.3986	4.7762
	static	neg	dyn	24	57.6383	21.4111	4.3705
	static	neg	fixed	24	59.7217	20.2145	4.1263
	moving	inv	dyn	24	70.1379	24.5632	5.0139
	moving	inv	fixed	24	55.5546	26.7692	5.4642
	moving	neg	dyn	24	63.1942	24.0678	4.9128
	moving	neg	fixed	24	54.1671	22.1169	4.5146

```
SOURCE: duration learning format condition
durat  learn   forma  condi        N    MEAN      SD        SE
short  static  inv    dyn         12  63.8892  23.3902   6.7522
short  static  inv    fixed       12  54.1658  24.7459   7.1435
short  static  neg    dyn         12  54.1658  22.6128   6.5278
short  static  neg    fixed       12  59.7225  18.0608   5.2137
short  moving  inv    dyn         12  65.2775  25.0834   7.2410
short  moving  inv    fixed       12  61.1108  32.8240   9.4755
short  moving  neg    dyn         12  62.5000  23.7048   6.8430
short  moving  neg    fixed       12  55.5558  24.9582   7.2048
long   static  inv    dyn         12  65.2767  27.0216   7.8005
long   static  inv    fixed       12  56.9442  22.9824   6.6345
long   static  neg    dyn         12  61.1108  20.5157   5.9224
long   static  neg    fixed       12  59.7208  22.9828   6.6346
long   moving  inv    dyn         12  74.9983  24.1004   6.9572
long   moving  inv    fixed       12  49.9983  18.8031   5.4280
long   moving  neg    dyn         12  63.8883  25.4599   7.3496
long   moving  neg    fixed       12  52.7783  19.8912   5.7421

FACTOR:     face     durn   learning   format   condition    score
LEVELS:      12        2        2         2         2          192
TYPE  :   RANDOM   WITH   WITH      WITH     WITHIN       DATA

SOURCE           SS          df        MS          F          p
===================================================================

duratio       52.0209        1      52.0209     0.058      0.814
df/         9809.2844       11     891.7531

learnin       92.6018        1      92.6018     0.184      0.676
lf/         5532.1066       11     502.9188

dl           144.6991        1     144.6991     0.232      0.640
dlf/        6868.8289       11     624.4390

format       370.2408        1     370.2408     0.326      0.579
ff/        12475.9125       11    1134.1739

df             5.7963        1       5.7963     0.010      0.921
dff/        6175.3146       11     561.3922

lf            92.5186        1      92.5186     0.289      0.601
lff/        3518.6620       11     319.8784

dlf            5.7755        1       5.7755     0.025      0.876
dlff/       2494.3078       11     226.7553
```

conditi	2800.8241	1	2800.8241	5.568	0.038 *
cf/	5533.2589	11	503.0235		
dc	700.2060	1	700.2060	1.735	0.215
dcf/	4438.6967	11	403.5179		
lc	833.2500	1	833.2500	2.399	0.150
lcf/	3820.2218	11	347.2929		
dlc	283.5324	1	283.5324	0.584	0.461
dlcf/	5340.9262	11	485.5387		
fc	833.4166	1	833.4166	3.772	0.078
fcf/	2430.2780	11	220.9344		
dfc	52.0417	1	52.0417	0.227	0.643
dfcf/	2517.7222	11	228.8838		
lfc	92.5741	1	92.5741	0.227	0.643
lfcf/	4490.5927	11	408.2357		
dlfc	468.9374	1	468.9374	1.994	0.186
dlfcf/	2586.6320	11	235.1484		

Experiment Ten: FP's

```
SOURCE: grand mean
durn   type   forma  cond        N     MEAN       SD        SE
                                 192   41.1454    29.9762   2.1633

SOURCE: duration
durn   type   forma  cond        N     MEAN       SD        SE
sh.tr                            96    43.7497    30.3260   3.0951
l.tr                             96    38.5411    29.5506   3.0160

SOURCE: type
durn   type   forma  cond        N     MEAN       SD        SE
       st                        96    42.0138    33.9410   3.4641
       mt                        96    40.2771    25.5558   2.6083

SOURCE: duration type
durn   type   forma  cond        N     MEAN       SD        SE
sh.tr  st                        48    43.0554    34.3530   4.9584
sh.tr  mt                        48    44.4440    26.0343   3.7577
l.tr   st                        48    40.9721    33.8547   4.8865
l.tr   mt                        48    36.1102    24.6341   3.5556

SOURCE: format
durn   type   forma  cond        N     MEAN       SD        SE
              inv                96    33.6796    29.2184   2.9821
              neg                96    48.6112    28.9869   2.9585

SOURCE: duration format
durn   type   forma  cond        N     MEAN       SD        SE
sh.tr         inv                48    35.4158    28.6887   4.1409
sh.tr         neg                48    52.0835    29.8997   4.3157
l.tr          inv                48    31.9433    29.9399   4.3215
l.tr          neg                48    45.1390    27.9238   4.0305

SOURCE: type format
durn   type   forma  cond        N     MEAN       SD        SE
       st     inv                48    34.7213    32.9474   4.7555
       st     neg                48    49.3062    33.6798   4.8613
       mt     inv                48    32.6379    25.2557   3.6453
       mt     neg                48    47.9163    23.7285   3.4249
```

```
SOURCE: duration type format
durn   type   forma  cond        N    MEAN      SD        SE
sh.tr  st     inv                24   34.7213   33.3036   6.7981
sh.tr  st     neg                24   51.3896   34.0217   6.9447
sh.tr  mt     inv                24   36.1104   23.9109   4.8808
sh.tr  mt     neg                24   52.7775   25.8530   5.2772
l.tr   st     inv                24   34.7213   33.3036   6.7981
l.tr   st     neg                24   47.2229   33.9330   6.9265
l.tr   mt     inv                24   29.1654   26.5808   5.4258
l.tr   mt     neg                24   43.0550   20.8055   4.2469

SOURCE: condition
durn   type   forma  cond        N    MEAN      SD        SE
                     dynam       96   43.7494   28.3321   2.8916
                     fixed       96   38.5415   31.4674   3.2116

SOURCE: duration condition
durn   type   forma  cond        N    MEAN      SD        SE
sh.tr                dynam       48   42.3604   29.7675   4.2966
sh.tr                fixed       48   45.1390   31.1264   4.4927
l.tr                 dynam       48   45.1383   27.0639   3.9063
l.tr                 fixed       48   31.9440   30.7197   4.4340

SOURCE: type condition
durn   type   forma  cond        N    MEAN      SD        SE
       st            dynam       48   45.1388   31.8768   4.6010
       st            fixed       48   38.8888   35.9501   5.1890
       mt            dynam       48   42.3600   24.5443   3.5427
       mt            fixed       48   38.1942   26.6234   3.8428

SOURCE: duration type condition
durn   type   forma  cond        N    MEAN      SD        SE
sh.tr  st            dynam       24   43.0554   33.3042   6.7982
sh.tr  st            fixed       24   43.0554   36.0887   7.3666
sh.tr  mt            dynam       24   41.6654   26.4680   5.4028
sh.tr  mt            fixed       24   47.2225   25.8530   5.2772
l.tr   st            dynam       24   47.2221   30.9550   6.3187
l.tr   st            fixed       24   34.7221   36.0886   7.3665
l.tr   mt            dynam       24   43.0546   23.0103   4.6970
l.tr   mt            fixed       24   29.1658   24.6971   5.0413
```

SOURCE: format condition

durn	type	forma	cond	N	MEAN	SD	SE
		inv	dynam	48	38.1931	29.1653	4.2097
		inv	fixed	48	29.1660	28.8682	4.1668
		neg	dynam	48	49.3056	26.6237	3.8428
		neg	fixed	48	47.9169	31.4413	4.5382

SOURCE: duration format condition

durn	type	forma	cond	N	MEAN	SD	SE
sh.tr		inv	dynam	24	36.1100	29.3523	5.9915
sh.tr		inv	fixed	24	34.7217	28.6235	5.8427
sh.tr		neg	dynam	24	48.6108	29.4557	6.0126
sh.tr		neg	fixed	24	55.5562	30.5623	6.2385
l.tr		inv	dynam	24	40.2763	29.4551	6.0125
l.tr		inv	fixed	24	23.6104	28.6227	5.8426
l.tr		neg	dynam	24	50.0004	24.0793	4.9152
l.tr		neg	fixed	24	40.2775	31.0523	6.3385

SOURCE: type format condition

durn	type	forma	cond	N	MEAN	SD	SE
	st	inv	dynam	24	41.6658	34.4039	7.0227
	st	inv	fixed	24	27.7767	30.5612	6.2383
	st	neg	dynam	24	48.6117	29.4557	6.0126
	st	neg	fixed	24	50.0008	38.0701	7.7710
	mt	inv	dynam	24	34.7204	23.0092	4.6967
	mt	inv	fixed	24	30.5554	27.6579	5.6457
	mt	neg	dynam	24	49.9996	24.0793	4.9152
	mt	neg	fixed	24	45.8329	23.7000	4.8378

```
SOURCE: duration type format condition
durn   type   forma  cond        N   MEAN      SD       SE
sh.tr  st     inv    dynam      12   38.8883   37.1553  10.7258
sh.tr  st     inv    fixed      12   30.5542   30.0114   8.6636
sh.tr  st     neg    dynam      12   47.2225   30.0128   8.6639
sh.tr  st     neg    fixed      12   55.5567   38.4906  11.1113
sh.tr  mt     inv    dynam      12   33.3317   20.1018   5.8029
sh.tr  mt     inv    fixed      12   38.8892   27.8300   8.0338
sh.tr  mt     neg    dynam      12   49.9992   30.1526   8.7043
sh.tr  mt     neg    fixed      12   55.5558   21.7138   6.2682
l.tr   st     inv    dynam      12   44.4433   32.8254   9.4759
l.tr   st     inv    fixed      12   24.9992   32.1770   9.2887
l.tr   st     neg    dynam      12   50.0008   30.1526   8.7043
l.tr   st     neg    fixed      12   44.4450   38.4909  11.1114
l.tr   mt     inv    dynam      12   36.1092   26.4327   7.6304
l.tr   mt     inv    fixed      12   22.2217   25.9505   7.4913
l.tr   mt     neg    dynam      12   50.0000   17.4112   5.0262
l.tr   mt     neg    fixed      12   36.1100   22.2868   6.4336

FACTOR:     subj     durn    type    format   condition   score
LEVELS:      96       2       2       2         2          192
TYPE  :   RANDOM    BETW    BETW    BETW     WITHIN      DATA

SOURCE          SS        df        MS        F          p
===============================================================

duration     1302.1874     1    1302.1874   1.266      0.264
s/dtf       90515.6823    88    1028.5873

type          144.7685     1     144.7685   0.141      0.708
s/dtf       90515.6823    88    1028.5873

dt            468.8125     1     468.8125   0.456      0.501
s/dtf       90515.6823    88    1028.5873

format      10701.8233     1   10701.8233  10.404      0.002 **
s/dtf       90515.6823    88    1028.5873

df            144.6644     1     144.6644   0.141      0.709
s/dtf       90515.6823    88    1028.5873

tf              5.7685     1       5.7685   0.006      0.940
s/dtf       90515.6823    88    1028.5873

dtf             5.7894     1       5.7894   0.006      0.940
s/dtf       90515.6823    88    1028.5873
```

conditi	1301.8751	1	1301.8751	1.837	0.179
cs/dtf	62365.8313	88	708.7026		
dc	3061.6087	1	3061.6087	4.320	0.041 *
cs/dtf	62365.8313	88	708.7026		
tc	52.1250	1	52.1250	0.074	0.787
cs/dtf	62365.8313	88	708.7026		
dtc	144.7338	1	144.7338	0.204	0.652
cs/dtf	62365.8313	88	708.7026		
fc	700.1297	1	700.1297	0.988	0.323
cs/dtf	62365.8313	88	708.7026		
dfc	5.8032	1	5.8032	0.008	0.928
cs/dtf	62365.8313	88	708.7026		
tfc	700.4351	1	700.4351	0.988	0.323
cs/dtf	62365.8313	88	708.7026		
dtfc	5.7894	1	5.7894	0.008	0.928
cs/dtf	62365.8313	88	708.7026		

Experiment Ten: A'

```
SOURCE: grand mean
durat  type   forma  condi        N    MEAN     SD      SE
                                  192  0.6154   0.1165  0.0084

SOURCE: duration
durat  type   forma  condi        N    MEAN     SD      SE
sh.tr                             96   0.6151   0.1171  0.0120
l.tr                              96   0.6158   0.1166  0.0119

SOURCE: type
durat  type   forma  condi        N    MEAN     SD      SE
       st                         96   0.6224   0.1226  0.0125
       mt                         96   0.6084   0.1104  0.0113

SOURCE: duration type
durat  type   forma  condi        N    MEAN     SD      SE
sh.tr  st                         48   0.6266   0.1203  0.0174
sh.tr  mt                         48   0.6036   0.1139  0.0164
l.tr   st                         48   0.6183   0.1259  0.0182
l.tr   mt                         48   0.6132   0.1077  0.0155

SOURCE: format
durat  type   forma  condi        N    MEAN     SD      SE
              inv                 96   0.6125   0.1158  0.0118
              neg                 96   0.6183   0.1178  0.0120

SOURCE: duration format
durat  type   forma  condi        N    MEAN     SD      SE
sh.tr          inv                48   0.6130   0.1135  0.0164
sh.tr         neg                 48   0.6172   0.1218  0.0176
l.tr          inv                 48   0.6121   0.1193  0.0172
l.tr          neg                 48   0.6194   0.1149  0.0166

SOURCE: type format
durat  type   forma  condi        N    MEAN     SD      SE
        st    inv                 48   0.6144   0.1176  0.0170
       st     neg                 48   0.6305   0.1281  0.0185
       mt     inv                 48   0.6106   0.1152  0.0166
       mt     neg                 48   0.6062   0.1065  0.0154
```

```
SOURCE: duration type format
durat  type   forma  condi        N    MEAN     SD      SE
sh.tr  st     inv                 24   0.6140   0.1166  0.0238
sh.tr  st     neg                 24   0.6392   0.1251  0.0255
sh.tr  mt     inv                 24   0.6119   0.1127  0.0230
sh.tr  mt     neg                 24   0.5953   0.1169  0.0239
l.tr   st     inv                 24   0.6149   0.1211  0.0247
l.tr   st     neg                 24   0.6217   0.1331  0.0272
l.tr   mt     inv                 24   0.6093   0.1201  0.0245
l.tr   mt     neg                 24   0.6171   0.0962  0.0196

SOURCE: condition
durat  type   forma  condi        N    MEAN     SD      SE
                     dynam        96   0.6109   0.1184  0.0121
                     fixed        96   0.6200   0.1151  0.0117

SOURCE: duration condition
durat  type   forma  condi        N    MEAN     SD      SE
sh.tr                dynam        48   0.6073   0.1163  0.0168
sh.tr                fixed        48   0.6229   0.1186  0.0171
l.tr                 dynam        48   0.6144   0.1216  0.0176
l.tr                 fixed        48   0.6171   0.1126  0.0163

SOURCE: type condition
durat  type   forma  condi        N    MEAN     SD      SE
       st            dynam        48   0.6009   0.1169  0.0169
       st            fixed        48   0.6440   0.1255  0.0181
       mt            dynam        48   0.6208   0.1203  0.0174
       mt            fixed        48   0.5960   0.0992  0.0143

SOURCE: duration type condition
durat  type   forma  condi        N    MEAN     SD      SE
sh.tr  st            dynam        24   0.5945   0.1124  0.0229
sh.tr  st            fixed        24   0.6587   0.1216  0.0248
sh.tr  mt            dynam        24   0.6202   0.1212  0.0247
sh.tr  mt            fixed        24   0.5870   0.1062  0.0217
l.tr   st            dynam        24   0.6074   0.1233  0.0252
l.tr   st            fixed        24   0.6292   0.1302  0.0266
l.tr   mt            dynam        24   0.6214   0.1221  0.0249
l.tr   mt            fixed        24   0.6050   0.0930  0.0190
```

SOURCE: format condition

durat	type	forma	condi	N	MEAN	SD	SE
		inv	dynam	48	0.6209	0.1266	0.0183
		inv	fixed	48	0.6041	0.1047	0.0151
		neg	dynam	48	0.6008	0.1101	0.0159
		neg	fixed	48	0.6359	0.1237	0.0179

SOURCE: duration format condition

durat	type	forma	condi	N	MEAN	SD	SE
sh.tr		inv	dynam	24	0.6205	0.1258	0.0257
sh.tr		inv	fixed	24	0.6054	0.1019	0.0208
sh.tr		neg	dynam	24	0.5941	0.1071	0.0219
sh.tr		neg	fixed	24	0.6403	0.1331	0.0272
l.tr		inv	dynam	24	0.6213	0.1301	0.0266
l.tr		inv	fixed	24	0.6028	0.1095	0.0224
l.tr		neg	dynam	24	0.6075	0.1148	0.0234
l.tr		neg	fixed	24	0.6314	0.1162	0.0237

SOURCE: type format condition

durat	type	forma	condi	N	MEAN	SD	SE
	st	inv	dynam	24	0.6142	0.1197	0.0244
	st	inv	fixed	24	0.6147	0.1181	0.0241
	st	neg	dynam	24	0.5877	0.1150	0.0235
	st	neg	fixed	24	0.6732	0.1284	0.0262
	mt	inv	dynam	24	0.6277	0.1353	0.0276
	mt	inv	fixed	24	0.5935	0.0906	0.0185
	mt	neg	dynam	24	0.6139	0.1057	0.0216
	mt	neg	fixed	24	0.5985	0.1090	0.0222

```
SOURCE: duration type format condition
durat  type   forma  condi        N    MEAN     SD       SE
sh.tr  st     inv    dynam        12   0.6252   0.1281   0.0370
sh.tr  st     inv    fixed        12   0.6028   0.1084   0.0313
sh.tr  st     neg    dynam        12   0.5637   0.0891   0.0257
sh.tr  st     neg    fixed        12   0.7146   0.1112   0.0321
sh.tr  mt     inv    dynam        12   0.6159   0.1289   0.0372
sh.tr  mt     inv    fixed        12   0.6079   0.0997   0.0288
sh.tr  mt     neg    dynam        12   0.6245   0.1185   0.0342
sh.tr  mt     neg    fixed        12   0.5661   0.1126   0.0325
l.tr   st     inv    dynam        12   0.6032   0.1153   0.0333
l.tr   st     inv    fixed        12   0.6266   0.1307   0.0377
l.tr   st     neg    dynam        12   0.6116   0.1359   0.0392
l.tr   st     neg    fixed        12   0.6319   0.1355   0.0391
l.tr   mt     inv    dynam        12   0.6395   0.1463   0.0422
l.tr   mt     inv    fixed        12   0.5791   0.0823   0.0238
l.tr   mt     neg    dynam        12   0.6033   0.0952   0.0275
l.tr   mt     neg    fixed        12   0.6309   0.0993   0.0287

FACTOR:    subj     duration   type   format   condition    score
LEVELS:    96       2          2      2        2            192
TYPE :     RANDOM   BETW       BETW   BETW     WITHIN       DATA

SOURCE        SS        df     MS       F         p
===============================================================

duratio       0.0000    1      0.0000   0.001     0.970
s/dtf         1.3317    88     0.0151

type          0.0095    1      0.0095   0.625     0.431
s/dtf         1.3317    88     0.0151

dt            0.0038    1      0.0038   0.253     0.616
s/dtf         1.3317    88     0.0151

format        0.0016    1      0.0016   0.107     0.744
s/dtf         1.3317    88     0.0151

df            0.0001    1      0.0001   0.008     0.931
s/dtf         1.3317    88     0.0151

tf            0.0050    1      0.0050   0.331     0.567
s/dtf         1.3317    88     0.0151

dtf           0.0055    1      0.0055   0.362     0.549
s/dtf         1.3317    88     0.0151
```

conditi	0.0040	1	0.0040	0.337	0.563
cs/dtf	1.0444	88	0.0119		
dc	0.0020	1	0.0020	0.165	0.685
cs/dtf	1.0444	88	0.0119		
tc	0.0553	1	0.0553	4.658	0.034 *
cs/dtf	1.0444	88	0.0119		
dtc	0.0105	1	0.0105	0.885	0.349
cs/dtf	1.0444	88	0.0119		
fc	0.0323	1	0.0323	2.725	0.102
cs/dtf	1.0444	88	0.0119		
dfc	0.0011	1	0.0011	0.090	0.764
cs/dtf	1.0444	88	0.0119		
tfc	0.0132	1	0.0132	1.109	0.295
cs/dtf	1.0444	88	0.0119		
dtfc	0.0307	1	0.0307	2.579	0.112
cs/dtf	1.0444	88	0.0119		

Experiment Ten: B"

SOURCE: grand mean

durat	type	format	presn	N	MEAN	SD	SE
				192	0.0480	0.5664	0.0409

SOURCE: duration

durat	type	format	presn	N	MEAN	SD	SE
brief				96	0.0226	0.5413	0.0553
long				96	0.0734	0.5921	0.0604

SOURCE: type

durat	type	format	presn	N	MEAN	SD	SE
	static			96	0.0656	0.6357	0.0649
	move			96	0.0303	0.4901	0.0500

SOURCE: duration type

durat	type	format	presn	N	MEAN	SD	SE
brief	static			48	0.0600	0.6376	0.0920
brief	move			48	-0.0149	0.4277	0.0617
long	static			48	0.0712	0.6405	0.0925
long	move			48	0.0756	0.5463	0.0788

SOURCE: format

durat	type	format	presn	N	MEAN	SD	SE
		inv		96	0.1504	0.5832	0.0595
		neg		96	-0.0545	0.5326	0.0544

SOURCE: duration format

durat	type	format	presn	N	MEAN	SD	SE
brief		inv		48	0.1431	0.5441	0.0785
brief		neg		48	-0.0980	0.5163	0.0745
long		inv		48	0.1577	0.6255	0.0903
long		neg		48	-0.0110	0.5504	0.0794

SOURCE: type format

durat	type	format	presn	N	MEAN	SD	SE
	static	inv		48	0.1706	0.6506	0.0939
	static	neg		48	-0.0394	0.6091	0.0879
	move	inv		48	0.1302	0.5131	0.0741
	move	neg		48	-0.0695	0.4493	0.0649

SOURCE: duration type format

durat	type	format	presn	N	MEAN	SD	SE
brief	static	inv		24	0.1697	0.6712	0.1370
brief	static	neg		24	-0.0496	0.5960	0.1217
brief	move	inv		24	0.1165	0.3913	0.0799
brief	move	neg		24	-0.1463	0.4298	0.0877
long	static	inv		24	0.1715	0.6439	0.1314
long	static	neg		24	-0.0292	0.6347	0.1296
long	move	inv		24	0.1439	0.6201	0.1266
long	move	neg		24	0.0072	0.4642	0.0948

SOURCE: presentation

durat	type	format	presn	N	MEAN	SD	SE
			fixed	96	-0.0735	0.5207	0.0531
			dyna	96	0.1695	0.5865	0.0599

SOURCE: duration presentation

durat	type	format	presn	N	MEAN	SD	SE
brief			fixed	48	-0.0326	0.5412	0.0781
brief			dyna	48	0.0777	0.5414	0.0782
long			fixed	48	-0.1145	0.5017	0.0724
long			dyna	48	0.2612	0.6204	0.0896

SOURCE: type presentation

durat	type	format	presn	N	MEAN	SD	SE
	static		fixed	48	-0.0459	0.5760	0.0831
	static		dyna	48	0.1771	0.6780	0.0979
	move		fixed	48	-0.1011	0.4634	0.0669
	move		dyna	48	0.1618	0.4852	0.0700

SOURCE: duration type presentation

durat	type	format	presn	N	MEAN	SD	SE
brief	static		fixed	24	-0.0056	0.6291	0.1284
brief	static		dyna	24	0.1256	0.6526	0.1332
brief	move		fixed	24	-0.0596	0.4486	0.0916
brief	move		dyna	24	0.0298	0.4103	0.0838
long	static		fixed	24	-0.0863	0.5279	0.1078
long	static		dyna	24	0.2287	0.7127	0.1455
long	move		fixed	24	-0.1427	0.4837	0.0987
long	move		dyna	24	0.2938	0.5258	0.1073

SOURCE: format presentation

durat	type	format	presn	N	MEAN	SD	SE
		inv	fixed	48	-0.0164	0.5475	0.0790
		inv	dyna	48	0.3172	0.5753	0.0830
		neg	fixed	48	-0.1307	0.4916	0.0710
		neg	dyna	48	0.0218	0.5655	0.0816

SOURCE: duration format presentation

durat	type	format	presn	N	MEAN	SD	SE
brief		inv	fixed	24	0.0663	0.5621	0.1147
brief		inv	dyna	24	0.2199	0.5261	0.1074
brief		neg	fixed	24	-0.1315	0.5121	0.1045
brief		neg	dyna	24	-0.0645	0.5293	0.1080
long		inv	fixed	24	-0.0990	0.5313	0.1084
long		inv	dyna	24	0.4144	0.6163	0.1258
long		neg	fixed	24	-0.1300	0.4812	0.0982
long		neg	dyna	24	0.1080	0.5982	0.1221

SOURCE: type format presentation

durat	type	format	presn	N	MEAN	SD	SE
	static	inv	fixed	24	0.0466	0.6322	0.1291
	static	inv	dyna	24	0.2946	0.6582	0.1344
	static	neg	fixed	24	-0.1385	0.5103	0.1042
	static	neg	dyna	24	0.0597	0.6909	0.1410
	move	inv	fixed	24	-0.0793	0.4522	0.0923
	move	inv	dyna	24	0.3397	0.4919	0.1004
	move	neg	fixed	24	-0.1230	0.4831	0.0986
	move	neg	dyna	24	-0.0161	0.4161	0.0849

SOURCE: duration type format presentation

durat	type	format	presn	N	MEAN	SD	SE
brief	static	inv	fixed	12	0.0901	0.7535	0.2175
brief	static	inv	dyna	12	0.2493	0.6003	0.1733
brief	static	neg	fixed	12	-0.1013	0.4898	0.1414
brief	static	neg	dyna	12	0.0020	0.7049	0.2035
brief	move	inv	fixed	12	0.0424	0.3027	0.0874
brief	move	inv	dyna	12	0.1906	0.4653	0.1343
brief	move	neg	fixed	12	-0.1617	0.5536	0.1598
brief	move	neg	dyna	12	-0.1309	0.2814	0.0812
long	static	inv	fixed	12	0.0031	0.5137	0.1483
long	static	inv	dyna	12	0.3400	0.7356	0.2123
long	static	neg	fixed	12	-0.1757	0.5490	0.1585
long	static	neg	dyna	12	0.1173	0.7028	0.2029
long	move	inv	fixed	12	-0.2010	0.5510	0.1591
long	move	inv	dyna	12	0.4888	0.4908	0.1417
long	move	neg	fixed	12	-0.0843	0.4222	0.1219
long	move	neg	dyna	12	0.0988	0.5041	0.1455

```
FACTOR: subj      duration   type  format presentation    score
LEVELS:      96      2         2       2      2             192
TYPE  : RANDOM   BET.        BET.   BET.  WITHIN          DATA

SOURCE             SS          df        MS        F               p
=========================================================================
duration       0.1239          1     0.1239     0.347           0.557
s/dtf         31.3952         88       0.3568

type           0.0597          1     0.0597     0.167           0.683
s/dtf         31.3952         88       0.3568

dt             0.0754          1     0.0754     0.211           0.647
s/dtf         31.3952         88       0.3568

format         2.0147          1     2.0147     5.647           0.020 *
s/dtf         31.3952         88       0.3568

df             0.0628          1     0.0628     0.176           0.676
s/dtf         31.3952         88       0.3568

tf             0.0013          1     0.0013     0.004           0.953
s/dtf         31.3952         88       0.3568

dtf            0.0347          1     0.0347     0.097           0.756
s/dtf         31.3952         88       0.3568

presnti        2.8348          1     2.8348    10.894           0.001 **
ps/dtf        22.8993         88       0.2602

dp             0.8451          1     0.8451     3.248           0.075
ps/dtf        22.8993         88       0.2602

tp             0.0191          1     0.0191     0.073           0.787
ps/dtf        22.8993         88       0.2602

dtp            0.0800          1     0.0800     0.307           0.581
ps/dtf        22.8993         88       0.2602

fp             0.3931          1     0.3931     1.511           0.222
ps/dtf        22.8993         88       0.2602

dfp            0.1068          1     0.1068     0.410           0.523
ps/dtf        22.8993         88       0.2602
```

tfp	0.2062	1	0.2062	0.792	0.376
ps/dtf	22.8993	88	0.2602		
dtfp	0.1208	1	0.1208	0.464	0.497
ps/dtf	22.8993	88	0.2602		