VISUAL BASES FOR THE PERCEPTION OF FACIAL EXPRESSIONS: A LOOK AT SOME DYNAMIC ASPECTS

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A Thesis

in

the Department

of

Psychology

Presented in Partial Fulfillment of the Requirements

for the Degree of Doctor of Philosophy at

Concordia University

Montréal, Québec, Canada

November 1997

0-612-40305-X

ABSTRACT

Visual Bases for the Perception of Facial Expressions: A Look at some Dynamic Aspects

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Concordia University, 1997

This series of experiments was designed to investigate ecological sequences of dynamic facial expressions. Several manipulations were performed to examine the visual system's sensitivity to dynamic in comparison to static facial expression displays. Experiment 1 investigated subjects' sensitivity to changes in the duration of a neutral expression embedded in a dynamic sequence. The sequences depicted a change in emotion from sadness to happiness (or vice versa). Both forward and backward presentation were utilized. The results showed sensitivity to subtle information associated with the presentation direction of a facial expression sequence. This proved to be independent of the type of presentation used, either real or induced. Experiment 2 was designed to screen for any possible artifacts (expressive noise) in the sequences and to establish a threshold of discriminability. The discriminability of the emotional expressions was found to be acute and judgment accuracy was approximately 100%. Nevertheless, this manipulation turned out to be sensitive to expressive noise present in the sequences suggesting that a sequence segment may, therefore, not accurately reflect the targeted emotion. Experiment 3 examined whether temporal parameters influence the perception of emotional expression. The results indicated that emotional intensity and realness judgments were only marginally affected by the speed variations. Experiment 4 compared the amount of information necessary for correctly identifying facial expressions presented either statically or dynamically. The results showed a none significant advantage of dynamic sequences over

static ones only for short sequences. This suggests that after a certain amount of information is presented no further benefit is gained. The advantage of dynamic expressions may be due to the contextual information preceding the required judgment. Experiment 5 explored this hypothesis via a priming paradigm. The static primes affected the ambiguous test which was judged opposite to them. Dynamic primes showed no effect. Taken together these findings caution the use of static material in postulating underlying perceptual mechanisms associated with emotional facial. This series of experiments supports the ecological perspective by showing that dynamic facial expressions contain relevant veridical contextual information which, as opposed to static facial expressions, is relatively immune to non veridical contextual influence.

ACKNOWLEDGMENTS

Foremost, I would like to thank my supervisor Dr. Michael von Grünau for his guidance, patience, and insightful advice throughout my graduate studies.

I would like also to thank Drs. Rick Gurnsey and Michael Bross for their invaluable help throughout this dissertation and for their useful advice on many issues.

Many thanks are also extended to Mr. Peter April and Mr. Paul Eifert. Their sound advice on the technical aspects of this project are much appreciated.

Also, I thank all of my posers and subjects whom gave many hours of their time for the successful completion of this project.

I greatly appreciate the support from Fonds pour la Formation de Chercheur et l'Aide à la Recherche (FCAR) that I received during my graduate studies.

I once read my fortune cookie which stated "wisdom will soon come to you". It certainly did the day I met my great friend Michael. Michael I would like to express my sincere appreciation for your mentorship, wisdom, enthusiasm, sense of humor, and tonkinese soup.

Finally, I would like to express my deepest gratitude and love to my wife and colleague, Michelle Kwas, for her support and advice throughout the completion of this project. Michelle you have been one of my foremost sources of motivation during all these years along with our children. For all this and more, I love you.

To my family

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GENERAL INTRODUCTION

1.1 OVERVIEW

Daily life situations offer plenty of occasions for social interactions among which one of the most utilized means of communication is facial expression. In this context, facial expressions are often the precursor of further interaction. As early as 1872, Charles Darwin wrote in his book entitled "The expression of the emotions in man and animal", "It has often struck me as a curious fact that so many shades of expression are instantly recognized without any conscious process of analysis on our part"(p.359). Darwin's observation reinforces the idea that processing face connotations may be based on specialized mechanisms that perform their tasks in a very fast and efficient manner. Support concerning the importance of facial expression in approaching or communicating situations is reinforced by Ekman's more recent observation (1984) that facial expression is a major source of information for inferring others' emotional states. All of these observations converge on the special role of facial expression for communication. But what is the perceptible signal for subsequent interactions to take place? Research shows that individuals confronted with either photographs or video-recordings of faces are able to identify the emotional meaning depicted far above chance (see Ekman, 1982; Fridlund, 1991; Wallbott, 1992; Izard 1990; Russell, 1994). To illustrate, a number of studies have demonstrated that children are able to attribute the correct emotions to facial displays early in development (Bullock & Russell, 1984; Harris, 1989). Others have shown more importantly that the accuracy of the emotional decoding in adults is cross-cultural (Ekman, 1984; Matsumoto, 1989).

Facial expressions, and faces, in general, seem to be special for animal behavior. Using single cell recordings, researchers found face selective responses from cells within the sheep's brain (Kendrick & Baldwin, 1989). The animal literature, mainly with monkeys, adds to the fascination raised by facial expression decoding. Similar and more complex responses to faces are described for cells within the monkey's brain. Behaviorally, monkeys have also been shown to perform with high reliability on a facial discrimination task (Rosenfield & Van Hoesen, 1979).

Human clinical neuropsychology also supports the peculiarity of faces and facial processing in the brain as exemplified by the prosopagnosic syndrome (Bodamer, 1947, see Farah 1990). Within this syndrome several subcomponents have already been identified which are specialized for different aspects of facial processing. These components include, for example, processing units responsible for the encoding of facial identity as opposed to facial expressions (Farah, 1990). The existence of these processing units converges with the suggestions of Buck (1988) and Bruce (1988) that a possible mechanism for the perception of faces may be the existence of specialized feature detectors.

Despite these observations, the question as to how we perceive emotional facial expressions is still subject to intense discussions. Little is yet known about the visual information involved in the recognition of emotion via facial expression. Research almost exclusively used static depictions of emotional facial expressions. However, within an evolutionary perspective, the system proposed to encode emotional facial expressions must be highly tuned to the movement of features in the face. This tuning would be necessary to account for the perception of emotional signals in every day life situations. Rarely are we confronted with other types than dynamic emotional facial expressions outside the laboratory. Recent technological advances, mainly digital recordings of emotional material, make it possible now to investigate emotional facial expressions with dynamic stimuli. The technology now permits a decomposition of the stimuli along their spatial and temporal components. This series of experiments mainly focuses on the second of these components.

1.2 EMOTIONAL FACIAL EXPRESSIONS: FUNDAMENTAL ISSUES

1.2.1 Diversity in Emotional Facial Expressions

Recently, Ortony and Turner (1990; see also Lazarus, 1991) reviewed the emotional literature and challenged the existence of basic emotions supported by several researchers in the domain (Darwin, 1872; Eibl-Eibesfeldt, 1970; Ekman & Friesen, 1984; Oatley & Johnson-Laird, 1987; Plutchick, 1980, Tomkins, 1984). Their discussion raises several interesting questions in reference to the concept of basic emotions. In the first part of their paper, they stress the heterogeneity of the type of emotion and the number of postulated basic emotions. Fundamental, primary or basic emotions as they may be called vary from theorist to theorist. For instance, Ortony and Turner (1990) list several theorists with their postulated primary or basic emotions. The main feature throughout that list is the diversity in the range of emotions that some researchers consider. James (1884, see Ortony et al., 1990) refers to fear, grief, love and rage, while others, like Izard (1971) would list anger, contempt, disgust, distress, fear, guilt, interest, joy, shame and surprise.

In response to Ortony and Turner, Ekman (1992) supports the existence of basic emotions based on the findings which, first, suggest universal facial expressions, second, show physiological patterns of activity which are emotion-specific, and third demonstrate that, there are theoretical advantages for postulating a basic emotions framework. In reference to the present discussion only the first argument is examined.

1.2.2 Identification of the Basic Emotional Facial Expressions

Since Ekman, Friesen & Ellsworth (1972), it has been widely accepted that six emotions seem to be reliably reported in the literature on emotional facial expressions. These emotions include happiness, surprise, fear, sadness, anger and disgust. In addition, Ekman (1992) reaffirms this observation and points out that over a span of 50 years, this list of emotions remains representative. The features of each emotion are well known and can be described in terms of muscle action and their effect on the skin surface appearance. There are specific descriptive systems to describe such changes (Ekman & Friesen, 1978; Izard 1979). One of them, the facial action coding system (FACS) was developed by Ekman & Friesen (1978). This system describes all of the possible facial movements which can be produced. However, it is not exclusive to the description of emotion but serves a larger objective since action units exist for facial behaviors which are not associated with any emotions.

The FACS is by far the most recognized and employed descriptive system. Forty-four action units are comprised within the system which permit a full description of facial behavior. The FACS is highly reliable as it accurately predicts which emotion is posed as well as its intensity (Ekman & Friesen, 1978). The authors, further, suggest that the coding process be made using video material. Still photographs are reported to be more difficult to score, in addition to, more vulnerable to errors. As a final remark, it is important to stress that the FACS describes the movement of facial features, as well as, of facial configurations when they are at their maximum, that is, when they have reached the apex.

Instead of attempting to understand this coding system in detail, the six basic emotions are described in terms of the features that can be noticed as facial behaviors. Two sets of descriptions were examined and compared. The first set of facial behaviors was obtained from Frois-Wittman (1930). This set of descriptors was then compared with the ones presented by Ekman and Friesen (1984).

To facilitate the review of the characteristics for each emotion, the order of the features will be kept constant and the progression will start at the brows and end at the mouth. Therefore, following this scheme and utilizing Frois-Wittman's (1930) observations, happiness is characterized by a depressed upper lid and a wrinkled lower lid. In addition, the nostrils are dilated while the lips have a tendency to be open. Finally, the corners of the mouth are raised and retracted. Sadness, on the other hand, is comprised of two main features. The brow may be frowning or raised but the corners of the mouth are depressed. Surprise, however, involves fewer features, and is characterized by raised upper lids, open lips and open teeth. Fear includes all the features already described for surprise with the addition of raised brows. The characteristics associated with disgust include a wrinkled lower lid, closed teeth when exposed, as well as, a raised upper lip. Finally, anger can be said to display the most features of all, which comprise the frowning of the brows, raised upper lids, wrinkled lower lids, dilated nostrils, open lips, lower teeth exposure and depression of the lower lip.

According to Ekman and Friesen (1978) the six basic emotional facial expressions can also be described as facial behaviors. Their description is reported and compared with the one made by Frois-Wittman (1930). This comparison proves to be highly correlated.

For instance, happiness is characterized by a configuration which involves the lower eyelids and the lower face. The lower eyelids show wrinkles below it and may be raised but not tense. A wrinkle runs down from the nose to the outer edges beyond the lip corners. The corners of the lips are drawn back and up. The mouth may or may not be parted, with the teeth exposed or not. Finally, the cheeks are raised.

Sadness is characterized by facial behaviors that center around the brows and the mouth. Sadness produces an elevation of the inner corner of the eyebrows and they are drawn together. The skin below the eyebrows is triangulated, with that inner corner up as the apex . The upper eyelid inner corner is also raised. As to the mouth, the corner of the lips are down, the lips might also tremble. A loss of muscle tone characterized the mouth region.

Expression of surprise comprises activation of the brows and mouth region, but, Ekman and Friesen (1984) also report behaviors which include the eyes. Surprise, therefore, produces brows that are curved and high, the skin below the brow is stretched by the lifting of the brow. The lifting of the brows also produces long horizontal wrinkles across the forehead. The eyes have a tendency to be wide opened. The lower lid is relaxed and the upper lid is raised. This facial behavior around the eyes exposes the sclera. This is highly noticeable as the white sclera above the iris is visible. Behaviors are also present in the lower face. The mouth is relaxed, the jaw is dropped, the lips and teeth are apart. This opening of the mouth varies with the intensity of the expression.

Fear and surprise have a lot of facial behaviors in common. Not surprisingly, they may be confused with each other on occasion. Fear is characterized by an elevation of the brows. This elevation is uniform and produces a straight line. The brows are also drawn together. The eyes are opened and tensed. Both the upper and the lower eyelids are raised

The elevation of the lower eyelids sometimes covers the iris. Both surprise and fear expose the sclera. The mouth is opened and the lips are tense. The lips may also be drawn back tightly. The intensity of the expression is mainly reflected in the mouth region.

The expression of disgust produces a lowering of the brows. The cheeks are raised which produces a change in the appearance of the lower eyelids. The raised cheeks also narrow the opening of the eyes and produce folds below the eyes. Facial behaviors of the lower face comprise an elevation of the upper lip, which causes a change in the appearance of the tip of the nose. The raised upper lip may be with or without wrinkling along the sides of the nose and bridge. According to Ekman and Friesen (1978), the most extreme expressions show this characteristic.

Finally, the expression of anger is characterized by eyebrows which are drawn down and together. The latter creates vertical wrinkles between the eyebrows. Other changes around the eyes comprise tension in the eyelids and the eyes may stare to impress. The upper and lower lips are pressed together or the shape of the mouth might be square. The intensity is revealed either by how wide the mouth is open, or in the case when the lips are pressed, by a bulge below the lower lip and wrinkling in the chin.

1.2.3 Posed versus Spontaneous Emotional Facial Expressions

In considering posed expressions (produced on request) over spontaneous expressions (produced by one's affect), most researchers advocate the use of spontaneous versions. The reasoning is that spontaneous expressions are true and therefore ecologically valid. Despite this position, O'Sullivan (1982) has raised several difficulties associated with spontaneous expressions such as the problem encountered with different individuals who do not express emotions in exactly the same way. Awareness of the recording also may produce an effect which prevents the expressions from being genuinely spontaneous. She concluded for these and other reasons that "the use of spontaneous expressions is neither desirable nor likely" (pp. 298). Instead, she proposes posed expressions as an alternative if some guidelines are followed. She supports the notion that tools like the FACS ensure stimulus validity by providing measurable facial change to accompany a particular emotion and that if these measurements are used to instruct the poser then one can expect to have a good emotional representation.

This line of reasoning, thus, possesses some great advantages in the production of typical posed emotional facial expressions. However, recently a few researchers have addressed the issue empirically and studied differences that may arise in comparing posed with spontaneous expressions (see below, Hess & Kleck, 1990; Gosselin & Kirouac, 1994). The principal motivation for such research is the need to obtain more ecologically valid representations since posed expressions are often exaggerated in their typicality (Ekman, 1982).

Neuro-anatomical evidence supports distinct neuronal pathways for volitional (posed) and emotional (spontaneous) innervation of the face (Rinn, 1984). Rinn links them to cortical (volitional) and subcortical (emotional) origins. He also stresses that cortically mediated events produce good awareness of the facial components involved. Individuals, therefore, can repeat these facial configurations with little difficulties. It is perhaps important to point out that Rinn's referral to cortically mediated events pertains to a set of facial behaviors already defined by different researchers as display rules (Ekman, 1973; Ekman & Friesen, 1984; Izard, 1977; Izard, 1990). These rules may be defined as socially learned techniques for managing facial behaviors. Examples of display rules include masking of fear, social smile, and more idiosyncratic sets which belong to specific individuals. Interestingly, however, individuals often have difficulty to pose veridical emotional expressions on request.

The difficulty to pose veridical emotional expressions is revealed by the emergence of several characteristics which distinguish posed from spontaneous expressions. Among these differences are reports showing that posed expressions are more asymmetrical with a more intense action on the left side of the face (Ekman, Hager & Friesen, 1981; see also Skinner & Mullen, 1991 for a meta-analysis review). The timing and the coordination of the various regions of the face (brows, eyes, mouth) are usually off in posed expressions (Ekman & Friesen, 1984; Rinn, 1984; Hager & Ekman, 1985; Weiss, Blum & Gleberman, 1987). Ekman also proposed that posed expressions are easier to score as the onset is more coordinated and abrupt, the apex frozen, and the scope very intense or exaggerated.

To summarize, it seems that typicality defined as overgeneralization is a common attribute which may affect the genuine aspect of an emotional expression. This aspect seems to be mostly observed with posed expressions. Other characteristics such as the timing variations between posed and spontaneous expressions are exclusive to the use of dynamic displays of emotional expressions since such characteristics do not exist with static versions.

1.2.4 Major Trends in the Study of Emotional Facial Expressions

Researchers have approached the study of emotional facial expressions from several angles including physiological recordings of muscle activity when individuals are thought to express an emotion to judgment studies. Judgment studies constitute most of the existing body of literature available in the domain. This type of study involves judges or observers which are often also called decoders. The decoder perspective allows for a decomposition of the emotional signal. It is the decoded information by naive observers as opposed to expert judges that provides valuable insights to the process of perceiving and identifying emotional signals in every day life. For this reason, these types of studies will be described further in the following sections.

1.2.4.1 The Categorical Approach

It is possible to group judgment studies within two major trends. The first, and most popular, is the categorical judgment type. The second is the dimensional judgment approach. In the categorical approach, observers are typically presented with several stimuli which depict different emotions. Their task is to categorize them as belonging to some predetermined categories introduced by the researchers. For emotional facial expressions, these categories include emotions such as happiness, sadness and so on. Other types of tasks such as, detection, recognition and discrimination of emotional facial expressions, would also be included within this type of approach.

Theoretically, categorical perception is a process that simplifies the task of interpreting external events by grouping them together as exemplars of the same concept or category (Harnad, 1987). It is important to spend some time to understand categorical judgment, since a dynamic emotional facial expression may vary as to which category it belongs from one time to another. One particularity of a categorical judgment is that a stimulus change in intensity at the boundary between two categories is more noticeable than a similar change within a category.

Etcoff & Magee (1992) and Calder, Young, Perrett, Etcoff & Rowland (1996) examined categorical perception of emotional facial expressions. Their studies are described here as examples of typical judgment studies based on the categorization principle. Both sets of research converged to support the categorization of emotional facial expressions. Etcoff and Magee (1992) utilized line drawings of emotional facial expressions. The stimuli were bipolar, that is the extremes depicted a different emotion or included a neutral emotion. Equal steps of physical changes were interposed between the extremes to produce a gradual shift from one emotion to another. The subjects were presented with two tasks in separate sessions. The first one involved discriminating pairs of faces, and the second required a category assignment. The results revealed the existence of perceptual boundaries within which faces were less discriminable from each other. At the perceptual boundaries, however, faces were discriminated more easily. The category assignment task also replicated previous results in the literature in terms of the six basic emotions (Ekman et al., 1987).

For Calder et al. (1996) only their third and fourth experiments are discussed here since their first and second ones were replications and confirmations of Etcoff and Magee (1992) with the exception of employing real face photographs morphed with each other. The third experiment was designed to assess or eliminate the existence of an artifact produced by tasks which involved only one judgment axis as it is the case in a two alternatives forced choice. They, therefore, introduced an additional expression within the set so that the choice was now among three different possible categories. Their results confirmed previous findings of categorical perception. In addition, they provided a basis to reject artifacts such as range effects, anchor effects, or learning of prototypes. The fourth experiment was designed to eliminate the possibility of a short-term memory effect rather than a perceptual one. The same stimuli as in experiment 3 were utilized. The discrimination task, however, was replaced with a matching one. Subjects were to decide whether two faces presented simultaneously were identical or different. The results also confirmed the existence of a categorization process. The findings obtained with the two tasks were highly correlated, that is regardless of whether subjects were required to discriminate or to match faces, their performance revealed distinct category boundaries.

1.2.4.2 The Dimensional Approach

The dimensional approach, on the other hand, is based on the idea that a stimulus can be decomposed into elementary components. Some of these components in relation to the emotional facial expression domain include dimensions such as pleasure-displeasure, aroused-asleep (Russell, 1980; Russell & Bullock, 1986) and attention-rejection (Schlosberg, 1954). To illustrate, Russell (1980) argues that the emotion space is bipolar. One axis is a continuum ranging from extreme displeasure to extreme pleasure. The other axis represents the degree of arousal from sleep to high arousal. Within this structural model emotions are represented in a circular order along the perimeter of the space. Categorization of facial emotion in reference to this model is not an all or nothing process but rather a question of degree. It depends on how close the expression and the category label fall within the emotional space (Russell & Bullock, 1986; Russell & Fehr, 1987).

Recently, Lyons, Kamachi, Tran, Gyoba & Akamatsu (1997) utilized the multi-dimensional scaling technique to examine judgments of similarity obtained from subjects and compared them with the ones obtained from their computational model. The results revealed similar axes for both the model and the subjects' estimates. In addition, they determined that two axes were sufficient to account for the data. These axes were the same as the ones previously reported by Russell & Bullock (1986), which comprised a pleasure-displeasure dimension, as well as an arousal-depression one (see also section 1.4.5).

According to Lyons et al. (1997), their model reflects the activity of cells in the primary visual cortex (i.e. area V1). Based on their point of view, these results suggest that the perception of emotional facial expression relies heavily on the activity of cells in area V1. This stage of processing occurs early in the visual system and is highly fluctuent since information continuously enters the system. This property is also characteristic of the dynamic aspects involved in the processing of emotional facial expressions.

Despite some theoretical divergences between the categorical and dimensional approaches, they both provide opportunities to understand how emotional facial expressions are represented in psychological space. Furthermore, the views advocated by both approaches are not necessarily incompatible with each other, as Etcoff and Magee (1992) have argued. In the process of assigning category membership to stimuli, they explained that continuous information about physical configurations is transformed into categorical information.

1.3 FACE SELECTIVE SYSTEMS

Over the past decades, and especially, during the last two decades, evidence has accumulated from different research domains, independently and concurrently, which converge on the notion that specialized areas in the brain of several mammals are responsible for the perception of facial identity and facial expression. The important contributions from the anatomical, physiological, clinical, functional imaging and Psychophysical domains are discussed in the sections to follow.

1.3.1 Anatomical and Physiological Support for Face Selective Systems in Monkey

The visual information travels from the eyes to several regions in the brain. These regions are known to be organized in their anatomical structure, as well as in the type of information they process (Van Essen, 1979, Rodieck, 1979). The following paragraphs review the visual-anatomical pathways and examine their contribution to the processing of information pertaining to faces.

1.3.1.1 Two Major Subdivisions: the M and P Pathways

The thalamo-cortical (geniculo-cortical) pathway is composed of two major subdivisions, the parvocellular and magnocellular pathways. Parvocellular-cells (P) in the lateral geniculate nucleus in the thalamus (LGN) originate from the B type ganglion cells and project principally to layer 4Cb of V1 (primary visual cortex) and to a lesser extent to layer 4A (Hubel & Wiesel, 1972). Within V1 the P pathway leads mainly to the superficial layers 2 and 3, but subsequent stages of analysis are less clearly identified. Livingstone and Hubel (1987; 1988) argued that some connections would exist between the blobs and both layers 4Cb and 4Ca.

On the other hand, magnocellular cells (M) in the LGN originate from the A type ganglion cells and project to layer 4Ca of V1. Outputs from this layer lead mainly to layer 4B. This layer projects either directly to MT, or passes through the thick stripes in the second visual cortical area (V2) before reaching the midtemporal cortical area (MT). Layer 4Ca also sends axons to the superficial layers in V1 (see Livingstone & Hubel, 1988 for a schematic representation of these connections). Area MT then projects to areas MST (medial superior temporal area) and intraparietal sulcus in the parietal lobe, which includes areas VIP and LIP, the ventral intraparietal area and lateral intraparietal area, respectively (Maunsell & Van Essen, 1983). Further, MST and LIP send their projections to area 7a (Andersen et al., 1990).

The distinctiveness of the M and P pathways is also revealed by their physiological properties. When recorded from the LGN, most M cells are not sensitive to color and possess less acuity because of their larger receptive field centers as compared with P cells. P cell responses, on the other hand, are slower and more sustained than those of M cells. P cells [most] are also sensitive to color and need higher contrast stimuli to respond. This functional segregation continues in higher cortical areas. In the M pathway, cells in V1 are somewhat selective for disparity (Poggio et al., 1985), but are better characterized by their directional-selectivity to moving oriented stimuli. These neurons, however, are without selectivity for color. Contrary to V1, cells in V2 show high disparity and orientation selectivity, and somewhat less direction selectivity (De Yoe & Van Essen, 1985; Hubel & Livingstone, 1987). In MT, an area "upstream" from V1 and V2 in the M pathway, neurons are primarily selective for aspects of motion, including direction and speed of the stimulus (Albright, 1984; Maunsell & Van Essen, 1983; Rodman & Albright, 1987). These cells have larger receptive fields than V1 cells (~10 times larger in diameter) and in addition, Maunsell and Van Essen (1983) found that nearly two thirds of MT units tested were selective for horizontal disparity. The authors interpret this as indicative of MT playing a role in analyzing the motion of visual stimuli in 3-D space. The same four categories of disparity-selective neurons were found as previously demarcated in cortical area V1 and V2: tuned excitatory, tuned inhibitory, near, and far (Poggio & Fischer, 1977).

Consequently, these segregated pathways are believed to subserve different visual capacities that grow in complexity in subsequent cortical areas. These observations and the strong neural connectivity that exists on the one hand between the M pathway and MT region, and on the other hand between the P pathway and the inferotemporal region (IF) have led some researchers (e.g. Livingstone and Hubel, 1987) to suggest that the M and P pathways may feed two different systems. This suggestion has been intimately related to the observations collected by Ungerleider and Mishkin (1982). They elegantly demonstrated, following monkey cortical ablations that the inferotemporal region was primarily responsible for the processing of color and form (What, ventral stream), while the MT region was more associated with the processing of motion and spatial relations (Where, dorsal stream). Perhaps this is better interpreted as a functional bias, with each stream associated with one or two perceptual properties, but should not be considered as exclusive segregation (Maunsell, Nealey & DePriest, 1990). An overemphasis on segregation of function can be misleading (DeYoe & Van Essen, 1988). Often, multiple cues help to determine a property of the external world, creating a more robust percept. It is useful to view neural information processing as taking place in a system which is at once functionally specialized and massively interconnected, and in which more complex response properties related to information about the physical properties of the 3-D world are elaborated (Sereno, 1993). In fact, Merigan and Maunsell (1993) reviewed the amount of independence of the M/P and ventral/dorsal streams and concluded that they were actually not as separated as once thought.

1.3.1.2 Face Selective Systems in the Ventral Stream

Significant progress was made in the description and understanding of facial processing in the macaque monkey. The following paragraphs are an attempt to summarize this progress. Several investigators have examined the properties of cells in the superior temporal sulcus of the macaque (Desimone & Ungerleider 1989; Perrett, Harries, Chitty & Mistlin 1990; Rolls 1992). It is now well established that this region is highly involved in the processing of facial information.

Anatomically the ventral stream or the infero-temporal lobe can be divided into several regions on the basis of cytoarchitectural, myeloarchitectural or afferent projections criteria. Following these criteria several areas are delineated, from the base of the lobe, the ventral part of the infero temporal lobe, to the top or the superior temporal sulcus. The first zone encountered is area TE1 followed in order by area TE2, TEm around the apex of the circumvolution. Then in the lower inferior lip of the sulcus area TEa is found followed by area IPa. The upper lip of the sulcus comprised areas PGa, TPO, TAa and Ts3. The areas in the upper lip of the superior temporal sulcus are multimodal, that is they receive input from more than one sensory modality (Seltzer and Pandya, 1978; Baylis, Rolls & Leonard, 1987).

Accordingly, Baylis et al. (1987) stressed the specialization of function associated with these areas. Their observations indicated that the TPO, PGa, and IPa regions responded to stimuli in the visual, auditory and somatosensory modalities. The TE3 ,TE2, TE1, TEa and TEm regions were, on the other hand, mostly unimodal responding primarily to visual stimuli. The same researchers found that areas TPO, TEa and TEm contained a higher proportion of neurons that respond to faces. Interestingly, in this vicinity, cells were also reported to be sensitive to moving visual stimuli.

Several investigators have examined the properties of cells in these regions and confirmed that some were selectively responsive to faces (Desimone & Gross, 1979; Bruce, Desimone & Gross, 1981; Perrett, Smith, Milner, Jeeves, & Rogers, 1982; Rolls, 1984; Desimone, Albright, Gross & Bruce, 1984; Perrett, Smith, Potter et al.1984, 1985; Perrett, Smith, Mistlin et al. 1985; Perrett, Harries, Benson et al. 1990; Perrett, Harries, Chitty et al. 1990; see Desimone, 1991; and Rolls, 1992 for a review). Despite, the large body of literature available in the domain, only a few studies will be reviewed in detail. These include studies which have examined or obtained direct evidence for distinct face selective systems within the brain.

1.3.1.2.1 Facial Expression Cells in the Ventral Stream

Perrett, Smith, Potter et al. (1985) and Perrett, Smith, Mistlin et al. (1985) have demonstrated that in an awake monkey, cells in the anterior portions of the superior temporal sulcus (STS) are selectively sensitive to biological motion. These cells correspond to a population of neurons referred to as facial expression sensitive (Rolls, 1986). Beside the selectivity to faces which is reported in at least 20% of the cells encountered, these neurons possess properties which are considered important to encode signals related to social interactions.

Perrett, Smith, Potter et al. (1985) found that cells respond to specific types of motion conveyed by the head or body movement. For instance, translation and rotation cells were identified. Interestingly, the response to both types was dissociated, that is, some (50%) cells were sensitive to translation but not to rotation and vice versa. Among these cells, however, some were found to respond to both types of motion. One explanation, provided by the authors to account for that, was that the translation selective cells may respond to rotating stimuli as well which do involve a translational component. Direction selectivity for these cells, could be described in 3-D space, selectivity to translations in all direction was observed as well as in depth. Therefore, some cells were selectively responsive to motion toward or away from the animal. One major characteristic of the motion sensitivity space found within these cells is that direction was defined relative to the observer. This characteristic has been referred to in the computational domain as a viewer centered description.

In summary, the viewer centered responses to directional motion of body movement observed by the authors suggest that the cells are organized to signal information about the intent of the perceived object. As already mentioned above this property is well suited to extract emotional signals conveyed within the face. Altogether, the cells would provide information which could then be used to direct social interactions. This suggestion is greatly supported by behavioral observations made with monkeys after temporal lobe ablation. The observed deficit comprised of severe perturbations in social and emotional behavior which are typical manifestations of the Kluver Bucy syndrome (Rolls, 1984; Aggleton, 1992).

In relation to the emotional facial expression cells, recent anatomical studies (Colby, Gattass, Olson & Gross, 1988; Boussaoud, Ungerleider & Desimone, 1990) suggest that a separate pathway, independent of MT, could provide motion information to the facial expression cells. This would support the possibility of an "action recognition" system in the temporal lobe receiving a separate motion input. These findings provide a neurophysiological substrate for a distinction already documented with clinical populations between facial expression and identity processing (Bruyer, Laterre, Seron, Feyereisen, Strypstein, Pierrard & Rectem, 1983; Campbell, Landis & Regard, 1986; Etcoff, 1989; Humphreys, Donnelly and Riddoch, 1993).

1.3.1.2.2 Facial Identity Cells in the Ventral Stream

Another group of cells shows selective responses to the identity of individuals and is therefore referred to as the identity cell group. Anatomically, this group of cells pertains to a different cortical region (Desimone & Gross, 1979; Rolls, 1992). The identity cells are found mainly in the TEa region, a subregion of the inferior temporal lobe.

There is one major particularity that needs to be stressed concerning identity cells beside their sensitivity to faces. Contrary to the expression cells discussed in the previous section, the representation of the visual space within the identity cell group is object centered. Object centered representations as discussed by Marr (1982) and Feldman (1989) are well suited to account for object constancy or in the present case to account for the recognition of a face view as being the same as a different view, all belonging to the same individual. Several investigators observed this property, though to a different extent in terms of the number of cells encountered (Desimone et al. 1984; Rolls, 1984; Perrett, Smith, Potter et al.1984; Hasselmo, Rolls, Baylis & Nalwa, 1989).

For instance, Hasselmo et al. (1989) used different individuals and different views to examine the cell responses. Among the 37 cells encountered, 18 were found to be significantly tuned to the individuals. Hasselmo et al. (1989) suggested that this result was evidence for object centered coding. Similar findings were also obtained by Perrett et al. (1991) and Rolls (1992). However, in the study by Perrett et al. (1991) a smaller proportion of cells was found that showed view invariant coding or object centered coding. They explained their diverging results by proposing that object centered coding may be found in other regions of the brain (subsequent stage).

Rolls (1992), on the other hand, reported a study where the properties of 45 neurons were examined using faces of different monkeys with three expressions for each. Human stimuli were also included in the set. The results revealed that 15 neurons were tuned to different individuals without being affected by the expression depicted on the face. Another group of 9 neurons showed the opposite type of response, and the cells were tuned to facial expressions and responded independently to face identity. Rolls concluded, despite the dissociation found among the responses of these two groups of cells that both types are important for appropriate social and emotional responses. He explained that it is as important to know the social context as it is to know the identity of the individual to produce a proper response.

To summarize, the identity cells are found mainly in the TEa region, a subregion of the inferior temporal lobe. On the other hand the superior temporal sulcus, more precisely the TPO subregion, regroups the cells responsive to facial expression. At the neuronal level, two important distinctions have been made from the properties of cells responding to the face. The identity cells are characterized primarily by their view-independent representations, whereas the facial expression cells encode the position and orientation of the stimulus. Such information is of great importance in social contexts. Mainly, it allows the monkey to determine the social context, that is, whether the individual is threatening or not (Hasselmo et al. 1989; Perrett, Mistlin & Chitty, 1987; Aggleton, 1992; Rolls 1992).

1.3.2 Clinical Support for Face Selective Systems

Among the clinical literature prosopagnosia by definition is the clinical support for face selective systems. Prosopagnosia has traditionally been associated with perturbation relating to the perception of identity. The existence of this syndrome is in itself evidence for a face selective system. In the following sections, prosopagnosia is examined, as well as other clinical findings.

1.3.2.1 Prosopagnosia

Prosopagnosia is one of the most dramatic dissociations in neuropsychology. It is characterized by the inability to recognize faces despite intact intellectual functioning and even apparently intact visual recognition of most other stimuli. Bodamer introduced the term in 1947 after studying 3 cases. Patients usually display good memory, have no problem with reading (or understanding what they have read) and have intact recognition and correct naming of other objects. They can describe complex scenes and line drawings and are able to recognize people from auditory cues or by detection of some unique characteristic (searching for the critical detail) of the person's face, body or clothes. Generally, they demonstrate impaired visual perception and recognition of faces, famous or otherwise. They do, however, know what a face is and are able to see all the individual parts, but are simply unable to "add them up" to form an image of a face.

In its currently accepted form, prosopagnosia is remarkably rare and is almost always accompanied by a constellation of various other deficits (Cole & Perez-Cruet, 1964; Rubens & Benson, 1971). To date, fewer than 100 cases have been reported (see Tiberghien & Clerc, 1986; Meadows, 1974; Benton, 1980; Damasio, Damasio & Van Hoesen, 1982; Michel, Poncet & Signoret, 1989; Shuttleworth, Syring & Allen, 1982 for reviews). There is extreme heterogeneity in the cognitive manifestations a prosopagnosic patient may express (Schweich & Bruyer, 1993). They do not necessarily have recognition problems only with faces. Sometimes, these patients have impaired recognition for facial expressions (Farah, 1990), as well as, other types of stimuli like animal faces or whole bodies (Pallis, 1955) both within a species (Newcombe, 1979) and between classes (Shuttleworth, Syring & Allen, 1982; Damasio, Damasio & Van Hoesen, 1982). Still others have found recognition deficits for plants (Boudouresques et al., 1979), buildings and public monuments (Gomori & Hawryluk, 1984), makes of automobiles (Damasio et al., 1982), articles of clothing (Shuttleworth et al., 1982), food (Whitely & Warrington, 1977), colors (Goodglass, Wingfield, Hyde & Theurkauf, 1986), indoor objects (Yamadori & Albert, 1973), and environment (Landis, Cummings, Benson & Palmer, 1986). In other words, there is evidence suggesting that the recognition impairment in prosopagnosia is not as selective as its definition implies.

In addition, there is evidence which suggests that (1) the visual perception of these patients may not be as intact as it should be for this sub-group of associative agnostics and (2) that their recognition is not as impaired as implied. Most patients have subjective visual complaints usually described as blurring, loss of color, some degree of distortion, and modality-general memory impairment (Farah, 1990). The current evidence thus suggests that prosopagnosics studied so far do not *perceive* faces normally. Secondly, recognition problems in some patients have been shown to be exaggerated or even induced by certain methodologies. Several recent investigations of prosopagnosic patients, for instance, have revealed evidence of face recognition in tasks that test recognition implicitly, that is, without requiring the subject to make a conscious decision about the familiarity or identity of the face. One approach has been to psychophysically measure the subject's response to faces with skin conductance responses (SCRs) and the other was to use event-related brain potentials (ERPs).

Bauer (1984), for instance, found that patients' SCR was greater when a stimulus name and photograph matched (where the stimuli shown were familiar faces). Likewise, Tranel and Damasio (1985) observed that the patients had overall greater SCRs in response to familiar photographs when compared with responses to unfamiliar photographs. It is important to note that in these two studies, when the patients were required to verbally report on the familiarity of faces, their performance was not greater than chance level. Thus, it is the verbal expression modality which is impaired at recognition, not necessarily recognition per se. As shown in this last section, prosopagnosic patients do not necessarily have a selective impairment of recognizing faces only, as the definition implies. Likewise, even though this subtype is probably the "purest" agnosia (i.e., it is mainly associative), the literature demonstrates that it is not solely associative, and in addition, recognition impairments range in type and amount.

As far as prosopagnosia is concerned, most researchers tend to agree that a right hemisphere lesion is necessary (Kolb & Wishaw, 1985). There is, however, less agreement in reference to the intrahemispheric location of the right hemisphere lesion and the necessity for a second, left hemisphere lesion (Meadows, 1974; Benson, Segarra & Albert, 1974). Indeed, some of the more recent studies, in addition to being enlightening, also may be confusing. Damasio, Tranel and Damasio (1990), for example, in their description of the neuroanatomical correlates of prosopagnosia, suggest there are five types of this subtype: face agnosia of the "associative" type, the "amnesic associative" type, the "apperceptive" type, the "not full-fledged" type, and the "deep prosopagnosia" type. Each of these has its own inconclusive neuroanatomical correlate. They conclude by stating "In brief, face agnosia is generally correlated with bilateral lesions located either posteriorly in the inferior occipital region or anteriorly in the temporal region. However, unilateral posterior lesions, especially those located in the right hemisphere and involving cortices in both occipital and parietal regions, can cause partial defects of face recognition." (p. 101).

1.3.2.2 Decomposing Prosopagnosia: A Dissociation within a Dissociation

Beside the debate as to the legitimacy of prosopagnosia as a pure deficit of face recognition, evidence is accumulating in terms of two major distinctions in the processing of faces, facial identity and facial emotion. For instance, Tranel, Damasio and Damasio (1988) found poor facial identity processing as compared to a relatively intact facial expression judgment performance in a group of patients suffering from closed head injuries. This dissociation could be interpreted as indicating the high specialization and independence of the two processing units (Etcoff 1984; Young, Newcombe, de Haan, Small & Hay, 1993).

Adolphs, Tranel, Damasio and Damasio (1994) reported comparable findings with a patient after bilateral damage to the amygdala. The task involved rating several emotional facial expressions according to emotional adjectives (the six basic types according to Ekman were used). The authors qualified the patient's performance as dramatically impaired since her ratings were less intense than the ones observed for the brain damaged controls. The impairment was significantly affecting the rating of fear, anger and surprise. Despite this impairment, identity recognition was preserved for both old and novel faces. They concluded that these data provided evidence for a double dissociation between the processing of facial identity and emotional facial expressions. This suggests that two separate neural systems may exist, one responsible for each type of processing (Tranel, Damasio & Damasio, 1988; Hasselmo, Rolls & Baylis, 1989).

Adolphs et al. (1994) further examined their patient's abnormal processing of faces using similarity judgments of different expressions. These judgments were then analyzed using the multi-dimensional scaling technique. The results demonstrated that the control group had a psychological space similar to that reported for normal subjects (Russell &

Bullock, 1985). Interestingly, however, the patient did not show the usual circular psychological space found with normals. Their subject appeared to be impaired in judging similarity across expressions, however, maintaining appropriate judgments of similarity within an expression. These results suggest that expressions were judged even more categorically than for normals. Altogether, fear was the most affected emotion which suggests that the amygdala is crucial for the processing of that specific emotion, an hypothesis already supported by the animal literature (Davis, 1992). In addition, that structure also seems to be essential in the recognition of many blends of multiple emotions.

Recently Stone, Nisenson, Eliassen and Gazzaniga (1996) also examined the processing of emotional facial expressions within the hemispheres. They tested the ability of each cerebral hemisphere of a split-brain patient to discriminate facial expressions of emotion. Their rationale was based on the suggestion that the right hemisphere may be superior at processing emotional facial expressions because it contains perceptual representations of facial expressions. On the other hand, the left-hemisphere representations of facial expressions have yet to be described. The subject judged whether pairs of facial expressions presented to the left or right visual field depicted the same or different emotions. The right hemisphere was superior at this task when no verbal labels were provided. However, when given verbal labels for each expression (e.g., happy, afraid, angry), left hemisphere performance equaled that of the right.

Consistent with findings in lesion patients (see Etcoff 1984, for a review), these results suggest that the right hemisphere is significantly better than the left at categorizing facial expressions of emotion on the basis of visual information alone. The authors also reported that the left hemisphere performance varied with the instructions given to the patient such that verbal labels for each emotion improved the left hemisphere's ability to categorize facial expressions. They also assessed their subjects' ability to judge whether an emotional scene matched an emotional facial expression presented to the same visual field. The results indicated that both hemispheres performed above chance and equally well on this task. These findings suggest that both hemispheres are able to interpret the meaning of a facial expression and match it to an emotional context.

Stone et al. (1996) interpreted the results of both experiments as evidence for a dual representation of facial expressions in the hemispheres and suggested that the way each hemisphere accesses these representations may be different as exemplified by the changes in the instructions, that is, the use of verbal labels. Based on the results of their first experiment, they further proposed that the left hemisphere performance on this task may be attributable to the use of verbal labels for both the scenes and the facial expressions.

Among the different dissociations discussed so far, Bauer (1984) and Tranel and Damasio (1985) have reported a different type of dissociation in prosopagnosic patients. Their observations suggest that even though prosopagnosics are unable to recognize familiar faces overtly, they still show larger electrodermal responses to familiar than to unfamiliar faces. From the nature and localization of the lesions Bauer (1984) proposed that the intact covert recognition could be mediated by a different pathway. He referred to this visual pathway as the dorsal pathway, already identified in the monkey by Ungerleider and Mishkin (1982). Further parallels between this pathway and a possible non-MT pathway subtending the processing of facial expressions is possible but purely speculative at this stage. One major difficulty encountered within this proposition, however, is that Bauer's stimuli did not include any motion signals. However, it is not impossible that archaic projections of both types might exist within the dorsal stream.

In a recent case study, Farah, Wilson, Drain and Tanaka (1995) investigated the visual processing of a patient suffering from prosopagnosia. The great originality of their procedure deals with the utilization of the inverted face effect. Normally, individuals display great difficulty to perceive or more precisely, to match identical faces when they are inverted. This effect, in itself, has been interpreted as strong evidence for a face specific mechanism (Carey and Diamond, 1977; Leehy, Carey, Diamond and Cahn, 1978; Valentine, 1988). Using this procedure, Farah et al. (1995) concluded that the impairment shown by their patient with upright faces over inverted faces was strong evidence for an impairment of a face-specific processing mechanism. They further proposed that involvement of this mechanism was mandatory, in the sense that, the worsening of the performance with upright faces was interpreted as the contribution of a face perception mechanism which is impaired and in this case maladaptive. This interpretation is supported mainly by the idea that both types of faces are identical in terms of visual attributes and, therefore should be processed equally well by a general pattern recognition system.

Moscovitch (1996) also used inverted faces to study face processing. In a paper intitled " What makes faces special? Evidence from agnosia", he reports a series of experiments performed with a patient suffering from dyslexia and agnosia for objects, but having an intact face processing ability. He proposed that this patient may provide an opportunity to study face recognition without the interference of other processes involved in the recognition of other objects. The reported findings suggest that recognition of faces was intact only when the stimuli were presented in an upright position and when the configuration of features was respected. Inversion and configurational disturbances caused a detrimental effect on the performance of the patient. Moscovitch concluded that face-recognition may, thus, involve two processes, one for faces specifically and one for recognizing objects in general.

The observations and conclusions of both Farah et al. (1995) and Moscovitch (1996) converge to support the existence of a face specific system. It seems , therefore, that what Farah et al. (1995) called the general pattern recognition system would not suffice to account for both sets of findings independently reported. Instead, and as both groups of researchers proposed, object recognition processing is better thought of as a system that may include subsystems specialized in the processing of particular objects. This modularity would also support a possible subsystem responsible for the processing of facial emotions.

Humphreys, Donnelly and Riddoch (1993) reported two case studies which showed a dissociation between the processing of facial identity information and facial expression information. They reported three experiments to support their claim. The first one comprised a basic naming and discrimination paradigm. Familiar faces were presented to the subjects who were required to provide a name for the picture. Following this task, 20 unfamiliar faces were mixed with the previous ones and the subjects were then required to decide as to whether the faces presented to them were familiar or unfamiliar. Finally, a gender discrimination task was also performed using unfamiliar faces. The results illustrated that H.J.A. (patient's initials) was impaired at naming and discriminating faces, as well as for judging gender (though he was a little above chance on the gender task). On the other hand, the second patient, G.K., performed well on both tasks of familiarity, though he experienced some difficulty with the gender judgments. Although, performance was above chance on these familiarity tasks it was worse than that observed for the normals.

For the second experiment, the patients were required to judge emotional expressions from static pictures. Three different expressions were shown which included happiness, anger and distress. Both patients were impaired on the task, but only H.J.A. was significantly impaired. Performance was, however, above chance level for both patients.

Experiment 3 was then introduced to further assess this deficit of perceiving emotional facial expressions employing point-light displays (see section 1.4.4, for a full description of the technique). The rationale for this experiment was based on the observation that H.J.A. seemed to be able to carry conversations without difficulty despite a marked deficit at processing faces. The stimuli used were obtained from Bruce and Valentine (1988, see section 1.3.3). As in the case of Bruce and Valentine (1988), three tasks were involved. First, judgments were obtained in relation to the type of movement present in the stimuli either rigid or non-rigid. During the same presentation, the subjects were additionally asked to identify the expressions. Finally, gender judgments were obtained. The results revealed that H.J.A.'s performance was comparable to normals demonstrating that based on motion alone he was able to accurately judge emotional facial expressions. On the other hand, G.K.'s performance was significantly impaired on judgments requiring emotional facial expressions and gender identifications. Judging the type of motion as rigid or non-rigid, although, was not affected.

The authors interpreted this set of results as evidence for the idea that expressions are computed separately from facial identity in the same way as expressions are computed separately for moving and static faces. Their conclusion is supported by the double dissociation they observed among their patients. Interestingly, H.J.A. is a patient that cannot identify faces either statically or dynamically. When presented with point-light displays, however, performance on expression categorization was accomplished normally, as opposed to when the faces were presented statically. The authors thus concluded that motion patterns do not aid in identity discrimination as much as in emotional expressions since "motion is little used for face identification" (p. 178).

Among all the studies reviewed so far which exemplified the existence of face selective systems it is probably the one realized by Humphreys, Donnelly and Riddoch (1993) which is the most intriguing. It provides a good basis for an argument in favor of a emotional facial expression system which differentiates between static and dynamic faces. Furthermore taken together with the anatomical and physiological literature (see section 1.3.1), this study supports the independence of the two processing units responsible for identity and expression processing. This observation also indicates fractionation within the expression processing units. It is, therefore, possible that a similar subsystem might exist within the identity system, as suggested by the Psychophysical observations obtained by Thornton and Kourtzi (1997, see section 1.4.5). Note, also, that Thornton and Kourtzi's (1997) findings may contradict the proposition made by Humphreys, Donnelly and Riddoch (1993) concerning the poverty of the motion signal in the processing of identity.

Finally, some researchers have shown that these different processing units are extensively interconnected (Harries & Perrett, 1992). This modular organization and the interconnection among the different modules are important for the processing integrity of the different processing units. Vaina, Lemay, Bienfang, Choi and Nakayama (1990) provided a good example of the complexity of the pathway that may be involved in the processing of visual information within the motion unit. In their case study, they described a patient impaired in motion perception mechanisms which revealed intact biological motion and structure from motion perception. The biological motion stimuli were actions already used by Johansson (1973) which depicted either an individual walking, climbing stairs, riding a bicycle etc. (see section 1.4.4). The authors also stressed the fact that the performance with higher-order stimuli, more precisely with point-light displays, cannot be explained without referring to the existence of a motion signal. They further interpreted this intact perception as to imply the existence of a separate motion pathway, specialized for the perception of biological actions (Colby et al., 1988).

1.3.3 Imaging Face Selective Systems in Human

Besides the physiological studies using single cell recordings and the clinical reports from brain damaged populations, face selective systems have also been identified using neuro-imaging techniques. For instance, human physiology using the magneto-encephalography technique reveals that three main areas in the brain are selectively activated besides the occipital lobe. These areas include the occipitotemporal junction, the inferior parietal lobe and the middle temporal lobe (Lu, Hämäläinen, Hari, Ilmoniemi, Lounasmaa, Sams and Vilkman, 1991) These researchers drew a parallel between their observations and what is known from the physiological literature with monkeys. They concluded that the inferior parietal lobe activation site might be a general associative visual area since it was activated by most of the visual stimuli presented. Finally the author suggested that the middle temporal lobe activation site they observed might be homologous to the superior temporal sulcus in monkeys. In addition, Sergent, Ohta, MacDonald and Zuck (1994) using a positron emission tomography technique were able to identify a segregated zone in the brain responsible for the processing of facial identity and facial emotion.

1.3.4 Psychophysical Support for Face Selective Systems

Bruce (1986) noticed a similar dissociation between identity and expression processing in normal subjects. The experiment consisted of showing different facial expressions of familiar and unfamiliar faces. This procedure was intended to reveal any dependence on or effect of familiarity in facial expression judgments. A complete absence of the influence of familiarity on the identification of facial expression was found. This is consistent with the view that the expression analysis is independent of the analysis of identity of faces. This experiment adds to the current theories of face perception in which separate routes are proposed for the analysis of expression and identity of faces (Bruce & Young, 1986; Ellis, 1986; Bruce, Green & Georgeson, 1996).

The idea of independence between these two systems, identity and emotional expression, is also compatible with the observation made by Bruce and Valentine (1988), who failed to obtain reliable identity judgments from dynamic facial expressions in which the features were filtered out by utilizing the Johanson point-light technique displays (see section 1.4.4, for a full description of the technique). This suggests that the information present in dynamic point light displays is sufficient to lead to expression recognition but fails in providing the necessary information about identity. Taken together, these observations support the existence of two different processing units each sensitive to specific and different types of information. Furthermore, the information can be considered to be integrated late in the recognition process since interactions between the two units are not emerging.

Prkachin and Prkachin (1994) directly tested the idea of the existence of feature detectors which are especially tuned to faces. Most of their rationale is based on physiological observations made with monkeys which were described in section 1.3.1. Using an adaptation paradigm they found that the adapted emotional expression led to a reduced level of correct identification whereas other emotional expressions were facilitated. The judged magnitude of the emotion was also reported to be less for the adapted emotions as opposed to the non-adapted ones. They interpreted their results as evidence for the existence of a specific system responsible for the processing of facial expressions. Using the inverted face paradigm Farah, Wilson, Drain and Tanaka (1995) provided further evidence for this notion (see below).

1.4 DYNAMIC FACIAL EXPRESSIONS

1.4.1 Methodological Concerns Associated with Dynamic Facial Expressions

There exist several methodological concerns with the use of facial expressions. Some of these concerns are associated with the poser, others are related to the characteristics of the stimulus. Stimulus characteristics determine whether the expression depiction is static or dynamic as well as whether it is posed or spontaneous. The poser's concern includes three separate issues: 1) The poser may not succeed in portraying the target emotion. 2) The poser may display a configuration which is well identified within a cultural group but lacks in emotional content (e.g. display rules). 3) The observers may agree in their ratings because of their agreement about stereotypic depictions of emotion, or response biases based on the stimulus person, the poser (see O'Sullivan, 1982 for discussion).

These issues are very important in considering theories of emotion (Ekman 1992). On a perceptual basis, however, the same issues are not real obstacles to the study of the mechanisms involved in the encoding of emotional facial expressions. The study of the internal apparatus (perceptual mechanisms) implies that perceptual performance would determine whether the emotional signal has value or not. Interestingly, the perceptual mechanisms associated with the encoding or decoding of emotional signals have not been studied as extensively as the mechanisms responsible for the perception of facial identity (Bruce, 1988).

Another type of factor arises by definition from the use of dynamic emotional facial expressions: Dynamic depictions include temporal aspects. Along the motion continuum there are trajectories which are bounded by a beginning and end point. Dynamic facial expressions in the temporal domain may also be described within that continuum. Ekman (1982) distinguished three major components, the onset time, the apex time and the offset time. The onset would be defined as the duration it takes from the initial movement of facial features until they cease moving. The duration comprised after the action stops and before the beginning of the offset or decay begins constitutes the apex time. Finally, the expression decays and the duration included between the end of the apex and the moment at which no more motion of the features is perceivable, defines the offset time. Within these components, researchers (Ekman, 1982; Hess & Kleck, 1990) have also stressed the fact that motion of the features may be either regular or irregular. Irregularities would be defined as one or many more interruptions in the full sequence of motion features. Complexity also occurs from the coordinated movement of the facial features or lack thereof. Another type of irregularity might occur as well. For instance, when expressing happiness, the corner of the mouth may still be dropping while the inner brows already display an apex. Links have been proposed between the jagged offsets of emotional expressions and deception (Ekman & Friesen, 1984; for a review see DePaulo, Stone & Lassiter, 1985) One point, however, needs to be made in reference to posed expressions. Posed expressions are normally not destined to deceive and may very well be different from expressions where a full attempt is made to deceive others. Nevertheless, these are issues that need to be further explored empirically (see section 1.4.5, Hess & Kleck, 1990).

1.4.2 Dynamic Facial Expressions as Visual Stimuli

The face is undoubtedly a multiple and complex source of information for the visual system to process. At a perceptual level, the face can be described as being made up of a set of visual attributes. The visual attributes are what the visual system uses as information to define discontinuities of the surface and, therefore, to extract and locate the boundaries of objects. These visual attributes are not exclusive to the face and are tied to any object. However, faces have the particularity to include several of these attributes at the same time. Often found in the face are discontinuities along the luminance, color, texture, depth and motion dimensions. Following this idea the expressing face does include a motion component that is, though recognized, not yet understood nor even investigated on the basis of visual characteristics. The goal of this research project was to investigate dynamic facial expressions along those dimensions using real face stimuli. More specifically, dynamic facial expressions offer a good opportunity to study the extraction of motion information with more natural stimuli. It is thought that dynamic facial expressions can be studied in order to understand the contribution of the motion dimension in the perception of facial expressions. The changes in facial features which accompany dynamic facial expressions are judged to be important in the perception of emotion. Despite this recognition little empirical findings exist to corroborate this belief. Within this framework, dynamic facial expressions can be viewed as examples of biological motion.

1.4.3 Dynamic Facial Expressions as Non-rigid Motion Stimuli

A remarkable ability of the human visual system is that it can recover the spatial structure of an object from the motion of its elements. Since the first observation of structure from motion, in a display made by Braunstein (1962), researchers have assumed the participation of the rigidity principle. This principle is based on the fact that the preferred interpretation of structure from motion is often the one in which the elements move together as a rigid object defining a highly correlated pattern of motion. On the other hand, there exists another type of motion (more local and complex) produced by non-rigid objects, which is referred to as non-rigid motion. One particularity of non-rigid motion is that it is largely, but not exclusively, emanating from living organisms. The most important characteristic of non-rigid motion is probably that the motion of the composing elements is not 100% correlated. This fundamental characteristic between rigid and non-rigid types of motion is now questioned by Ishiguchi (1988a, 1988b), who has shown that the assumption of rigidity is not sufficient to destroy the rubber pencil illusion. Because in this demonstration the correlated motion in the display is 100%, this leads to a dissociation between the correlated aspect of motion and the rigidity assumption. This dissociation is important since the human visual system is as sensitive to non-rigid as to rigid motion. One question remains, and it relates to the identification of the mechanism responsible for integrating the motion signals. Parts of this answer may be found in the shared aspects of both types of motion. Natural situations via the use of facial expressions may offer the opportunity to investigate some obscure aspects of motion mechanisms which are always concomitant.

Another fascinating aspect of non-rigid motion and consequently of biological motion is the coherence of the percept produced. The coherence has been shown to be linked with the amount of correlation present among the elements in the display. Despite these converging pieces of evidence on the role of correlated information, little is yet known about the interaction between the spatial and temporal components of the display. This can be exemplified easily with faces. When looking at faces we are often confronted with multiple views. When these changing configurations are emanating from the poser's direction of gaze, they are referred to as rigid transformations (i.e. nodding and rocking).

Rigid transformations can be conceived as involving the temporal changes in the display with the preservation of the spatial relation among features. On the other hand, non-rigid transformations elicited by different facial expressions involve both temporal and spatial changes to which human observers are also highly sensitive. In this perspective, dynamic facial expressions are raising an important challenge and offer an opportunity to understand the interaction between the spatial and temporal components of the motion system. The challenge is stressed by the assumption that the cue for all this processing to occur is the extraction, through successive transformations, of correlated schemata. This suggestion is plausible considering its success in explaining the graded perception associated with the number of correlated elements in a rigid display and its resistance to noise.

Recently, Psychophysical evidence has been obtained in favor of a second motion system. According to Freeman and Harris (1992), the relative motion system, would be composed of three image motion components: expansion, rotation and deformation. Cells responsive to such visual characteristics have already been identified in the macaque monkey (Gallant, Braun & Van Essen, 1993). Hoffman and Flinchbaugh (1982) as well as Dodwell (1983) have stressed the importance of such motion components for the perception of pattern in general. The existence of these cell properties is very interesting since the expansion/contraction and deformation components are a major part of the signal found in non-rigid motion images (Hoffman & Flinchbaugh, 1982). Freeman and Harris (1992) also suggested that the mechanisms underlying these components would function independently of each other. This proposition does not support the interaction which is necessary with non-rigid motion. One solution would be the introduction of a third system. This alternative, however, is less plausible than an integration stage which simply incorporates the processing of the three motion component mechanisms.

1.4.4 Psychophysical Findings Associated with Dynamic Facial Expressions

As seen previously, a great amount of energy has been devoted to the understanding of the decoding of static facial expressions. On the other hand, few studies have addressed the dynamic aspects of facial expressions. The first formal study performed on dynamic facial expressions was done by Bassili in 1978.

Perhaps it is mainly due to a lack of technical resources that had us wait so long before reports started to appear regarding this issue. It is with a new methodology developed by Gunnar Johansson (1973) that the study of biological motion gained interest and momentum. This method is now referred to as the point light display. The point light display technique utilized sources of light or similar apparatus which are attached to an actor. The actor's behavior is subsequently perceptible through the movement of the lights. This technique reduces the visual information present in the stimulus to its motion component exclusively. This method is part of a more general framework designed to study the perception of biological motion. An attempt to define what biological motion may be would include all the movement that a living organism may produce, to which observers are sensitive and from which they can subsequently derive meaning. Biological motion is often included in a larger set of motion signals referred to as non-rigid motion. Other researchers have exploited this avenue and added to Johansson's demonstration that human movement can be identified from a dynamic configuration of point-light sources attached to a walker's major joints. To illustrate, Cutting & Kozlowski (1977) demonstrated that point-light displays can even convey knowledge about gender and personal identity. Others reported that information about relative age is also present and revealed from parameters such as human gait (Montepare & Zebrowitz-McArthur, 1988). Subtle perception of accurate effort and deception from point-light displays of a person's movement also supports the richness of information provided through human action (Runeson & Frykholm, 1981). Despite these various findings, the question remained, what would happen if such a procedure was applied to faces?

Faces are an important source of dynamic information. They continually undergo complex patterns of deformation and more gradual transformations to which an observer is quite sensitive. People extract qualities such as personal identity (Ellis, Shepherd & Davies, 1979), gender (Berry, 1990), age (Mark, Todd & Shaw, 1981) and emotional state (Ekman, Friesen & Ellsworth, 1982) from faces. As mentioned earlier, two seminal papers by Bassili (1978, 1979) opened the discussion concerning the importance of dynamic information for the perception of facial emotions. In an attempt to isolate the dynamic information present in expressive faces, Basilli utilized the point-light displays. He had the face of actors covered with black make up. Subsequently, 100 dots were painted on the faces of the actors while expressing specific emotional facial expressions and other types of facial movement such as grimaces. The only visible information available was delivered by the dots. With this technique he showed that observers where able to identify the emotion depicted far above chance, even though they were more accurate with a display depicting a real face (Bassili, 1978). If one takes a closer look at the control conditions used (foams undergoing twists or compressions) it is interesting that even though none of them were perceived as mimicking the movement of a face, most observers described them as living things or animals without reference to faces, as if such movement by itself pertained to animated and alive organisms.

Using the stimuli originally constructed by Johansson, Sumi (1984) obtained similar results. The aim of his study was to determine whether familiarity with the stimuli was sufficient to induce the correct perception of a person either walking or running. This question arose from the observation that upside-down presentations of the point light display sequences appeared as movements of an upright human, though strange. The results indicated that the information was retained even in the reverse condition (played backward) emphasizing the translatory motion component as the important motion signal for human biological motion.

Bassili (1979) investigated the ability for observers to decode emotional expressions with such displays further and examined the importance of the upper and lower parts of a face as cue carriers. Bassili's apparent concern was to delineate the facial patterns that give rise to the judgment of different emotions. As he emphasized, previous studies have restricted their observations to static representations of facial expressions and therefore elaborated some feature-based descriptions that ignored aspects of facial information relevant to the judgment of emotions (Ekman, Friesen & Ellsworth, 1982).

Using the same methodology as previously described but including the six basic emotions proposed by Ekman (1982), Bassili showed that all expressions were more accurately recognized in the moving conditions as compared to the static ones. However, accuracy was lower when compared with full face presentations. The results also illustrated that different regions of the face were more informative for different emotions. Such results are highly consistent with observations made with static representations (Ekman, Friesen & Ellsworth, 1982).

Based on these results, it becomes difficult to argue that the motion signal conveyed in dynamic facial expressions contributes significantly to the recognition process in general. On the other hand, point light displays are highly impoverished stimuli, in that they include only part of the motion signal and therefore this type of display should not be expected to lead to judgments with equal accuracy as compared to those obtained with still faces. The number of moving elements in a point-light display is probably several times less than that observed with real face stimuli. Nevertheless, these findings suggest that motion signals can be sufficient to lead to recognition of facial expressions, even when the information is impoverished to a certain degree. As argued by Bassili, it appears to be a necessity for future research to delineate the cues relevant to the expression of specific emotions and to scale their relative information value. Another issue raised by these results is the type of cooperation that exists between the feature information and the movement information signals.

Bruce and Valentine (1988) replicated Bassili's results from a different perspective but in a similar setting. They investigated whether observers could recognize the identity of the posers through point-light displays. The subjects were required to judge (a) whether the poser was a female or male; (b) the poser's identity; (c) whether the motion was rigid or non-rigid; and (d) the expression or the type of rotation. The results indicated that for all types of judgments, moving displays were always more accurate than still ones. The expression judgment was twice as accurate with the moving displays as compared to the non-moving ones, that is, 87% and 42%, respectively. The researchers concluded that motion may provide redundant information when other cues such as contours and shading are present in static pictures. With point-light displays the motion signal could play an important role in contributing to a description of the 3D structure of the face which may underlie the extraction of certain global parameters of facial variation such as face shape and age.

Despite Bruce and Valentine's (1988) failure to obtain reliable identity recognition rates with dynamic displays, other researchers have found superior recognition performance with short dynamic sequences of individual behaviors (Schiff, Banka & de Bordes Galdi, 1986). However, the two procedures are too different to allow for direct comparison. Nevertheless, an advantage for dynamic sequences over static ones suggests that in some circumstances moving information can increase identity recognition capabilities.

To summarize previous studies, dependent on the stimuli and the context, motion from a display alone is generally a weaker signal for recognizing facial expression than the static depiction. When static representations are compared, on the other hand, with real facial expressions that include both motion and feature signals, there is typically no significant difference. On some occasions, however, motion and feature signals can improve recognition performance of identity.

Among the different studies described so far, none has addressed the issue concerning the minimal amount of information required to correctly identify an expression using point-light displays, as Johanson had first proposed for the recognition of biological motion. Recently, Matsuzaki and Sato (1997) demonstrated that eighteen dots were sufficient to allow for recognition of emotional facial expressions, provided that the dots are positioned at appropriate locations. Their demonstration differed from Bassili's who utilized 100 dots. Furthermore, the apparent motion paradigm was used and only two frames were presented which included a neutral and an emotion sequence. The results showed that recognition was possible but that the rate varied with the emotion portrayed. Happiness and surprise, for instance, were recognized better than anger and sadness.

The authors did not attempt to interpret the results other than stating that these are consistent with the happy face advantage reported in the literature. The emotions that were recognized better, however, possess one common characteristic, that is, they both involve stronger feature displacements. This is not a flaw in terms of procedure since this characteristic pertained to these expressions. On the other hand, it may very well exemplify the richness of dynamic representations that include all the features of the face as opposed to impoverished point-light displays. Recognition rates with the former are consistently reported to be higher than the one reported here (Kirouac & Doré, 1984)

1.4.5 Static versus Dynamic Facial Expressions

The attempts to address the issue of dynamic facial expressions have been greatly limited both in the quantity of research and in the information that they provided us with. While the perception of facial expressions with static presentations has been well described (see Ekman, 1992), the perception of dynamic presentations of the same emotions is less clear. This lack of descriptions is perhaps in part due to the belief that static representations are segments taken from an ongoing expression and that therefore the expression itself is entirely represented within the chosen segments. This assumption, however, faces two major criticisms that make it difficult to defend. The first one refers to the valence value of the segment chosen. This difficulty is usually solved by choosing the apex of the emotion displayed as the target stimulus. This on the other hand, raises major limitations in terms of ecological validity, as discussed earlier, since the utilization of static facial expressions relies on instances that are highly typical and exaggerated forms of expression (see Wallbott and Scherer, 1986). Real life situations involve much more subtle interpretations of the visual signal than what is usually employed in the static domain. An additional serious difficulty is the absence of information about the previous segments, that is, the expression sequence itself. Ekman & Friesen (1984) have already raised this flaw and described specific emotions where it happens that the rate with which they are displayed produces misjudgments of their intents. For example, they found that disgust was perceived as mimicked when the presentation was too brief. This example does not correspond to a cross over from one expression to another, but when socially considered, it is sufficient to seriously perturb a conversation.

This important characteristic of dynamic information was also identified and stressed more recently by Hess and Kleck (1990). Using happiness and disgust, they compared whether elicited and deliberate emotional facial expressions differed in their dynamic features. In reference to this discussion, their results indicated that the type of expression, either posed or spontaneous, differed from one another. Overall, posed expressions were found to be longer and with more phases, that is, more irregular.

More recently, Gosselin & Kirouac (1994) examined the effect of the type of communication signal used, as well as the effect of posed and spontaneous emotional facial expressions on the recognition of emotional categories. Their study did not directly address the distinction between static and dynamic emotional facial expressions, however, their experiment is worth mentioning since it combines the posed and spontaneous question, in addition to the static and dynamic one. The first deals with the fact that distinguishing between posed and spontaneous expressions shows that the decoder may be able to perceive differences in the intent. The second refers to the idea that differences between posed and spontaneous expressions that are detectable by the decoder, would be even more pronounced with dynamic displays. This rationale is supported by the fact that additional clues are present in dynamic expressions such as timing and vertical asymmetry of the facial features.

The results of greatest interest to the present discussion are the judgments of accuracy for emotional category and the judgments of authenticity for the same category when the facial signal is considered alone. It is important to point out that the concept of authenticity to which the authors refer is defined, in our terms, as whether the emotion is judged to be posed or spontaneous. Their results indicate that the accuracy for all types of emotions utilized is well above chance. Interestingly, for some emotions, like surprise and sadness, posed expressions were judged with more ease in comparison to spontaneous ones. The reverse pattern was observed with happiness. These results seem to further exemplify the existence of display rules which were discussed earlier on, while providing little information in relation to the posed and spontaneous distinction.

A closer inspection of the judgments of authenticity reveals, however, that decoders were able to parse between posed and spontaneous expressions using the facial signal alone. The percentages were 56% and 67.4%, respectively. The authors, however, computed a bias index and found that the decoders were significantly biased in responding toward spontaneous expressions. The percentages in the condition where the facial signal alone was considered were 43.5 and 56.5, respectively.

In conclusion, these results do not unequivocally support an advantage of spontaneous over posed emotional facial expressions. Two possibilities may have arisen. It is possible that the actors which were used as encoders were able to portray the desired emotions with great accuracy in both conditions. On the other hand, their expertise may have interfered with the contention that spontaneous and posed emotional expressions may be distinguished. It is possible that the inducing technique they used produced depictions which were closer in nature to posed emotions than to spontaneous ones. If the first account were true, it would mean that given the proper setting an encoder would be able to produce equivalent versions of emotional facial expressions. More research would be needed to clarify this issue. However, Gosselin & Kirouac (1994) pointed out that the results they obtained were comparable to the studies examining the masking of emotions (Zuckerman, Amidon, Bishop & Pomerantz, 1982; Ekman, O'Sullivan, Friesen & Scherer, 1991). It might, therefore, be suggested that their stimuli contained some information that made them resemble posed or masked emotions more than spontaneous ones.

A review of the literature on the comparison between static and dynamic emotional facial expressions reveals an astonishing lack of knowledge in this respect. There seem to be only a few researchers that have examined the static and dynamic problem directly. Among them, Lemay, Kirouac and Lacouture (1995) compared static and dynamic emotional facial expressions using multi-dimensional scaling and categorical judgment. The main observations were that dimensionallity was found to be similar for both types of stimuli, however, categorical judgment was easier when dynamic stimuli were presented. The authors concluded that the static stimuli were impaired in comparison to the dynamic ones since temporal information was missing during static presentations. They referred to this information as the succession of movement of the facial features over time. Finally, the authors also pointed out that their results replicated Landry's (1993) research with categorical judgment. One methodological distinction, however, between the two studies worth mentioning is that Landry's (1993) static stimuli were not the apex of the emotion but the image that corresponded to the middle of the dynamic sequences. Russell and Fehr (1987) have shown that the context surrounding an expression may affect the judgment of this expression. They called this effect the relativity thesis. The importance of context was also reported by Feenan & Snodgrass (1990) who found that the context affects the discrimination of pictures and words in recognition memory. Based on Russell and Fehr's relativity thesis, the degree of similarity between static and dynamic versions found in Lemay, Kirouac & Lacouture (1995) might depend on the context, i.e., it might be different if the static version was to be replaced by an image other than the apex. This suggestion remains to be evaluated empirically. Nevertheless, it would provide a test for the representation sensitivity of the emotional space.

Dubé, von Grünau & Kwas (1995) also reported an advantage for dynamic over static emotional facial expressions. Their rationale was based on the sensitivity that individuals have for biological motion. Real emotional facial expressions, happiness and sadness, collected from two posers were presented to subjects for judgments. The task was a categorical judgment with a two alternatives forced choice procedure. Six different types of clip were constructed for each expression. The total clip durations were always kept at 2 seconds. The clip content was varied according to the amount of information present as defined by the number of frames presented. In order to achieve this, the number of dynamic frames presented was always preceded by a replication of a static frame (the first frame of the sequence was presumed to be neutral) with as many frames as necessary to fill the 2 seconds total duration (i.e. 60 frames). Altogether, two conditions (dynamic versus static) were compared with two types of expression (smile and frown) for six different levels of visual information content. The stimuli were presented with all the conditions mixed and randomized. The results of interest were the percentages of correct identification compiled for each condition. Dynamic facial expressions were identified with more accuracy than static depictions of the same expression. However, this was true only for conditions where a minimum level of visual information was presented (at least 20 dynamic frames). For conditions including more visual information (more dynamic frames), performance was qualified as having reached ceiling. These results suggest that the visual information present in emotional facial expressions varies in strength when dynamic and static comparisons are made.

This point is even more important as comparisons between the two conditions were always made with the same amount of visual information intensity in the spatial domain. That is, the final frame of the dynamic sequence was compared to a repetition of the same frame over the entire duration of the sequence. Interestingly, this procedure should have biased the stimuli in favor of the static sequences in the temporal domain. The observed results, therefore, support the idea that the information present in frames preceding the final, or static depiction, provide important information for the disambiguation of the emotional expression. This would suggest that a particular emotional facial expression captured in a frame may vary in its interpretation depending on the information which precedes it. In a similar way, it can be predicted that the subsequent presentation of information would also affect this interpretation and the identified emotion.

One major limitation, however, associated with this experiment was that only two posers were utilized. Though limiting the possibility for generalization of the results obtained due to the possible idiosyncratic aspect of the emotional facial expressions, the existence of a differential effect of dynamic and static sequences should not be negated by this limitation as it is thought to be an independent issue. The authors also reported one other difficulty associated with the stimuli. The posers were instructed to display a neutral affect which would progress toward either happiness or sadness. However, it seems that posers had great difficulties to pose a neutral affect. One reason that may come to mind deals with the absence of feedback given to the posers as to what the expression on their face looked like at any moment in time. In addition, one may suggest that the anticipation in the production of a desired emotional facial expression would color the initial facial configuration toward the target expression leaving the posers to believe that they depicted a neutral affect. Therefore, it appears of great importance to obtain emotional facial expressive sequences which possess a true neutral phase.

Similar results were reported recently by Thornton and Kourtzi (1997) who found an advantage of dynamic over static depictions of human faces. The rationale for their experiment was that dynamic information may provide a richer representation of the face and therefore produce better identity discriminations. The expressive content of the faces was not studied explicitly. However, emotions were introduced in the task such that subjects had to discriminate between two stimuli as to whether they were the same or not while the faces displayed either a smile or a frown. Four types of stimulus pairs were constructed, same person same emotion, same person different emotion, different person same emotion and different person different emotion. The pairs were also different in terms of the type of prime that preceded the probe. On half of the trials, the prime was a dynamic sequence whereas on the other half it was the apex frame of the dynamic sequence.

The results indicated that subjects' performance was identical for dynamic and static primes in the same/same condition. However, a dynamic advantage was found when the person was the same but the expression was different. No difference was found for the other conditions. The authors interpreted the results as evidence for a modulation of identity performance as a consequence of the type of information which is presented at the time of encoding. Dynamic information would produce a representation that facilitates matching of identity when expressions are different.

These findings support the general dynamic advantage discussed so far. Interestingly, and similarly to the comparison that was used by Dubé et al.(1995), static stimuli were constructed by presenting the apex frame of the dynamic sequence. As discussed earlier, this choice in the procedure may bias the results in favor of the static representation and, therefore, a stronger effect may occur if the bias could be removed.

1.5 Outline of the Present Experiments

To address these considerations, the present thesis is an attempt to improve our understanding of the processing of dynamic facial expressions. A Psychophysical approach was proposed to investigate this issue in order to fragment the components of facial expressions. Some temporal aspects of dynamic facial expressions were examined and a comparison was made between dynamic and static facial expressions. This comparison was motivated and judged essential to substantiate or reject the notion that facial expressions of both types may be identical in the information that they convey.

The goal pursued by this set of experiments was first of all, to delineate some of the important dynamic parameters that are conveyed by the motion signal in dynamic emotional facial expressions and secondly, to determine how these parameters influence the judgment of facial expressions.

In this series of experiments, emphasis was put on two specific emotional expressions, happiness and sadness. This choice was motivated primarily by the fact that these two emotions are commonly referred to as opposites of each other. Another factor which also motivated this choice were the findings made by Basilli (1979). He has shown that these two emotional facial expressions yielded reliable judgments of recognition when tested with point-light displays.

In Experiment 1, forward and backward sequences of the stimuli were presented in order to determine the point of neutrality within the dynamic sequences. These always comprised happiness and sadness expressions which were separated by a transition period which is referred to as the zone of neutrality. In Experiment 2, a categorization of the stimulus faces posed by different individuals was performed to arrive at a set of typical stimuli among the sequences obtained from experiment 1. The typicality of the excerpts was determined through experimentation. The excerpts that led to superior concensus judgments were retained. Experiment 3 examined the effect of manipulating the temporal presentation of the previously selected sequences. This manipulation was performed to assess whether temporal factors might influence the judgment of typicality.

It has often been argued that the effect of dynamic presentations could not be seen because the effect produced with static presentations already was too strong to allow a dynamic presentation to improve the percept in a noticeable way. To further evaluate such a claim, Experiment 4 compared the type of mode of presentation (i.e. static and dynamic) in order to estimate the relative contribution of each mode, using a two alternatives forced choice procedure. Finally, Experiment 5 further investigated the idea put forward by Prkachin & Prkachin (1994) concerning the existence of feature detectors using an adaptation paradigm.

GENERAL METHOD

2.1 Construction of the Bank of Dynamic Emotional Facial Expressions

A few researchers have collected emotional facial expressions for the purpose of studying their categorization (Ekman & Friesen, 1976; Izard, 1980; Gosselin & Kirouac, 1994). Despite the existence of these banks, a new bank was obtained for this series of experiment. Prior to the construction of this stimulus bank, a Concordia University Human Ethics Protocol Form was completed and approved by the university (Appendix A). A few factors were important to be controlled in order to produce a set of stimuli which would stress the visuo-spatial characteristics of emotional facial expressions. This approach emphasized the motion signal in the stimuli. Consequently, the stimuli were collected according to a series of rules described below. Beside these guidelines, two other characteristics of the stimuli were controlled. The posers were instructed not to move their heads and to keep their mouths closed. One major disadvantage associated with this new bank, however, was the absence of data as to how representative the new sequences were (see Experiment 2).

2.1.1 Apparatus and Materials

A Sony Handycam camera, model TK1070U, was used to record emotional facial expressions. A Sony Trinitron KV-13TR27 conventional television monitor was connected to the camera for direct viewing purposes. The television was also used to provide feedback to the posers during the recording sessions. The video signal from the camera was sent to a Power Macintosh series 8100/80 computer equipped with a video board capable of digitizing the signal on-line. The video board, the first generation of Video Vision Studio models manufactured by Radius, was responsible for the compression of the video signal. The digitized information was stored on a DAT drive with ejectable cartridges of 90 gigabytes manufactured by Dynatec. Other memory requirements included 32 megabytes of active memory. Transformation and/or adjustment of the video sequences as well as the compression of the signal were performed with the Adobe Premiere version 4.0 software. This software combined with the video vision compression software was used to produce video sequences that were Quicktime compatible. The stimulus presentation was controlled and responses were collected using Hypercard version 2.2 with Hypercard QuickTime Tools XCMD extensions.

2.1.2 Stimuli

The emotional facial expression stimuli were constructed in the laboratory. Following instructions, the posers were asked to elicit two specific emotional facial expressions, happiness and sadness. An expressing sequence of a particular emotion consisted of both directions of motion. That is, sequences included both the development and the decay of the target emotion. In order to eliminate some of the difficulties experienced in the past (Dubé, von Grünau & Kwas, 1995), the posers were allowed to see and adjust their expressions through direct video feedback. The neutrality phase of the expressions collected in the study by Dubé, von Grünau & Kwas (1995) study was questionable. At the beginning of some emotional sequences (neutral phase), several observers reported sadness for sequences which were to develop into facial expressions of happiness. Therefore, in order to obtain a better neutral expression phase the posers were asked to express an affect of happiness followed by a neutral expression which would also be followed by the expression of sadness. These instructions were repeated and the emotions were interchanged. Altogether, sequences were either starting with happiness and finishing with sadness or they were starting with sadness and finishing with happiness. The rationale behind these instructions was that during the transition period, for which they were asked to express a neutral affect between the two end points of the emotional expressions, the posers would necessarily depict a neutral phase at some point.

2.1.3 Procedure

All potential posers were first asked to read and sign a consent form prior to their participation (Appendix B). The posers were seated on a chair in front of a blue screen attached to the wall behind them. The location in the room was determined by the condition of illumination, as to prevent as much as possible the miscellaneous shadows on the face. The recordings were made at ambient illumination under fluorescent light. The posers were positioned in the room in such a way as to reduce any possible shadow originating from the ambient light source. This was accomplished by seating the posers in the middle of the room under one source of light and facing the next one, since the room was illuminated with only two sets of lights. The position of the camera was such that only the face of the poser was recorded. The camera was adjusted manually to prevent any positioning variations across posers. Landmarks were established to facilitate proper positioning. The landmarks corresponded to the bridge of the nose, more precisely the line joining the center between the two pupils, and the chin. The experimenter made sure that the posers were comfortable both physically and emotionally before introducing the instructions. This phase included familiarization with the feedback device placed in front of them. The posers were able to see at all times, live, the expression on their faces. After a short period the experimenter introduced the posers to the task.

> "You are required to portray within the same sequence two emotions, happiness and sadness, in a way where you should express happiness followed by a decay toward what you might judge being neutral before expressing sadness. These instructions are to be followed until you are informed to stop. Similarly, you are also asked to produce sequences where the starting emotion is sadness and the ending one is happiness. Whether you decide to produce them consecutively or to alternate between the two types is left up to you."

A few practice trials were often given to the posers before the recordings actually began. Ten exemplars of each emotional sequence were collected on average from each poser. These sequences composed the corpus of the bank of stimuli.

2.1.4 Bank of stimuli

It is important to mention that the recordings included a large amount of sequences that were inadequate. For instance, some posers were unable to portray the desired affect despite their good will and determination. They were therefore thanked for their participation. Altogether, the bank of stimuli contains more than three hundred excerpts which are not cataloged in any way. This bank contains a great deal of information that could be studied. For the purpose of this series of experiments, however, the excerpts were simply scanned for the presence of the two target emotions. Attention was also paid to the presence of gross artifacts like blinks or laughs. This procedure was motivated by Experiment 1 but principally Experiment 2, which was designed to assess the representativeness of the excerpts chosen. In order to reduce the pool of excerpts, it was decided to present the sampled expressions to a panel of three to four judges first. The sequences which obtained unanimous agreement among the judges were kept.

EXPERIMENT 1

3.1 Introduction

This experiment was designed to investigate dynamic facial expressions. Past literature reported conflicting results in reference to the ecological validity of posed versus spontaneous facial expressions. Recent reports demonstrate that posed facial expressions can be as typical as spontaneous ones when posed expressions are not designed to deceive or to mask the intended emotion (Gosselin & Kirouac, 1994; Lemay, Kirouac & Lacouture, 1995). Another limitation encountered in many studies of facial expressions is that the stimuli employed are often oversimplified versions of the natural scene such as static or more recently, morphed depictions (Ekman, 1992, Etcoff & Magee, 1992). Even though studies using biological motion à la Johannson have had promising results, ecological validity with this type of stimulus remains an issue. In order to further examine this question, volunteers in the present experiment were asked to pose two of the six basic facial expressions, namely happiness and sadness, as classified by Ekman and Friesen (1976).

In the first experiment, therefore, a set of dynamic facial expressions was collected depicting happy-neutral-sad and sad -neutral- happy emotional facial expression sequences. The main goal was to establish a set of prototypical emotional facial expressions that could be used in the subsequent experiments (see section 2.1.4). One difficulty, however, dealt with the determination of a neutral emotional facial expression within these sequences. In order to obtain a veridical judgment of neutrality in the dynamic presentations, a static or slow motion mode of presentation was discarded since one's visual system does not typically encounter visual input in this manner. Instead, the dynamic sequences were presented in a real life fashion, that is, their true speed of recording. It was, however, impossible to proceed with an adjustment technique and have the subjects adjust back and forth the stimulus as the procedure requires. Thus, for the determination of the neutral segment, the direction of presentation was introduced as a further experimental manipulation. To locate the neutral zone the subjects were presented with the sequences backward and forward. This procedure was judged preferable to obtain a threshold of neutrality. This threshold was defined as the time during which the subjects judged the excerpt to be neither happy nor sad.

This zone was postulated to be clear in terms of emotional boundary. Evidence for this postulate was reported by Etcoff and Magee (1992). They studied the categorical perception of emotional facial expressions. Their stimuli depicted different emotions as well as some neutral depictions. Interestingly, their results showed that categorical boundaries are also found between emotions and neutral affect. They proposed that neutral faces are not simply low in their degrees of emotionality but constitute a category by themselves. They also stressed from their results that the transition between emotions and non-emotions is sharply defined. Altogether, Etcoff and Magee's (1992) results suggest that the chosen procedure in this experiment should identify clear boundaries between each emotional state depicted.

Interestingly, this procedure further permitted the experimenter to investigate possible temporal effects with dynamic facial expression sequences. The subject's sensitivity to changes in the perceived duration of a neutral expression embedded in a dynamic sequence was measured when the sequence was presented either forward (i.e. in its original recorded direction, e.g. sadness-neutral-happiness) or backward (i.e. opposite to its recorded direction, e.g. happiness-neutral-sadness). It was hypothesized that the perceived neutral segment of the dynamic sequences would remain unaffected by the direction of presentation, since no physical changes were made to the stimuli.

3.2 Method

3.2.1 Subjects

Ten individuals participated in this experiment. All participants were recruited on a single basis through solicitation among, though not exclusively, the department of psychology population at Concordia University. Overall, the ratio of participants was biased towards fellow graduate students, and both genders were recruited. The age of the participants varied between 21 and 52 years old. The subjects were informed of the research domain but were kept naive as to the purpose of the experiment.

3.2.2 Stimuli

Six different posers were used from the bank of source clips. The selection of the posers' sequences was determined by the agreement of at least three different observers as to whether the expressions depicted were acceptable exemplars of the target categories. The selected movie clips included the two types of sequences which started either with a smile or a frown, included a neutral or transition phase, and ended with the other expression. Therefore, the clips displayed an emotion decaying toward a neutral phase before the onset of the opposite emotion. Backward versions of the same sequences were also constructed by simply playing the original movie clips backward. This yielded four different sequences per poser: two starting emotions (happiness and sadness) and two presentation directions (forward and backward), for a total of 24 different stimuli. In terms of duration, the total clip duration varied dependent on the poser and the type of emotional sequence. The shortest sequence had a duration of approximately 5 seconds while the longest lasted for 24 seconds. The stimulus area was a rectangle of 240 by 320 pixels containing the sequences. Therefore, the stimulus had a visual angle of 7.75 by 11.5 degrees. The mean luminance of the display was 35 cd/m^2.

3.2.3 Procedure

Verbal instructions were given to the subjects prior to commencement of the experiment and a consent form was signed (Appendix C). The subjects were seated in front of the computer screen at a distance of 57 cm. At all times they were instructed to look at the screen after they initiated the trial. The subject initiated each trial by pressing the space bar when ready and fixated. The dynamic sequence then played starting with one emotion, for instance, happiness, decaying into a neutral state, and then developing into the other emotion, for instance, sadness. Half of the time this was the sequence's true recorded direction and half of the time it was the original movie played backwards. While the movie was in progress, the task of the subjects was to click down the mouse key when they started to perceive the neutral phase (i.e. when the expression appeared neither happy nor sad) and hold the mouse key down for as long as they still perceived the expression to be neutral, releasing it only when they no longer believed the depiction was neutral. The sequences were shown one at a time in a randomized order of presentation. Each sequence was repeated 5 times for a total of 120 trials. The entire procedure lasted about 20 minutes.

3.2.4 Statistical design

The statistical design for Experiment 1 was a 6x2x2 repeated measures factorial analysis of variance (ANOVA), with Posers (6 levels), Direction of presentation (2 levels: backward and forward), and type of Starting emotion (2 levels: sadness and happiness) as variables.

3.3 Results

For each of the 24 combinations of poser, starting expression, and movie direction, the neutral duration was measured at each of the five repetitions, for each observer. Subject, and thereafter, group means were then established in three different manners to yield three subsequent repeated measures analyses of variance (ANOVAs).

3.3.1 Neutral Duration Data

First of all, it was important to transpose the neutral durations into a ratio of neutral duration to total movie length so as to equate this dependent measure across different posers, who invariably had different movie durations. Thus, for each subject's response, his/her calculated neutral duration was divided by the total movie length of the poser for the particular stimulus sequence. In this manner, neutral duration ratios were calculated for each subject per condition and a repeated measures ANOVA was conducted on the neutral duration data to determine if it was dependent on the type of Poser (6 levels: poser 1, poser 2, poser 3, poser 4, poser 5, and poser 6), the type of starting Emotion (2 levels:

sadness and happiness), and the Direction the movie was played in (2 levels: forward and backward).

Different posers were found to yield different neutral durations in their movie clips [main effect of Poser, $F(5, 45)=84.620$, $p<.05$]. Neutral duration ratios of .5344, .3672, .2459, .2635, .1989, and .2203 were computed for posers one through six, respectively. This, however, is not surprising since each poser's movie was a different duration and each poser is unique in the manner in which s/he expresses emotions. Without any control time restriction for emotion expression for the posers (i.e. inform posers how long to express each emotion and the neutral) this variable's main effect is somewhat artificial for the present analysis and thus will not be discussed. It is, however, relevant to investigate possible interactions between this variable and the others. It was also determined that the type of starting expression produced different neutral durations, with for instance, a ratio of .3167 for the sadness-to-happiness sequence, which was significantly larger than the ratio of .2934 found for the happiness-to-sadness sequence [main effect of Emotion, $F(1, 9)=5.374$, $p<.05$]. Again, there was no a priori reason for predicting these two expressions would yield similar neutral durations given the fact that a poser's sadness-to-happiness and happiness-to-sadness depictions were different movies thus having different lengths and possibly simulated in a qualitatively different manner. Like the poser variable, while a main effect of starting emotion may be of little interest and research value, interactions between this and other variables would be insightful. The direction in which the movie was played to the subject also led to significantly different neutral duration ratios. When movies were played forward, neutral duration ratios (.3282) were significantly longer than when movies were played backward (.2818) [main effect of Direction, $F(1, 9)=21.015$, $p<.05$]. Unlike the previous two main effects, this main effect is in itself important, as well as its possible interactions.

The main effects of starting emotion and direction were found to be significantly dependent on the poser [Poser x Emotion interaction, $F(5, 45)=79.803$, $p<.05$, and Poser x Direction interaction, $F(5, 45)=4.417$, $p<.05$]. The main effect of starting emotion was also found to be dependent on the direction of the movie [Emotion x Direction interaction, $F(1, 9)=17.391$, $p<.05$]. All of these two-way interactions, however, change across the third variable. In other words, the three-way interaction was significant [$F(5, 45)=11.309$, $p<.05$] and thus took precedence over the two-way effects. A simple interaction analysis was then conducted on the Poser x Emotion x Direction interaction. It was revealed that the three-way interaction was due to the fact that the neutral duration for starting emotion was dependent on the direction for Poser 1 [$F(1, 45)=29.268$, $p<.05$], Poser 3 [$F(1, 45)=4.782$, $p<.05$], and Poser 6 [$F(1, 45)=40.332$, $p<.05$], but not for the remaining three posers [Poser 2, $F(1, 45)=3.359$, $p>.05$, Poser 4, $F(1, 45)=.116$, $p>.05$, and Poser 5, $F(1, 45)=.515$, $p>.05$].

A simple effects analysis was thereafter performed on the significant simple interactions, Emotion x Direction at Poser 1, Emotion x Direction at Poser 3 and Emotion x Direction at Poser 6. The first analysis revealed that this simple two-way interaction was present because direction of movie significantly affected the neutral duration only for the happiness-to-sadness [simple effect of Direction at Happiness for Poser 1, $F(1, 45)=58.225$, $p<.05$] but not for the sadness-to-happiness [simple effect of Direction at Sadness for Poser 1, $F(1, 45)=.0004$, $p>.05$] sequence. To illustrate, the neutral duration in sadness-to-happiness was found to be about equal for forward (.6498) and backward (.6503) movies, but for happiness-to-sadness the neutral duration was found to be longer for forward movies (.5122) than for backward (.3253) movies.

The analysis of Emotion x Direction at Poser 3 illustrated no significant simple effects [simple effect of Direction at Happiness for Poser 3, $F(1, 45)=2.216$, $p>.05$ and simple effect of Direction at Sadness for Poser 3, $F(1, 45)=2.573$, $p>.05$]. The differences between forward and backward presentations for the happiness-to-sadness and the sadness-to-happiness movies, therefore, must have combined to create an overall interaction effect.

The simple effect analysis of Emotion x Direction at Poser 6 demonstrated a partially similar effect to Poser 1. The analysis indicated that this simple two-way interaction was due to the fact that the direction of movie significantly affected the neutral duration for the happiness-to-sadness [simple effect of Direction at Happiness for Poser 6, $F(1, 45)=47.412$, $p<.05$] as well as for the sadness-to-happiness [simple effect of Direction at Sadness for Poser 6, $F(1, 45)=4.392$, $p>.05$] sequences, but in opposite ways. For example, the neutral duration in sadness-to-happiness was found to be shorter for forward (.1469) than backward (.1982) movies, but for happiness-to-sadness the neutral duration was found to be longer for forward movies (.3523) than for backward (.1837) movies. In conclusion, for Posers 1 and 6, but not for Posers 2 through 5, playing the movie clip backwards significantly shortened the neutral duration only for the expression of happiness-to-sadness.

A closer examination of all the data graphically (Figures 3.1 to 3.6) aids in the understanding of this effect. As shown in the figures, when a sequence commences with sadness, the neutral window is shortened. For instance, the original sadness-to-happiness movie played forward leads to shorter neutral durations than the original sadness-to-happiness sequence played backward (which in fact becomes a simulated happiness-to-sadness sequence). Likewise, the original happiness-to-sadness sequence played backward (i.e. a simulated sadness-to-happiness sequence) leads to shorter neutral durations than playing the original happiness-to-sadness forward. The reason that the Poser x (starting) Emotion x Direction for neutral duration data was significant was,

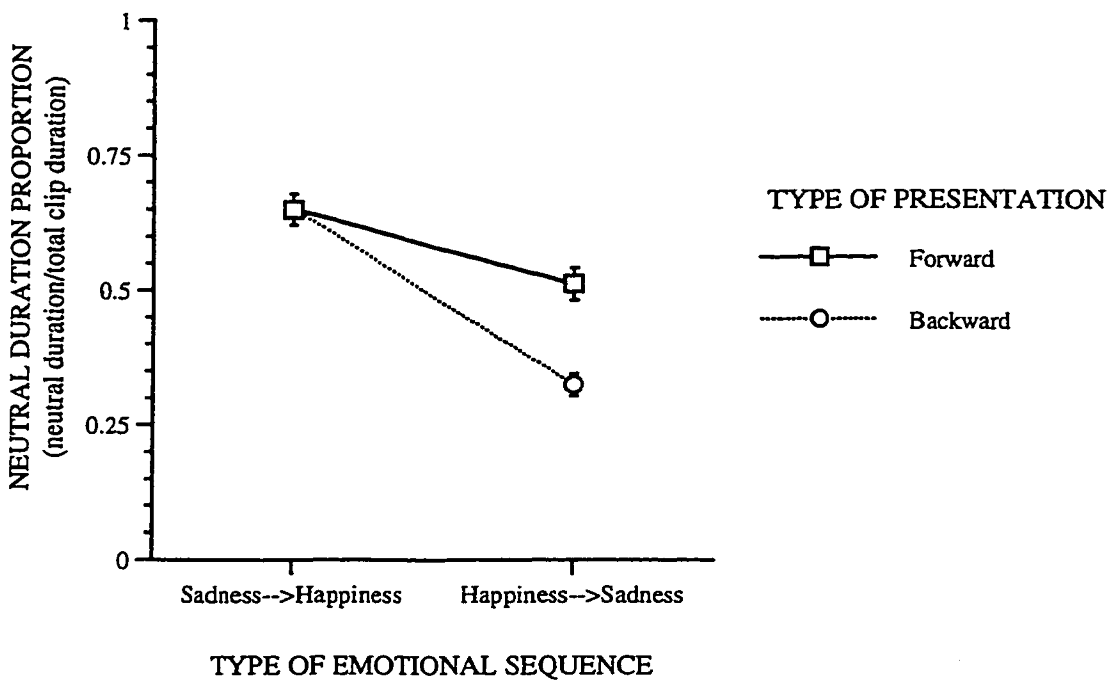

Figure 3.1. Neutral duration of expression as a function of both the type of emotional sequence and the type of presentation for Poser 1.

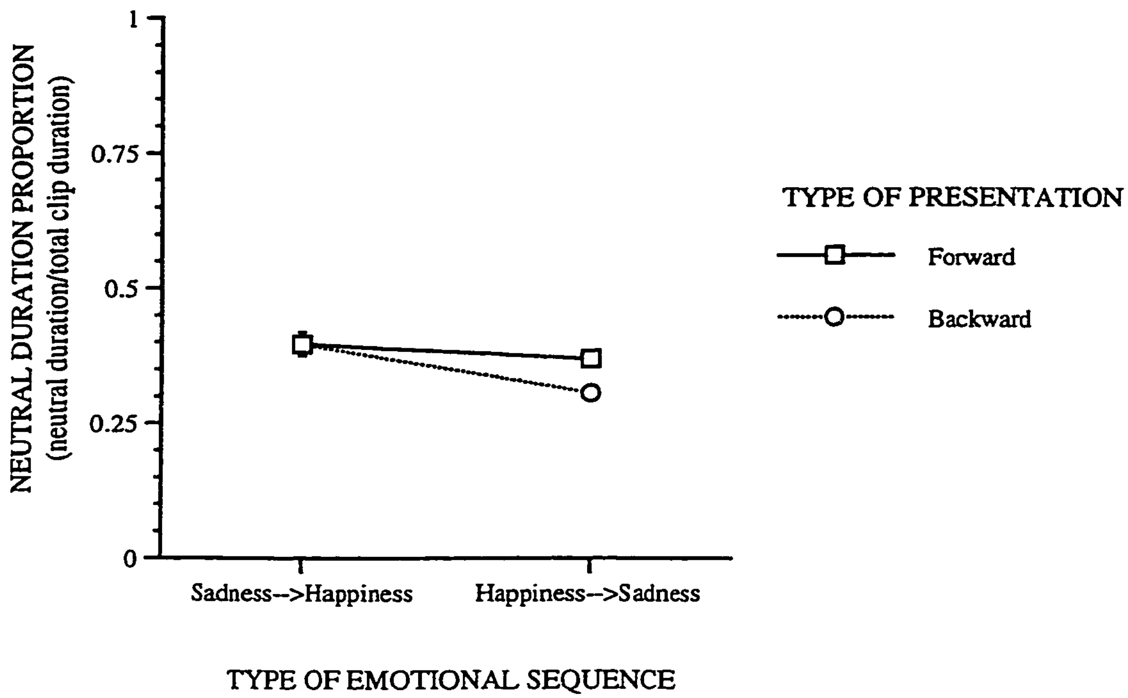

Figure 3.2. Neutral duration of expression as a function of both the type of emotional sequence and the type of presentation for Poser 2.

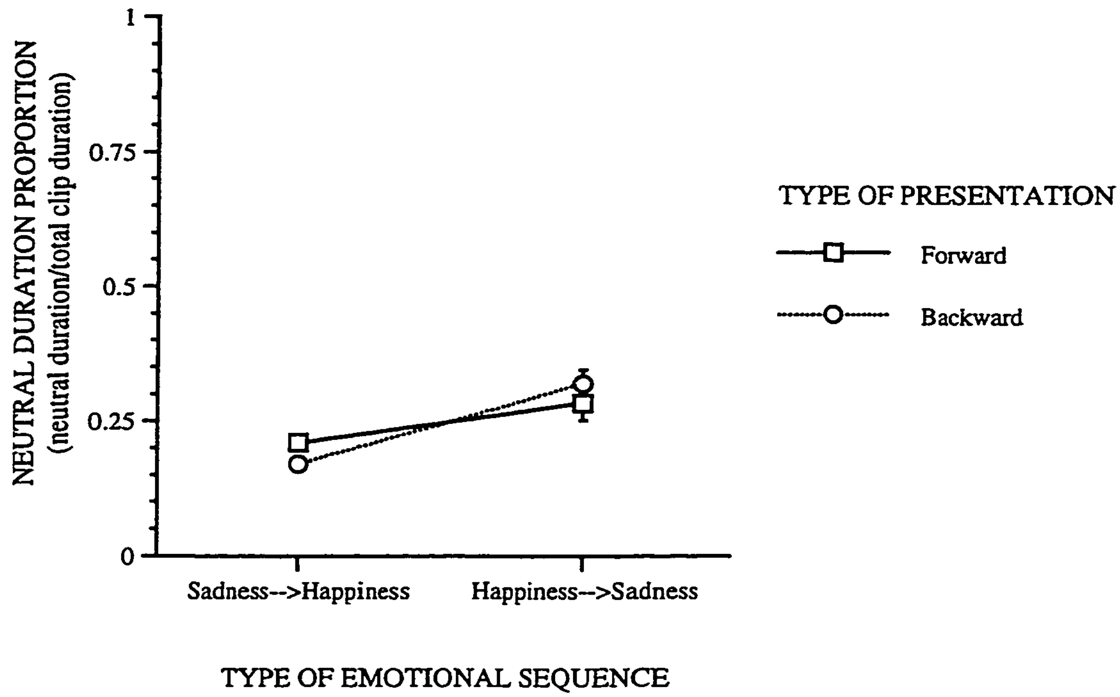

Figure 3.3. Neutral duration of expression as a function of both the type of emotional sequence and the type of presentation for Poser 3.

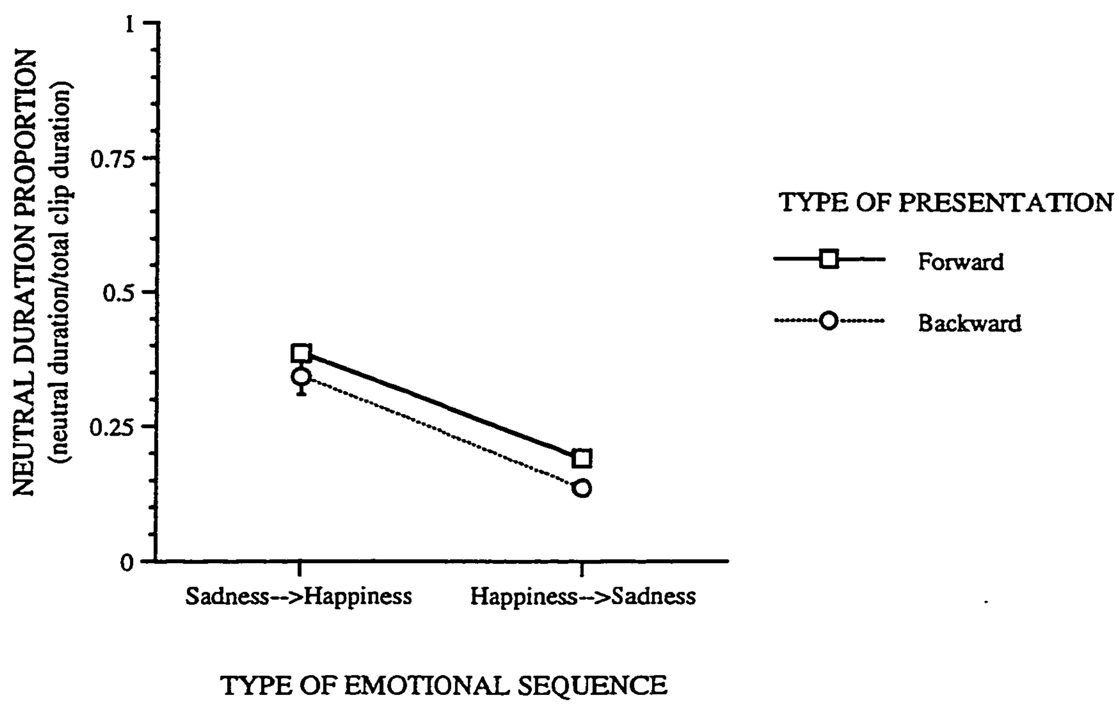

Figure 3.4. Neutral duration of expression as a function of both the type of emotional sequence and the type of presentation for Poser 4.

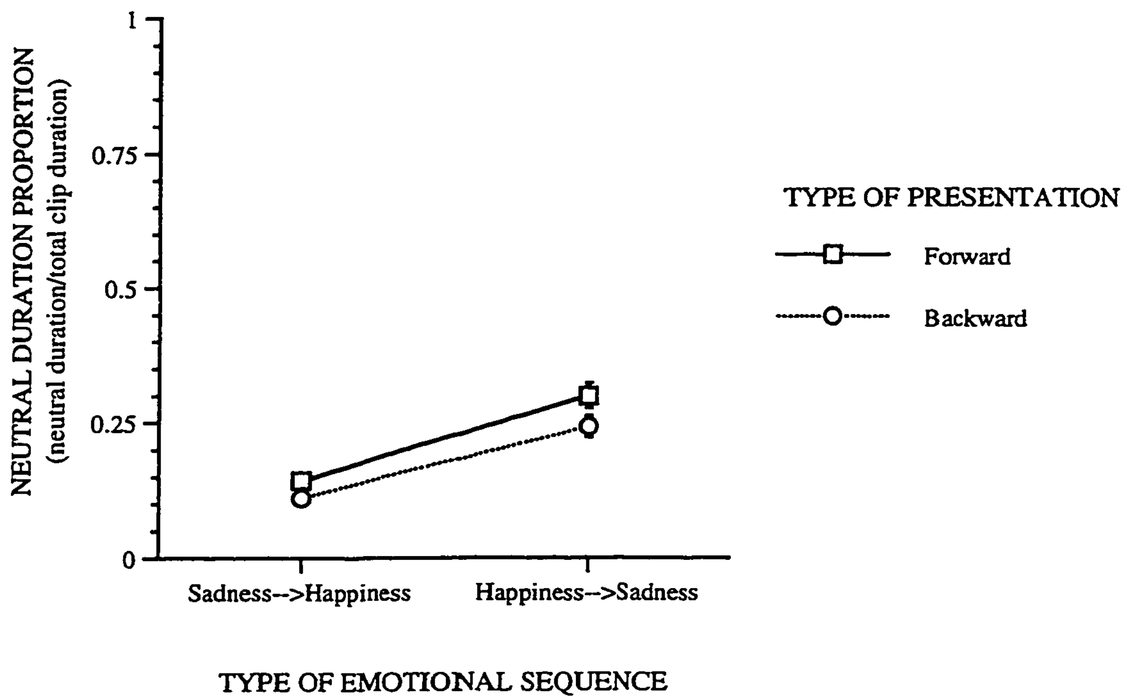

Figure 3.5. Neutral duration of expression as a function of both the type of emotional sequence and the type of presentation for Poser 5.

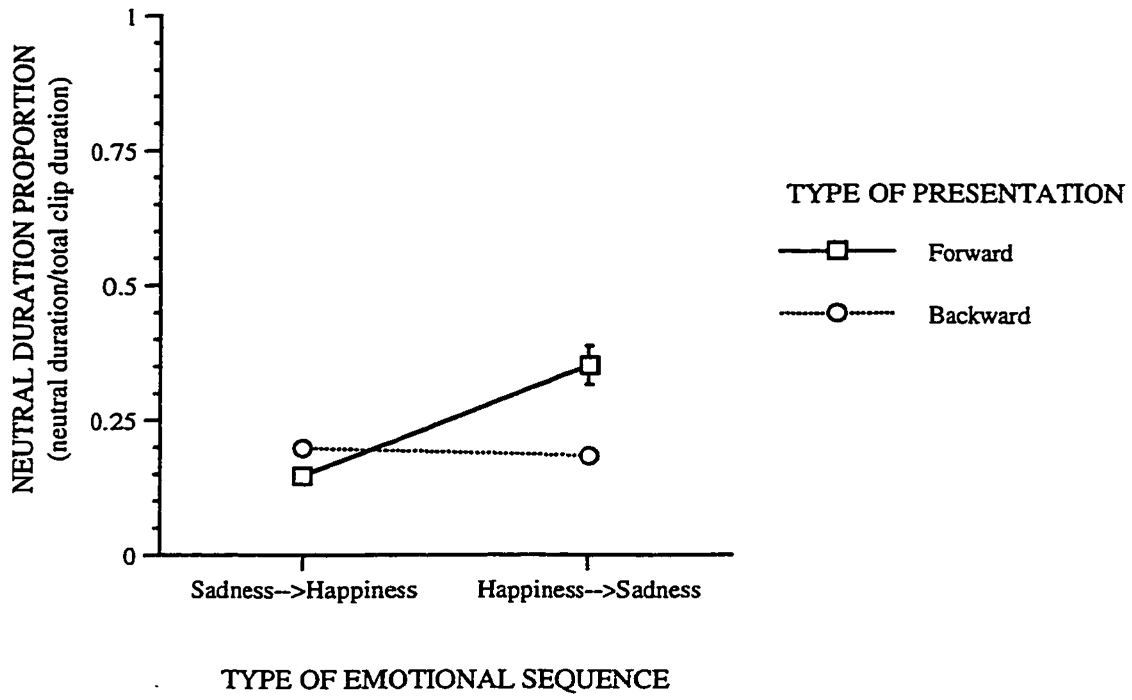

Figure 3.6. Neutral duration of expression as a function of both the type of emotional sequence and the type of presentation for Poser 6.

therefore due to the fact that (1) despite the trend, only those sequences starting with sadness due to backward presentations (i.e. originally happiness-to sadness) were typically significantly shortened, and (2) one poser did not demonstrate this effect (Poser 3).

3.3.2 Neutral Edges Data

The poser x emotion x direction interaction in the previous analysis suggested something interesting was occurring for the neutral duration of happiness-to-sadness sequence when the movie was played backward (i.e. starting emotion becomes sadness). The data were, thus, reorganized in a different manner to isolate this effect. From the original neutral duration data, each subject's start (when the subject first pressed the mouse key) and end (when the subject released the mouse key) neutral points were determined for each of the combined poser, starting emotion, and direction conditions. These will be referred to as the left (start of neutral duration for forward presentation but the end of the neutral duration for backward presentations) and right (end of neutral duration for forward presentations but the start of the neutral duration for backward presentations) edges for the present discussion (see Figure 3.7 for a graphic explanation of this conversion). A repeated measures ANOVA was executed to determine whether the neutral edges varied according to the type of Poser (6 levels: poser 1, poser 2, poser 3, poser 4, poser 5, and poser 6), the type of starting Emotion (2 levels: sadness and happiness), and the Direction the movie was played in (2 levels: forward and backward). For the purpose of investigating possible interactions between the location of the neutral edges and the variables just outlined, neutral Edge was added as a variable (2 levels: left and right).

The four main effects are not meaningful in this analysis for the following reasons. The neutral Edge main effect [$F(1, 9)=2234.204$, $p<.01$] is necessarily significant because

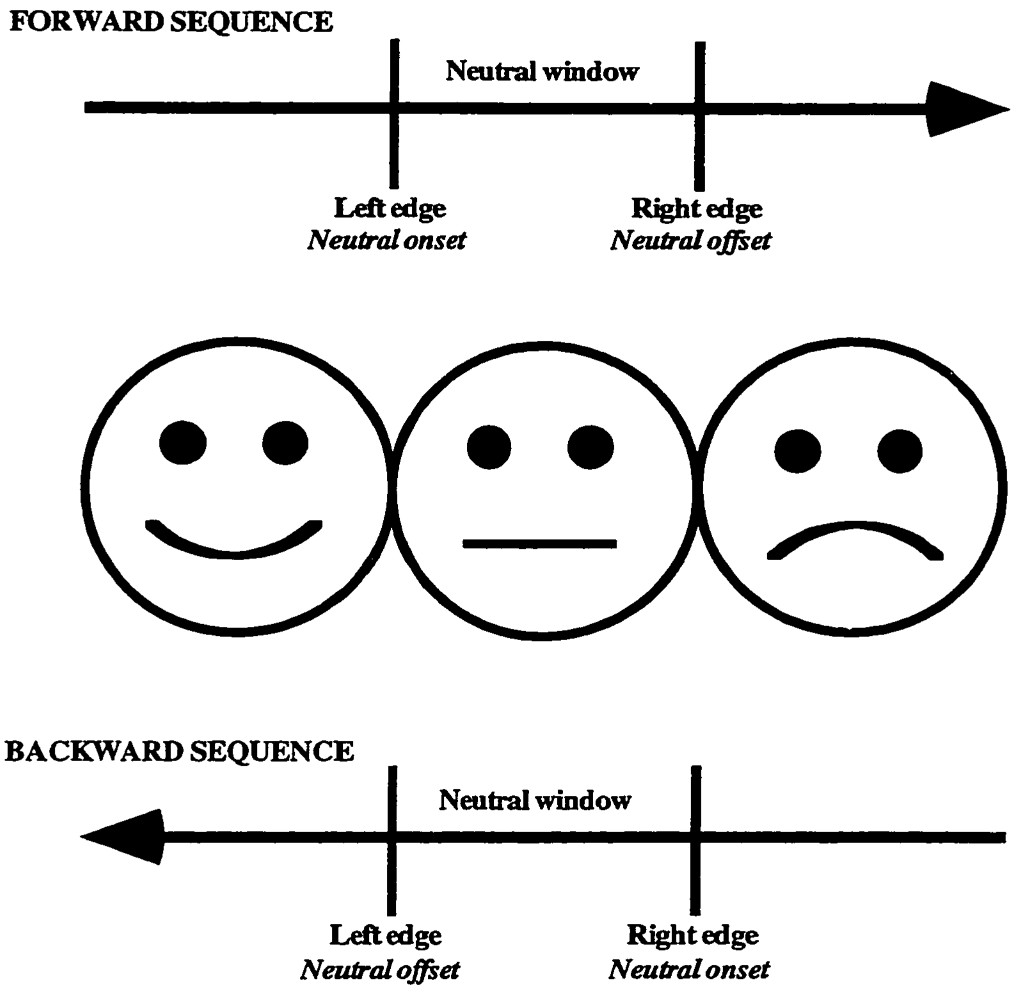

Figure 3.7. The conversion of neutral edges into neutral onset and offset. This illustrates how the left edge is a neutral onset when the sequence is played forward and is a neutral offset when the sequence is played backward.

these are real differences in the data themselves (i.e. in order to have a neutral duration we must have a start and end edge). The remaining three main effects Poser, Emotion, and Direction [$F(5, 45)=1331.126$, $p<.01$, $F(1, 9)=2425.946$, $p<.01$, and $F(1, 9)=2.848$, $p>.01$, respectively] are also meaningless since by definition they require collapsing across the neutral edge variable. By doing so, the dependent variable of interest for the present analysis is lost (i.e. the measure is no longer two edges but rather the mean between the two edges). Thus, for the analysis to be meaningful, only higher order effects which do not collapse across the Edge variable will be examined.

For this reason, the following two- and three-way interactions are not statistically relevant: Poser x Emotion [$F(5, 45)=217.858$, $p<.01$], Poser x Direction [$F(5, 45)=8.162$, $p<.01$], Emotion x Direction [$F(1, 9)=4.112$, $p>.01$], Poser x Emotion x Direction [$F(5, 45)=27.986$, $p<.01$]. The following two- and three-way interactions are statistically meaningful: Poser x Edge [$F(5, 45)=56.811$, $p<.01$], Edge x Emotion [$F(1, 9)=95.220$, $p<.01$], Edge x Direction [$F(1, 9)=19.814$, $p<.01$], Poser x Edge x Emotion [$F(5, 45)=68.214$, $p<.01$], Poser x Edge x Direction [$F(5, 45)=5.124$, $p<.01$], and Edge x Emotion x Direction [$F(1, 9)=13.619$, $p<.01$] but are subsided by the highest order significant effect in this data set [Poser x Edge x Emotion x Direction, $F(5, 45)=7.108$, $p<.01$]. Simple three-way interaction analyses were then performed to isolate this four-way interaction. Specifically, the Edge x Emotion x Direction interaction was examined for each level of Poser. This analysis revealed that the four-way interaction was present because there were significant three-way interactions for Posers 1 [$F(1, 9)=24.595$, $p<.01$] and 6 [$F(1, 9)=93.075$, $p<.01$] but not for Posers 2 through 5 [$F(1, 9)=3.688$, $p>.01$, $F(1, 9)=3.345$, $p>.01$, $F(1, 9)=.013$, $p>.01$, and $F(1, 9)=.140$, $p>.01$, respectively]. For clarity, the two significant simple three-way interactions will be discussed separately by poser.

The Edge x Emotion x Direction simple three-way interaction at Poser 1 was examined via simple two-way interaction analysis. This analysis indicated that the three-way effect for Poser 1 was a result of edge location for starting emotion being dependent on the direction for the Left Edge [$F(1, 9)=48.430$, $p<.05$] but not for the Right Edge [$F(1, 9)=.003$, $p>.05$]. A simple effects analysis was thereafter performed on the significant simple interaction, Emotion x Direction at the Left Edge. The analysis revealed that this simple two-way interaction was present because direction of movie significantly affected the left edge of the neutral period for the happiness-to-sadness [simple effect of Direction at Happiness for Left Edge, $F(1, 9)=25.011$, $p<.05$] and for the sadness-to-happiness [simple effect of Direction at Sadness for Left Edge, $F(1, 9)=23.432$, $p<.05$] sequences, but in opposite ways. To illustrate, the left edge in sadness-to-happiness was found to be shifted away from the right edge for backward (46.72/60 sec) as compared to forward (76.88/60 sec) movies, while for happiness-to-sadness this shift in left edge was toward the right edge for backward (132.72/60 sec) as compared to forward (101.56/60 sec) movies. After converting the left and right edges back into their original onset and offset terms (remembering that the left edge is the onset for forward movies and the offset for backward movies, while the right edge is the offset for forward movies and the onset for backward movies), the results become as follows. The left edge for sadness-to-happiness which was found to be shifted away from the right edge for backward movies indicated that the neutral period's offset was later in the sequence. The left edge for happiness-to-sadness, on the other hand, which was shifted toward the right edge for backward movies illustrated that the neutral period's offset was earlier in the sequence. This pattern of results explained the Edge x Emotion x Direction simple three-way interaction for Poser 1.

The Edge x Emotion x Direction simple three-way interaction at Poser 6 was also examined via simple two-way interaction analysis. This analysis indicated that this three-way effect was a result of edge location for starting emotion being dependent on the direction for the Left Edge [$F(1, 9)=127.356$, $p<.05$], and to an even greater extent, for the Right Edge [$F(1, 9)=621.453$, $p<.05$]. A simple effects analysis was thereafter performed on each significant two-way simple interaction. The analysis of Emotion x Direction at the Left Edge revealed that this simple two-way interaction was present because direction of movie significantly affected the left edge of the neutral period for the happiness-to-sadness [simple effect of Direction at Happiness for Left Edge, $F(1, 9)=103.253$, $p<.05$] and for the sadness-to-happiness [simple effect of Direction at Sadness for Left Edge, $F(1, 9)=33.621$, $p<.05$] sequences, but in opposite ways. To illustrate, the left edge in sadness-to-happiness was found to be shifted toward the right edge for backward (222.66/60 sec) as compared to forward (208.44/60 sec) movies, while for happiness-to-sadness this shift in left edge was away from the right edge for backward (38.10/60 sec) as compared to forward (63.02/60 sec) movies. In summary, the left edge for sadness-to-happiness which was found to be shifted toward the right edge for backward movies was indicative of an earlier neutral offset. The left edge for happiness-to-sadness, on the other hand, was shifted away from the right edge for backward movies thus meaning that there was a delayed offset. Note that this pattern of results is opposite to that found for Poser 1.

Also contrary to Poser 1, the other simple two-way interaction was significant for Poser 6. A simple effects analysis was thereafter performed on the Emotion x Direction at the Right Edge (Poser 6). The analysis indicated that this simple two-way interaction was due to the same pattern of results as the Emotion x Direction at the Left Edge (Poser 6). The direction of movie significantly affected the left edge of the neutral period for the happiness-to-sadness [simple effect of Direction at Happiness for Right Edge, $F(1, 9)=465.637$, $p<.05$] and for the sadness-to-happiness [simple effect of Direction at Sadness for Right Edge, $F(1, 9)=187.040$, $p<.05$] sequences, but in opposite ways. For instance, the right edge in sadness-to-happiness was found to be shifted away from the left edge for backward (294.86/60 sec) as compared to forward (261.32/60 sec) movies, while for happiness-to-sadness this shift in right edge was toward the left edge for backward (68.04/60 sec) as compared to forward (120.96/60 sec) movies. In summary, the right edge for sadness-to-happiness was found to be shifted away from the left edge for backward movies illustrating an earlier neutral onset. The right edge for happiness-to-sadness, on the other hand, was shifted toward the left edge for backward movies demonstrating a delayed neutral onset. In conclusion, the results for these two simple two-way interactions taken together, for Poser 6, indicate the following. For the sadness-to-happiness segments played backward (i.e. becomes a happiness-to-sadness), the neutral duration has an earlier onset and offset and thus the neutral window is shifted to earlier on in the movie segment. For the happiness-to-sadness segments played backward (i.e. becomes a sadness-to-happiness), on the other hand, the neutral duration has a delayed onset and offset and thus the neutral window is shifted to later on in the movie sequence. This pattern of findings explained the Edge x Emotion x Direction simple three-way interaction for Poser 6.

In conclusion, a graphical illustration helps to comprehend this pattern of findings. Figures 3.8 through 3.13 demonstrate the shifts in onset and offset for each poser. As shown in these figures, backward presentations typically lead to a delayed onset and a delayed offset which can be partially explained by the time needed to respond. What caused the four-way (Poser x Edge x (starting) Emotion x Direction) interaction effect for neutral edges data is that only Posers 2 and 5 demonstrated this pattern of findings in all of the conditions, while the remaining posers at times did not show both the delayed onset and offset.

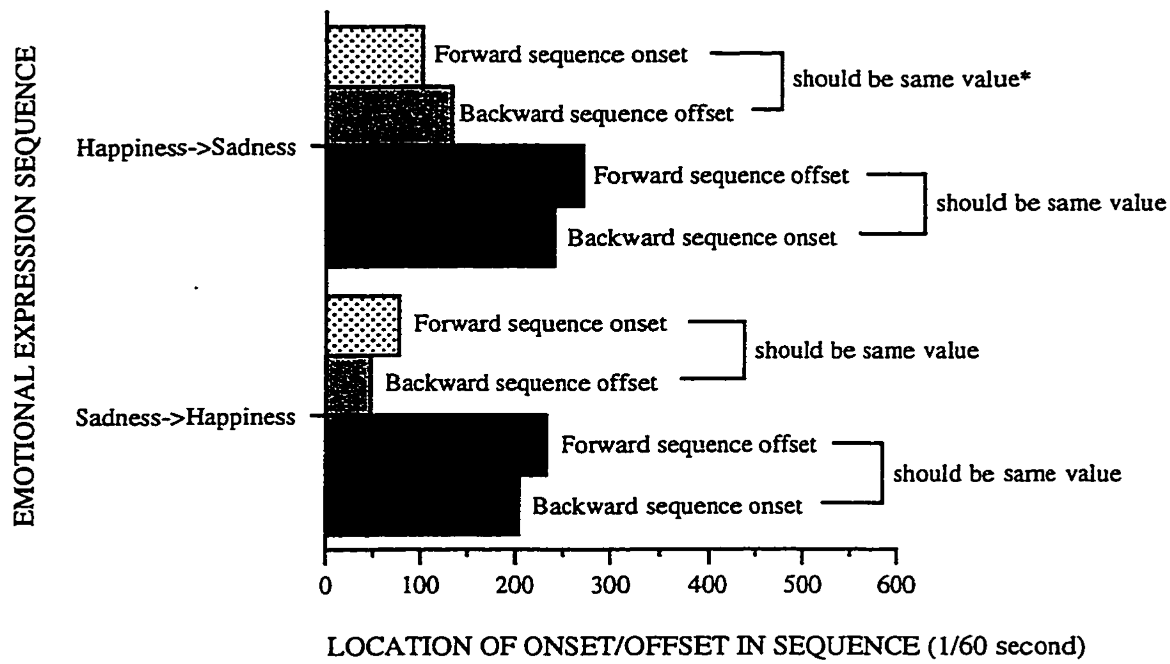

Figure 3.8. Perceived neutral edges of an emotional expression sequence as a function of both the type of emotional sequence and the type of presentation for Poser 1.

*Note that this is theoretically the same value. Reaction time necessary for key presses, however, would predict a consistent delay in onset and offset when the sequence is played backward in comparison to forward.

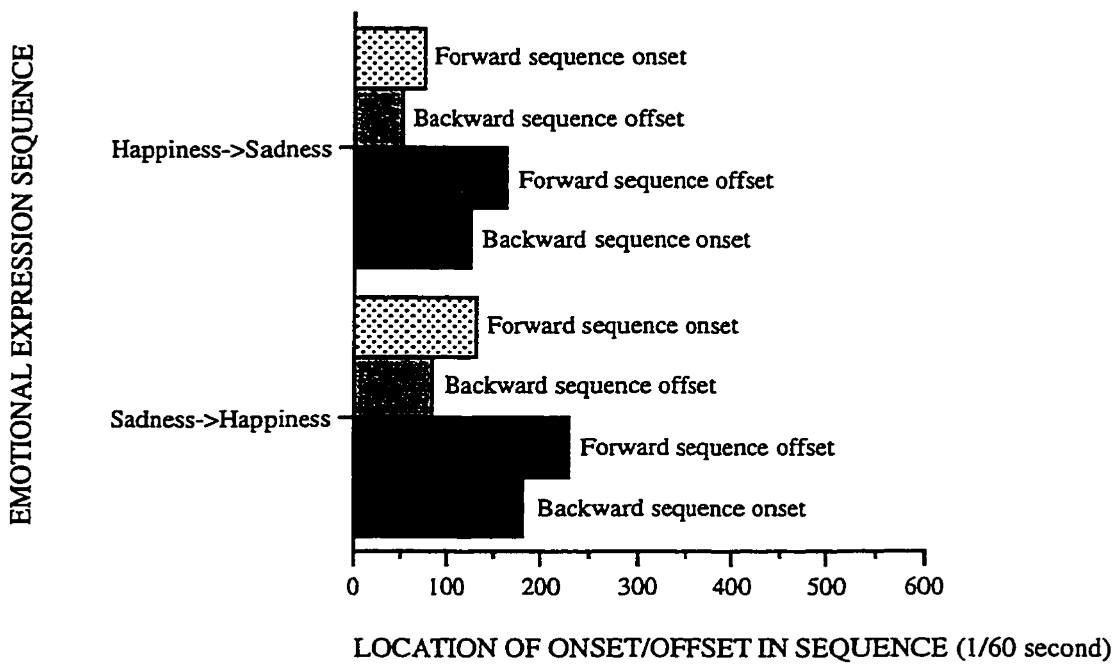

Figure 3.9. Perceived neutral edges of an emotional expression sequence as a function of both the type of emotional sequence and the type of presentation for Poser 2.

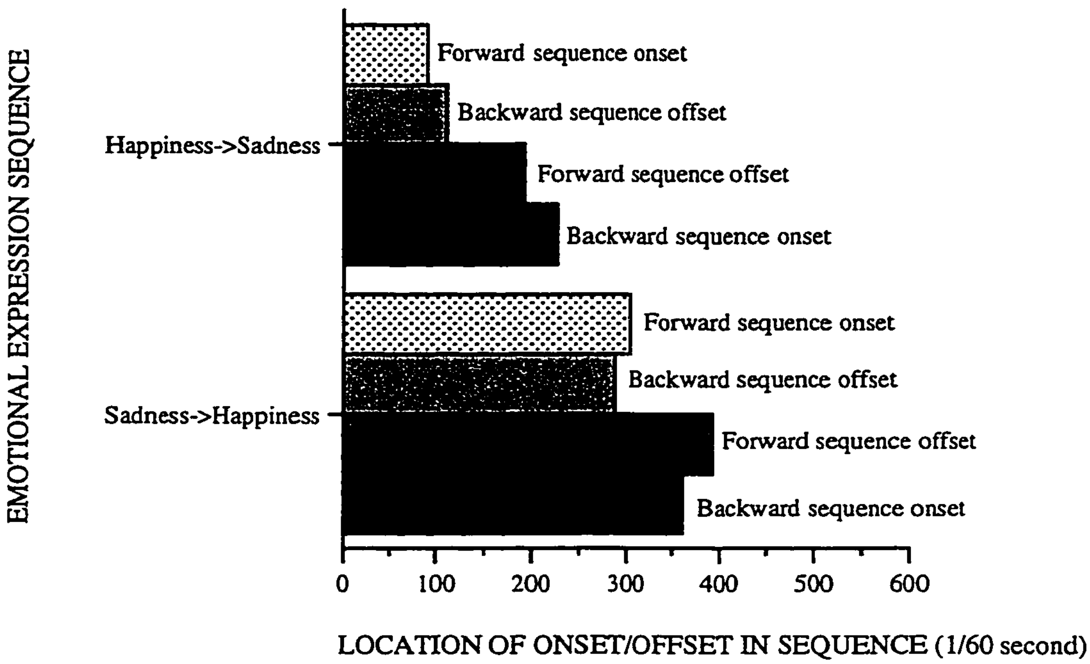

Figure 3.10. Perceived neutral edges of an emotional expression sequence as a function of both the type of emotional sequence and the type of presentation for Poser 3.

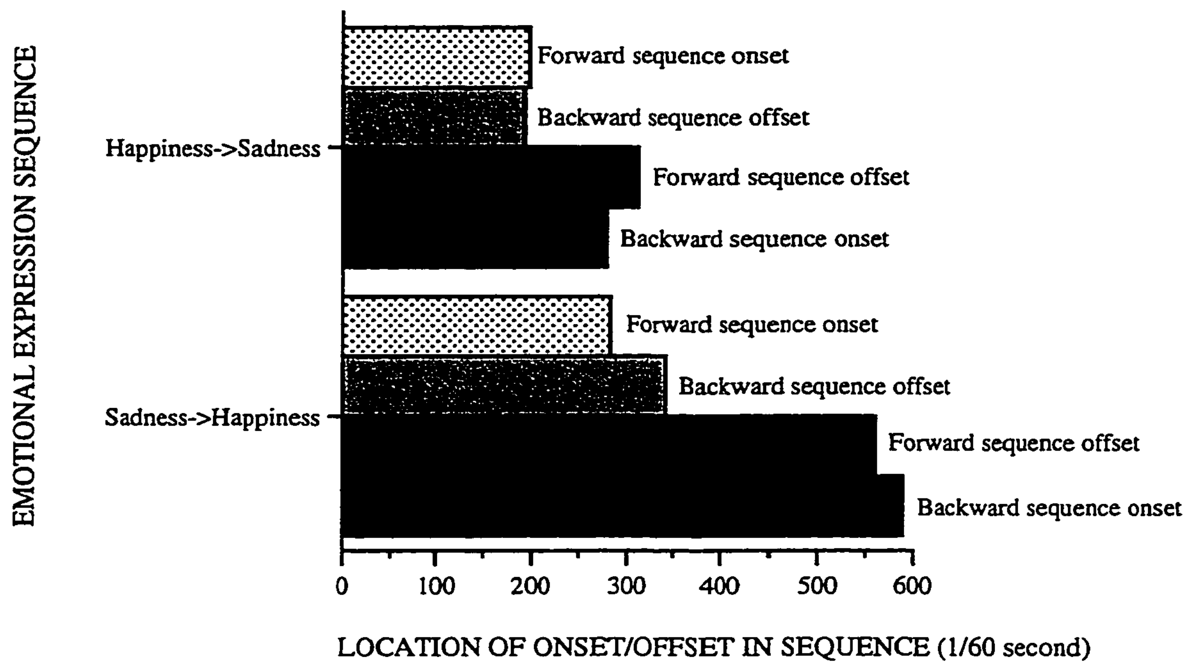

Figure 3.11. Perceived neutral edges of an emotional expression sequence as a function of both the type of emotional sequence and the type of presentation for Poser 4.

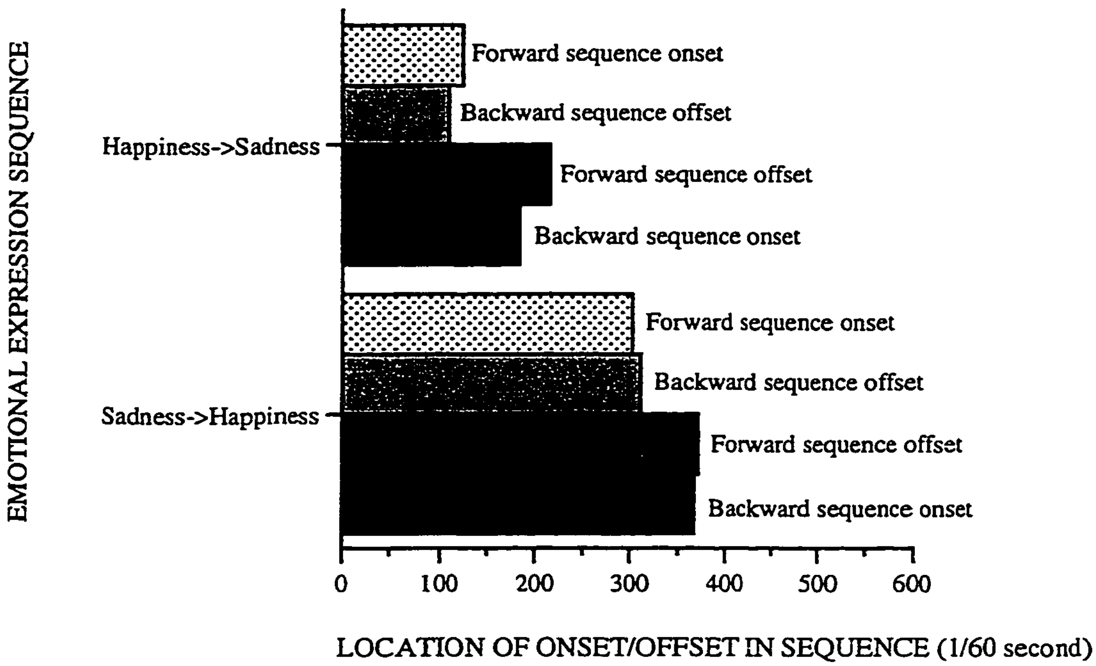

Figure 3.12. Perceived neutral edges of an emotional expression sequence as a function of both the type of emotional sequence and the type of presentation for Poser 5.

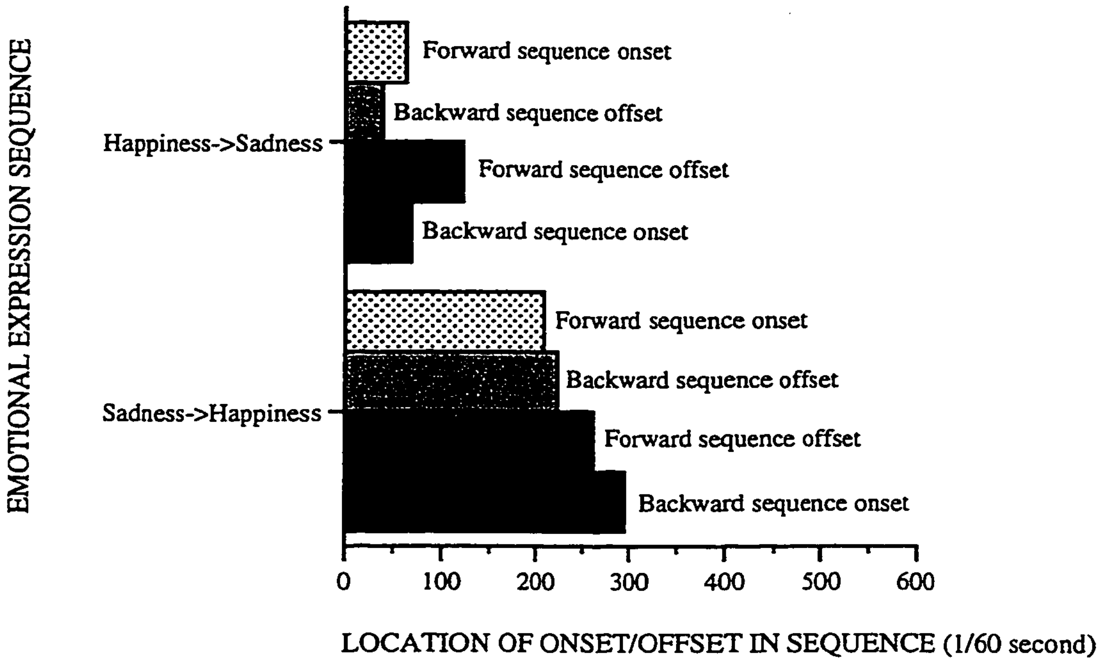

Figure 3.13. Perceived neutral edges of an emotional expression sequence as a function of both the type of emotional sequence and the type of presentation for Poser 6.

3.3.3 Neutral Point Data

Finally, the average between the start and end points of the neutral duration was calculated for each subject in each of the possible combinations of poser, starting emotion, and direction. This new datum will be referred to as the neutral point and was necessary to calculate so as to create new movie sequences for Experiment 2 (see Experiment 2's Method section for more details). Prior to the construction of these new movie clips, a repeated measures ANOVA with the type of Poser (6 levels: poser 1, poser 2, poser 3, poser 4, poser 5, and poser 6), the type of starting Emotion (2 levels: sadness and happiness), and the Direction the movie was played in (2 levels: forward and backward) was conducted to determine if the neutral point data would also be affected by these variables in the same manner as the neutral duration and neutral edges data.

The analysis indicated that the neutral point again depended on Poser [$F(5, 45)=1337.437$, $p<.01$] and starting Emotion [$F(1, 9)=2409.735$, $p<.01$], but not Direction [$F(1, 9)=2.855$, $p>.01$]. The significant main effects are, however, not statistically important for the aforementioned reasons. Two of the three two-way interactions were additionally significant: Poser x Emotion [$F(5, 45)=217.854$, $p<.05$], Poser x Direction [$F(5, 45)=8.275$, $p<.05$], and Emotion x Direction [$F(1, 9)= 3.997$, $p>.05$]. These effects are, however, overridden by the fact that the Emotion x Direction interaction is dependent on type of Poser, i.e. the significant three-way interaction [$F(5, 45)=27.837$, $p<.05$]. A simple interaction analysis was thereafter conducted to isolate this three-way interaction. The analysis indicated that the poser x emotion x direction interaction was a result of neutral point for starting emotion being dependent on the direction for Posers 1, 3, 4, 5, and 6 [$F(1, 45)=10.769$, $p<.05$, $F(1, 45)=28.908$, $p<.05$, $F(1, 45)=47.638$, $p<.05$, $F(1, 45)=7.985$, $p<.05$, and $F(1, 45)=46.021$, $p<.05$, respectively] but not for Poser 2

[F(1, 45)=3.716, p>.05]. A simple effects analysis was thereafter performed on each of the significant simple interactions (i.e. five).

For Poser 1, the analysis revealed that this simple two-way interaction was present because direction of movie significantly affected the neutral point for the sadness-to-happiness [simple effect of Direction at Sadness for Poser 1, F(1, 45)=21.088, p<.05] but not for the happiness-to-sadness [simple effect of Direction at Happiness for Poser 1, F(1, 45)=.002, p>.05] movies. To illustrate, the neutral point for sadness-to-happiness sequences was earlier in the segment when the movie was played backward (124.76/60 sec) as compared to forward (154.86/60 sec).

A comparable effect was found following the simple effect analysis of the Emotion x Direction simple interaction with Poser 3. The direction of movie not only significantly affected the neutral point for the sadness-to-happiness [simple effect of Direction at Sadness for Poser 3, F(1, 45)=12.142, p<.05] but also for the happiness-to-sadness [simple effect of Direction at Happiness for Poser 3, F(1, 45)=16.968, p<.05] movies, but, in an opposite manner. For example, while the neutral point for sadness-to-happiness sequences was earlier in the segment when the movie was played backward (324.58/60 sec) as compared to forward (347.42/60 sec), the neutral point in happiness-to-sadness segments was found to occur later in the sequence when the movie was played backward (168.58/60 sec) as compared to forward (141.58/60 sec).

For Posers 4, 5, and 6, however, an opposite pattern of results was observed for the simple effect analysis. For Poser 4 for instance, the direction of movie significantly affected the neutral point for both the sadness-to-happiness [simple effect of Direction at Sadness for Poser 4, F(1, 45)=46.548, p<.05] and the happiness-to-sadness [simple effect of Direction at Happiness for Poser 4, F(1, 45)=8.634, p<.05] expression sequences, but, in an opposite manner. For example, while the neutral point for sadness-to-happiness sequences was later in the segment when the movie was played backward (465.62/60 sec) as compared to forward (420.90/60 sec), the neutral point in happiness-to-sadness segments was found to occur earlier in the sequence when the movie was played backward (235.66/60 sec) as compared to forward (254.92/60 sec).

The analysis for Poser 5, partially the same as Poser 4, illustrated that the direction of movie significantly affected the neutral point for the happiness-to-sadness [simple effect of Direction at Happiness for Poser 5, $F(1, 45)=12.898$, $p<.05$] but not for the sadness-to-happiness [simple effect of Direction at Sadness for Poser 5, $F(1, 45)=.164$, $p>.05$] expression sequences. The neutral point in happiness-to-sadness segments was found to occur earlier in the sequence when the movie was played backward (146.58/60 sec) as compared to forward (170.12/60 sec).

Finally, Poser 6's simple effects analysis was identical to Poser 4's pattern. The direction of movie significantly affected the neutral point for both the sadness-to-happiness [simple effect of Direction at Sadness for Poser 6, $F(1, 45)=13.262$, $p<.05$] and the happiness-to-sadness [simple effect of Direction at Happiness for Poser 6, $F(1, 45)=35.429$, $p<.05$] movies, but, in an opposite manner. While the neutral point for sadness-to-happiness sequences was later in the segment when the movie was played backward (258.75/60 sec) as compared to forward (234.88/60 sec), the neutral point in happiness-to-sadness segments was found to occur earlier in the sequence when the movie was played backward (52.98/60 sec) as compared to forward (91.99/60 sec).

In conclusion, the same general effect as with the neutral duration and neutral edge data was observed here (see Figures 3.14 to 3.19). That is, sequences starting with sadness tended to yield earlier neutral points than sequences starting with happiness. As

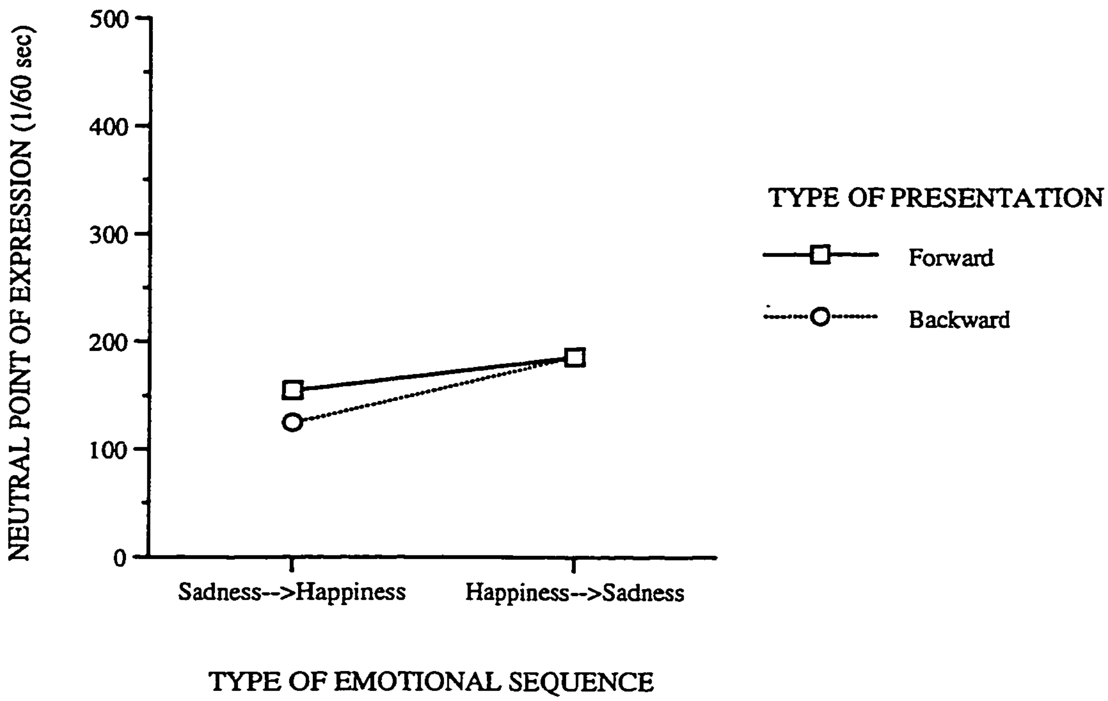

Figure 3.14. Neutral point of expression as a function of both the type of emotional sequence and the type of presentation for Poser 1.

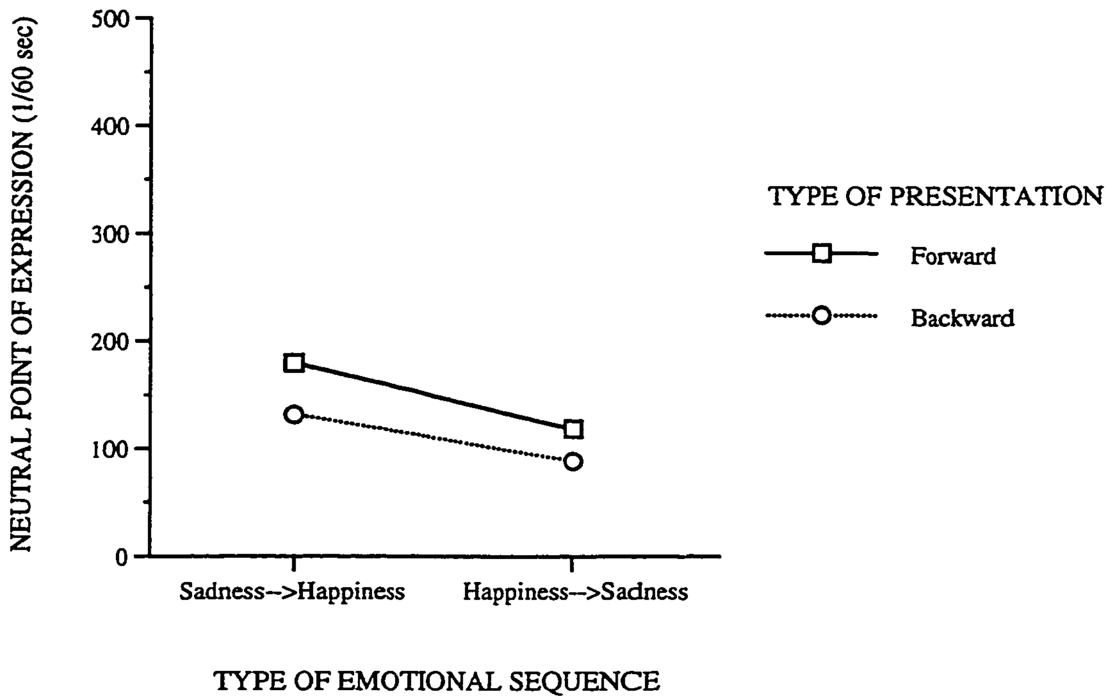

Figure 3.15. Neutral point of expression as a function of both the type of emotional sequence and the type of presentation for Poser 2.

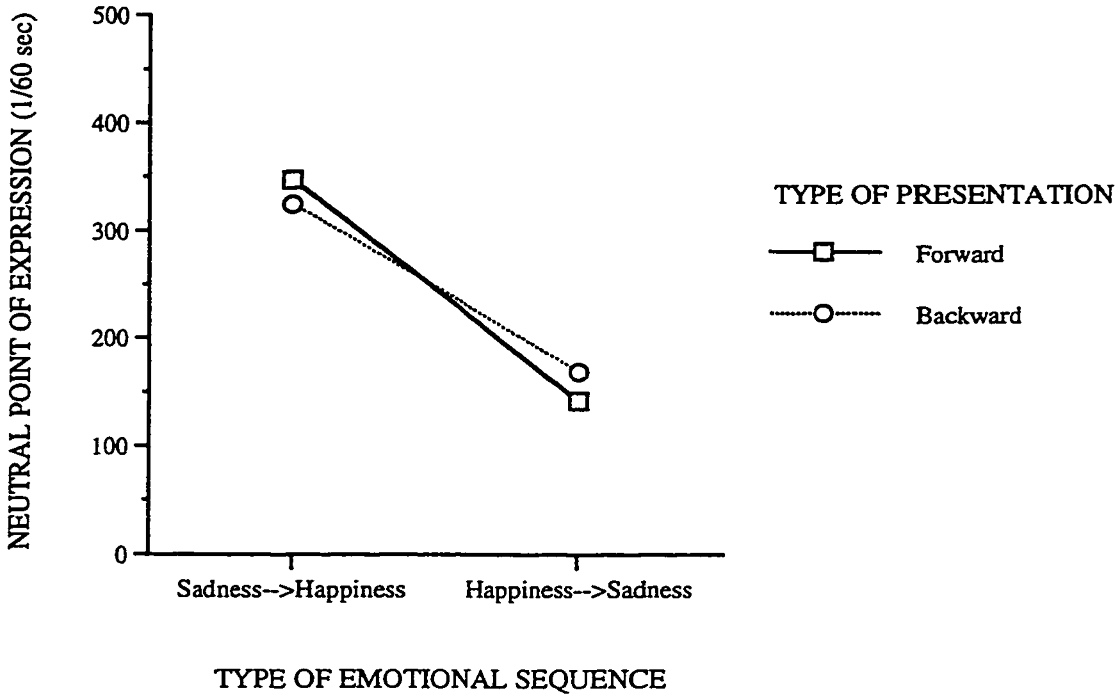

Figure 3.16. Neutral point of expression as a function of both the type of emotional sequence and the type of presentation for Poser 3.

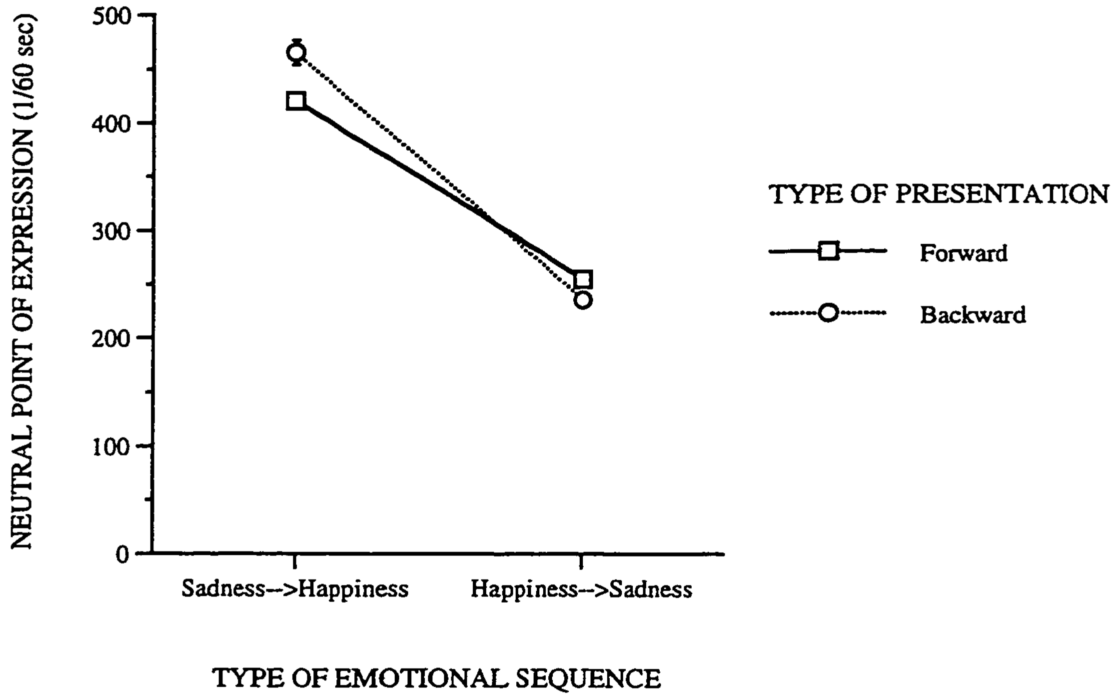

Figure 3.17. Neutral point of expression as a function of both the type of emotional sequence and the type of presentation for Poser 4.

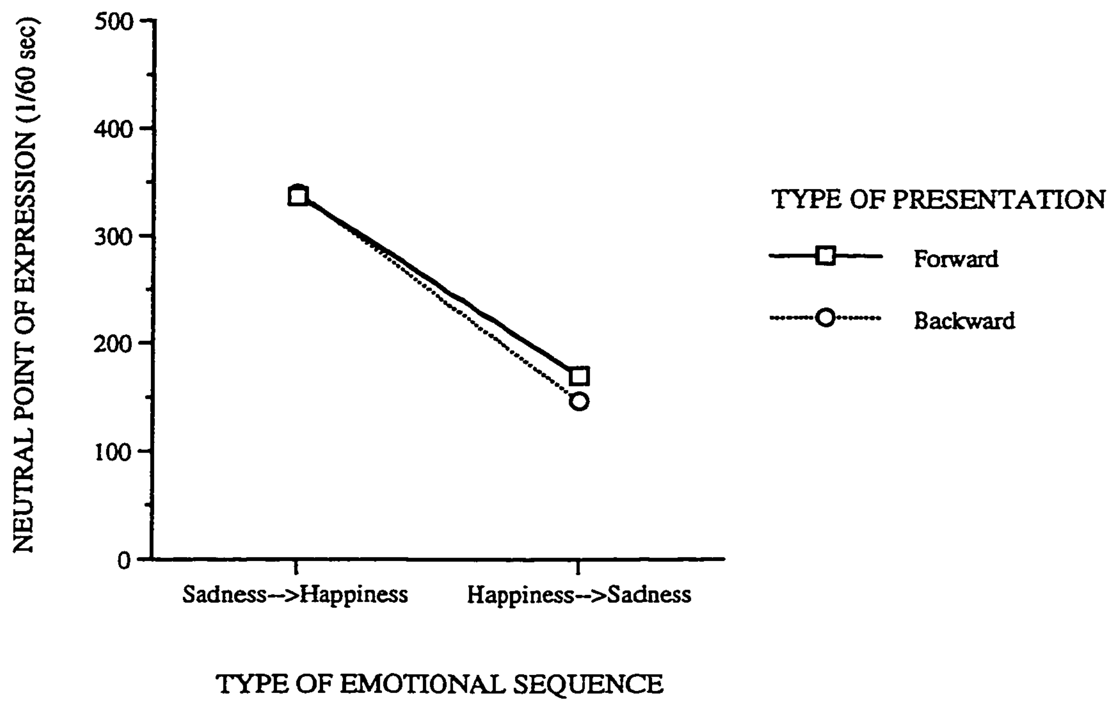

Figure 3.18. Neutral point of expression as a function of both the type of emotional sequence and the type of presentation for Poser 5.

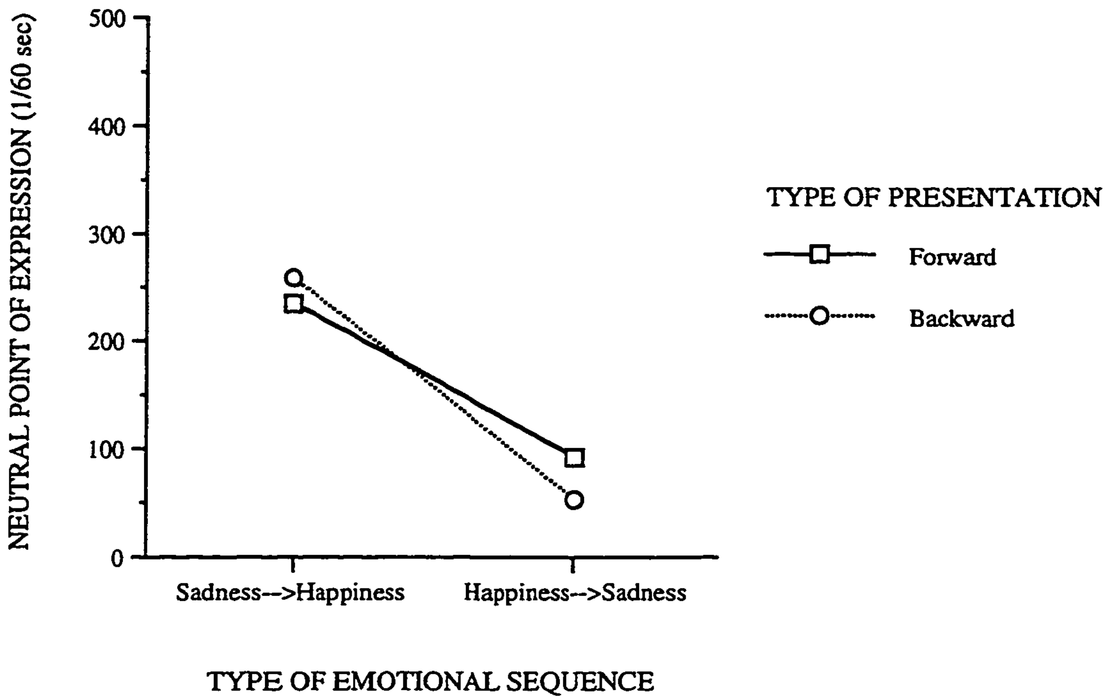

Figure 3.19. Neutral point of expression as a function of both the type of emotional sequence and the type of presentation for Poser 6.

with the other analyses, this is most pronounced for the composite or induced sadness movies (i.e. the originally recorded happiness-to-sadness segment played backward). It is this pattern of findings that caused the three-way (Poser x Emotion x Direction) interaction effect for neutral point data.

3.4 Discussion

Among the different variables that were analyzed in the results section, several of them were expected to lead to significant statistical differences due to the idiosyncratic characteristics of each poser as well as to the type of sequence depicted (happiness to sadness and vice versa). In fact, the experimental conditions were not planned to be equated across each other (i.e. the posers were not coached as to how long each emotional expressions should be displayed). For this reason, the emergence of differences across posers reported in the results section is not surprising. Altogether, one might easily characterize the situation by assuming that each poser produces dynamic emotional facial expressions of different strengths as well as of different lengths. Similarly, the selection process to extract an exemplar of each emotional expression was not designed to screen for such differences either (i.e. equating the characteristics of the sequences across posers and across starting emotions). The selection criteria were simply based on the typicality of the sequence as a representation of the two emotions, as determined by a panel of judges (see section 2.1).

Interestingly, the direction in which the movies were played was found to make a difference. This does not support the hypothesis according to which the perceived neutral segment of the dynamic sequences should remain unaffected by the direction of presentation. This original hypothesis was based on the rationale that there are no physical changes between the forward and backward sequences which are introduced by the reversal. The results, however, suggest that the physical changes that occur across time might be typical of the emotion portrayed and the direction in which it is presented. With the type of stimuli used in this experiment, it is difficult to determine which information is important. The measured neutral duration was found to be significantly longer in the forward direction as opposed to the backward one (this was true for the original happiness-to-sadness movie). This suggests that there is specific information in the presentation direction of a emotional facial expression sequence which is utilized in the processing of facial affect.

In addition, although not significant, a trend was found where the neutral duration was longer in the backward presentation for the original sadness-to-happiness movie. This, as aforementioned, is what accounted for the interaction effects. While at first glance these findings seem to be contradictory, they indeed reflect an overall effect of emotional sequence. Sequences which start with the expression of sadness tend to produce shorter neutral durations. Movies starting with sadness were either the real sadness-to-happiness sequences (i.e. played forward) or induced sadness-to-happiness sequences (i.e. happiness-to-sadness segments played backward). Note that this was observed for five out of the six posers (1, 2, 4, 5, and 6).

For the original sadness-to-happiness sequence, this means (1) that part of the neutral duration portion for forward presentation is perceived as sadness offset and/or happiness onset, *and/or* (2) that the neutral duration portion for backward presentation may comprise part of the offset happiness signal and/or part of the sadness onset. Likewise, for the original happiness-to-sadness sequence, this means (1) that the neutral duration portion for forward presentation may comprise part of the happiness offset and/or sadness onset, *and/or* (2) that part of the neutral duration portion for backward presentation is perceived as part of the sadness offset signal and/or part of the happiness onset.

Analysis of the neutral edge revealed that for the original happiness-to-sadness sequences for four out of the six posers (2,4,5, and 6) more confusion seemed to exist at the edge between neutral and sadness than at the edge between happiness and neutral. This is supported by the large delay in neutral onset as compared with the small delay in neutral offset for backward presentations. It was demonstrated that for Posers 1 and 3 there was also some confusion at the edge between sadness and neutral but more at the edge between happiness and neutral. This pattern of results tended to lead to shorter neutral durations for the movie starting with sadness i.e. the backward presentation of this sequence.

This analysis additionally revealed that for the original sadness-to-happiness sequences the confusion at the edge of the neutral window if present was equal for both edges for all six posers. For posers 1, 2, 3, and 5, this is illustrated by about equal delays in neutral onset and offset for backward presentations. For posers 4 and 6, however, this is shown by about equal earlier on- and offsets of the neutral durations for backward presentations. This approximately equal confusion at both edges is why, although showing a trend for shorter neutral durations for the movie starting with sadness (i.e. the forward presentation of this sequence) the difference was non-significant.

As predicted the analysis of the neutral point data supported the neutral edge analysis such that shifts in the location of the edges affected the neutral point location. This is the point from which new sequences for Experiment 2 were constructed for each emotional sequence and for each poser. Although the information obtained was somewhat redundant the computation of this point was important for Experiment 2 in order to determine its stability. The effect of the type of presentation direction on this stability was therefore essential to assess whether forward and backward neutral points could be collapsed. Considering the response time, shifts in the onset and offset of the neutral window should have caused the neutral point to be different for forward and backward directions. Accordingly, backward neutral points should always be lower than forward ones (caused by earlier on- and offsets of the neutral edges). This could explain only some of the data. Generally, the same effect as with the neutral duration and neutral edge data was observed here. That is, sequences starting with sadness tended to yield earlier neutral points than sequences starting with happiness. As with the other analyses, this is most pronounced for the induced sadness movies (i.e. the originally recorded happiness-to-sadness segment played backward). For these reasons, the obtained neutral points for forward and backward presentations were maintained separate rather than collapsed in the construction of the sequence for Experiment 2.

One difficulty related to the interpretation of this pattern of results (mostly the one for neutral edges since other types of measure derive from it) deals with the fact that only the original happiness-to-sadness sequence produced the reduced neutral duration effect by shifting the neutral edge of the sequence when played backward. The trends observed with the other type of sequence (original sadness-to-happiness played forward), however, suggest that this effect might be real as opposed to just an artifact present in some sequences. The particularities associated with this reduction in neutral durations can not be explained easily on the basis of the present findings. This experiment was not constructed to assess such a question. It might be possible to answer this question by designing an experiment in which this variable might be directly examined.

Similarly because of this observed uniformity, it is possible to think that this effect may be dependent on the subject's perceptual processing of the emotional signal which is evidenced by the procedure used in this experiment. It is difficult to exclude the effect of direction as the major factor producing the neutral duration reduction. It might be, however, that the order in the emotional sequence is the crucial factor. Confusion that exists at the boundary between emotions might exist in a similar way as confusion at the boundary between one emotion and neutrality (Etcoff & Magee, 1992; Calder, Young, Perrett, Etcoff & Rowland, 1996). Consequently, it could be proposed that the observer's extraction of the emotional visual signal will be tuned in the temporal domain to specific features and changes among these in a similar way as the one encountered with the inverted face effect (Moscovitch, 1996; Farah et al. 1995; Sumi, 1984).

EXPERIMENT 2

4.1 Introduction

The purpose of the second manipulation was to screen for any possible artifacts in the dynamic facial expression sequences and to establish a threshold of discriminability which would be used for the construction of the dynamic sequences utilized in Experiment 4. This manipulation was necessary to insure that the newly constructed sequences were not contaminated by the selection of the neutrality point obtained in Experiment 1. The new set of stimuli also provided a good opportunity to measure the sensitivity of different observers to the information conveyed within the new excerpts. These excerpts, now, all originated from a neutral state, as determined by the observers' reports obtained in Experiment 1, and grew into a particular emotional facial expression. Each original dynamic sequence utilized in Experiment 1 was, therefore, divided into two portions according to the location of the neutral point. This point was defined as the arithmetic mean obtained from averaging the edge values of the neutral phases collected across all observers in the first experiment.

Because of the different effects found between forward and backward presentations in the previous experiment, it was decided not to collapse the two types of sequences in Experiment 2. This decision also provided an opportunity to further examine the observations collected in the first experiment. It might be possible that judgments in reference to the neutral portion of a dynamic sequence may be based on information which is qualitatively different from the information which the observer may attend to when judging the emotional content in a dynamic excerpt. In other words, the variable's effects may be task dependent and thus, it may be premature to remove this variable.

4.2 Method

4.2.1 Subjects

Fourteen individuals participated in this experiment. All participants were recruited on a single basis through solicitation among, though not exclusively, the department of psychology population at Concordia University. Overall, the ratio of participants was biased towards fellow graduate students and both genders were recruited. The age of the participants varied between 21 and 52 years old. Some of the subjects recruited for the second experiment had also been solicited for the first experiment. The subjects were informed of the research domain but were kept naive as to the purpose of the experiment.

4.2.2 Stimuli

Short movie clips were constructed from the clips used in the first experiment. All began with a neutral expression as previously defined by the subjects of Experiment 1, and ended with either a happy or a sad expression. This simply meant splitting the original movie used in Experiment 1 into two segments. The segmentation point was the middle of the neutral or transition window obtained in Experiment 1. This point, therefore, corresponded to the statistical average between the two edges of the neutral window across subjects (i.e. the neutral point). From the neutral expression or segmentation point, the sequence terminated with either an expression of happiness or sadness. Since the two types of presentation directions (forward and backward) were maintained in the present study, these sequences were played in their originally recorded direction or backwards, yielding four types of new movie clips per poser (see Figure 4.1 for examples of the four

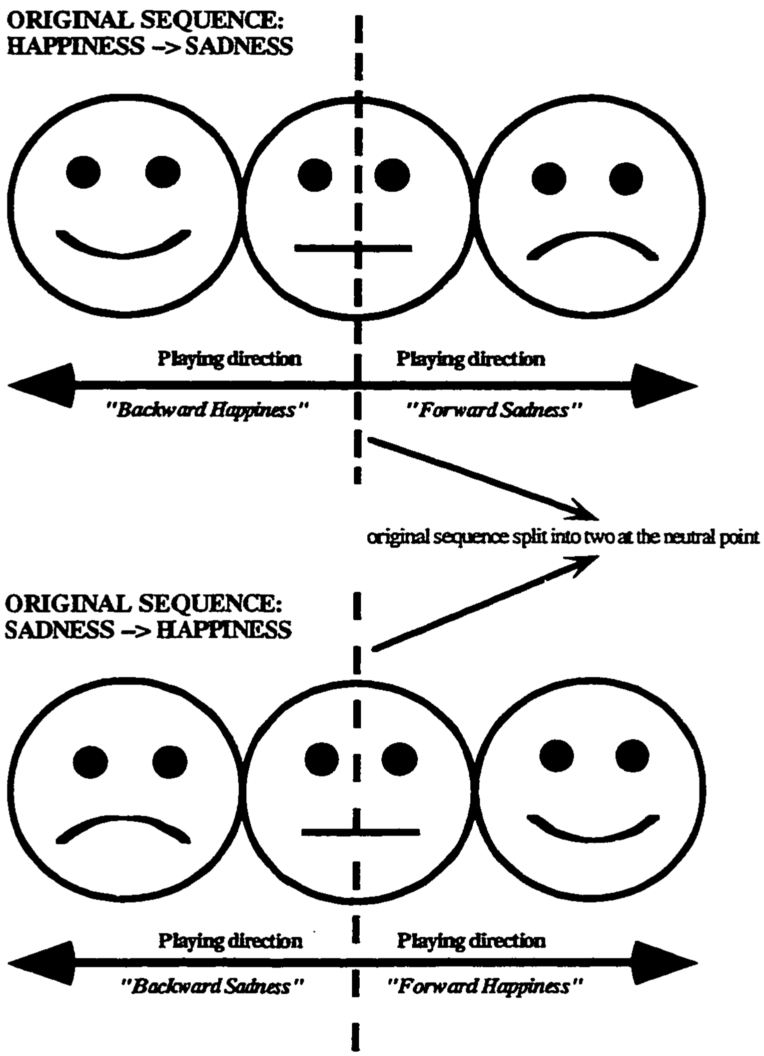

Figure 4.1. Original movie sequences from Experiment 1 were split at the mean perceived neutral point to form two new sequences. The direction that these constructed segments were played in (from the neutral point backward or forward) would determine the type of emotional sequence used for Experiment 2.

types of sequences). The total clip duration varied according to the poser and location of the previously determined neutral point.

4.2.3 Procedure

All participants first read and signed the consent form (Appendix C). The subjects were then tested individually in a quiet room, seated in front of the computer screen at a distance of 57 cm. At all times they were instructed to look at the screen following the initiation of each trial. The dynamic sequences were presented one by one in a randomized order. The task of the subjects was to press as soon as possible on the mouse key when they thought that the occurrence of an expression was present. After this key press the dynamic sequence was immediately stopped and replaced by a checkerboard mask which lasted for one second. Thereafter, the subjects were presented with an on-screen dialogue box to enter their next response. A two alternatives forced choice judgment was required from the subjects in which they were to indicate which emotion they thought was depicted, by depressing either the letter "S" (sadness) or "H (happiness) on the keyboard. Each sequence was repeated 10 times for a total of 240 trials. The entire procedure lasted about 30 minutes. By utilizing this method, a threshold could be determined for each sequence as an index of discriminability. The percentage of correct identification was also collected as an index of agreement on the discriminability of the sequences. It could as well serve as an index of purity. The purity would be defined as the presence of expressive noise (movement of different features that would mislead the subjects) in the sequences. Therefore, the purity would correspond to the absence of noise. As a consequence, pure sequences should lead to less confusion around the thresholds.

4.2.4 Statistical design

Consequently the statistical design of Experiment 3 was a 6x2x2 repeated measures factorial analysis of variance (ANOVA), with Posers (6 levels), Direction of presentation (2 levels: backward and forward), and the type of Emotion (2 levels: sadness and happiness) as variables.

4.3 Results

For each of the 24 combinations of poser, expression, and movie direction, both the percent correct identification of emotional expression and the threshold for this correct identification were measured at each of the 10 repetitions, for each observer. Subject, and thereafter, group means were then computed for each the percent correct and threshold to yield two subsequent repeated measures analyses of variance (ANOVAs).

4.3.1 Percent Correct Identification of Emotion Data

The percent correct for the identification of each emotional sequence was calculated for each subject per condition and a repeated measures ANOVA was conducted on the percent correct data to determine if it was dependent on the type of Poser (6 levels: poser 1, poser 2, poser 3, poser 4, poser 5, and poser 6), the type of Emotion (2 levels: sadness and happiness), and the Direction the movie was played in (2 levels: forward and backward).

Different posers were found to yield different percent correct identifications of emotion type in their movie clips [main effect of Poser, $F(5, 65)=6.783$, $p<.05$]. Percent correct of 93.39, 98.21, 90.71, 98.39, 98.39, and 99.46 were computed for posers one through six, respectively. This, however, is not surprising since each poser is unique in the manner in which s/he expresses emotions. Without training in emotion expression for the posers (i.e. inform posers how to express each emotion) this effect is important as it reveals which posers are superior at expressing the emotions. It was also determined that the type of expression produced no difference in percent correct, with for instance, 95.48 percent for the sadness sequence, which was about equal to the 97.38 found for the happiness sequence [main effect of Emotion, $F(1, 13)=3.292$, $p>.05$]. The direction in which the movie was played to the subject did, on the other hand, lead to significant differences in percent correct. When movies were played forward, percent correct scores (94.46) were significantly lower than when movies were played backward (98.39) [main effect of Direction, $F(1, 13)=9.750$, $p<.05$].

The poser main effect, however, was found to interact with both the direction and the emotion variables, yielding the following significant two-way interactions: Poser x Direction interaction [$F(5, 65)=7.217$, $p<.05$] and Poser x Emotion interaction [$F(5, 65)=7.689$, $p<.05$]. The main effects of emotion and direction, on the other hand, did not interact with each other [Emotion x Direction interaction, $F(1, 13)=.786$, $p>.05$]. The interaction between emotion and direction did, however, differ significantly across posers [Poser x Direction x Emotion interaction $F(5, 65)=12.171$, $p<.05$] and thus took precedence over the two-way effects. A simple interaction analysis was then conducted on the Poser x Emotion x Direction interaction. It was revealed that the three-way interaction was due to the fact that the percent correct identification of emotion type was dependent on the direction for Poser 1 [$F(1, 65)=17.129$, $p<.05$] and Poser 3 [$F(1, 65)=44.561$, $p<.05$], but not for the remaining four posers [Poser 2, $F(1, 65)=.071$, $p>.05$, Poser 4,

$F(1, 65)=.018$, $p>.05$, Poser 5, $F(1, 65)=.018$, $p>.05$, and Poser 6, $F(1, 65)=.018$, $p>.05$].

A simple effects analysis was thereafter performed on the significant simple interactions, Emotion x Direction at Poser 1, as well as Emotion x Direction at Poser 3. The first analysis revealed that this simple two-way interaction was present because direction of movie significantly affected the percent correct for the happiness movie [simple effect of Direction at Happiness for Poser 1, $F(1, 65)=17.254$, $p<.05$] but not for the sadness movie [simple effect of Direction at Sadness for Poser 1, $F(1, 65)=2.888$, $p>.05$]. For instance, the sadness sequences were identified equally well for forward (99.29) and backward (92.86) movies, whereas, happiness sequences were identified better in backward (98.57) rather than forward (82.86) movies.

The simple effect analysis of Emotion x Direction at Poser 3 demonstrated a contradictory effect to Poser 1. The analysis indicated that Poser 3's simple two-way interaction was due to the fact that the direction of movie did not affect the percent correct identification for the happiness movies [simple effect of Direction at Happiness for Poser 3, $F(1, 65)=.036$, $p>.05$] but did significantly affect the sadness movies [simple effect of Direction at Sadness for Poser 3, $F(1, 65)=92.723$, $p<.05$]. For instance, happiness segments played forward and backward produced about equal identification with 99.29 and 100.00, respectively. Sadness movies, however, yielded better identification for backward presentations (100.00) as opposed to forward presentations (63.57).

In conclusion, happiness movies played backward and sadness movies played forward were identified better for Poser 1, while sadness movies played backward were identified better for Poser 3. This pattern accounted for the significant poser x direction x emotion interaction.

As illustrated by Figures 4.2 to 4.7, discriminability of the emotional expression was found to be acute as the rate of accuracy judgment ranged from 64 to 100%. Indeed, a ceiling effect appeared to be present as the majority of identification rates were in the 90 percent range.

4.3.2 Threshold for Correct Identification of Emotion Data

The threshold (1/60 sec) for the correct identification of each emotional sequence was thereafter calculated for each subject per condition and a repeated measures ANOVA was conducted on this threshold data to determine if it was dependent on the type of Poser (6 levels: poser 1, poser 2, poser 3, poser 4, poser 5, and poser 6), the type of Emotion (2 levels: sadness and happiness), and the Direction the movie was played in (2 levels: forward and backward).

As with previous findings, different posers were found to yield different thresholds for correct identification of emotion type in their movie clips [main effect of Poser, $F(5, 65)=6.783$, $p<.05$]. Thresholds consisted of 121.98, 104.08, 56.87, 66.28, 61.93, and 44.13 (1/60 sec) for posers one through six, respectively. This, however, is not surprising since each poser is unique in the manner and perhaps capability in which s/he expresses emotions. The type of expression also produced different thresholds, with, for instance, a threshold of 80.00 (1/60 sec) for the sadness sequences, which was higher than the threshold of 71.75 (1/60 sec) found for happiness sequences [main effect of Emotion, $F(1, 13)=8.917$, $p<.05$]. A difference here would not have been surprising since there was no a priori reason for predicting these two expressions would yield similar thresholds given the fact that a poser's sadness and happiness depictions were different movies and possibly simulated in a qualitatively different manner. The main effect for the

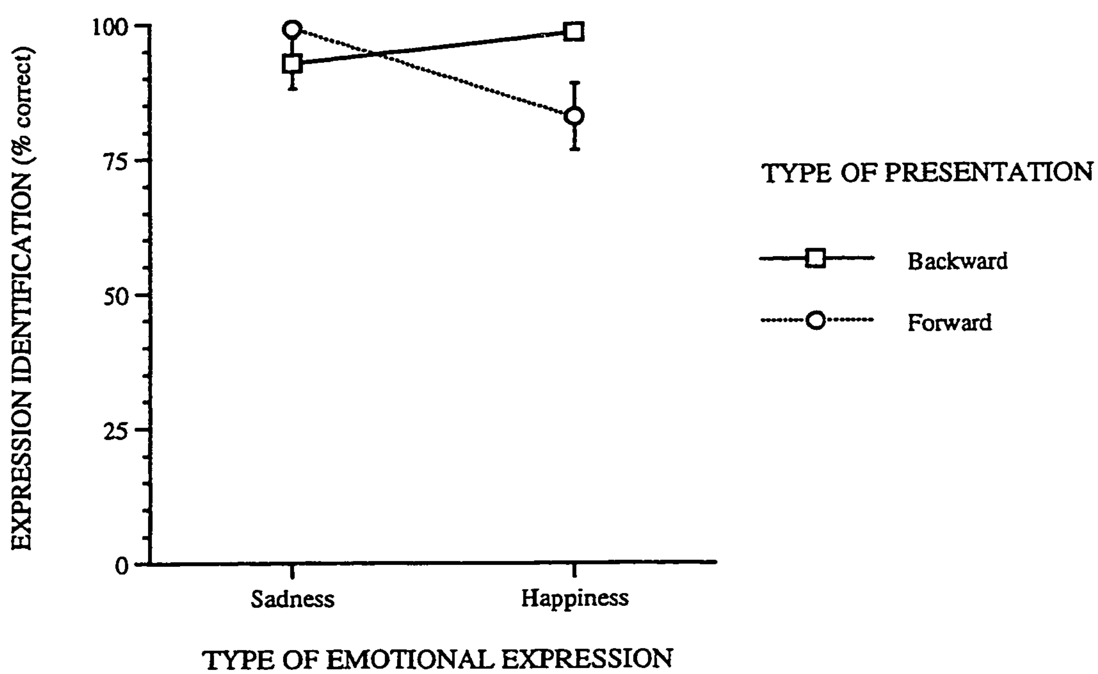

Figure 4.2. Identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 1.

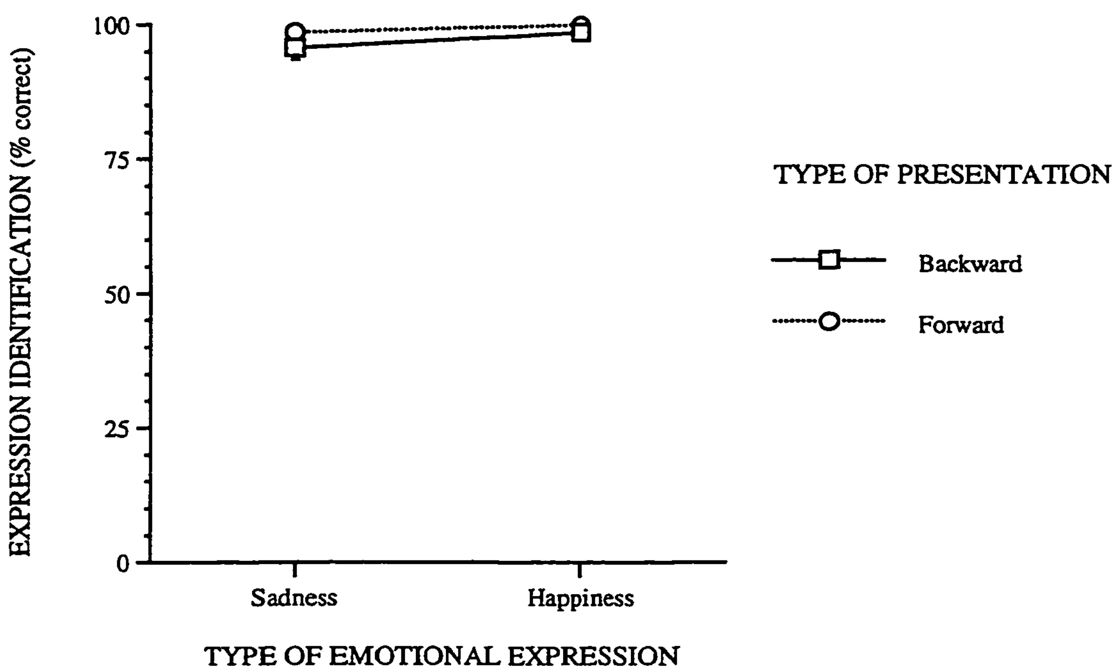

Figure 4.3. Identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 2.

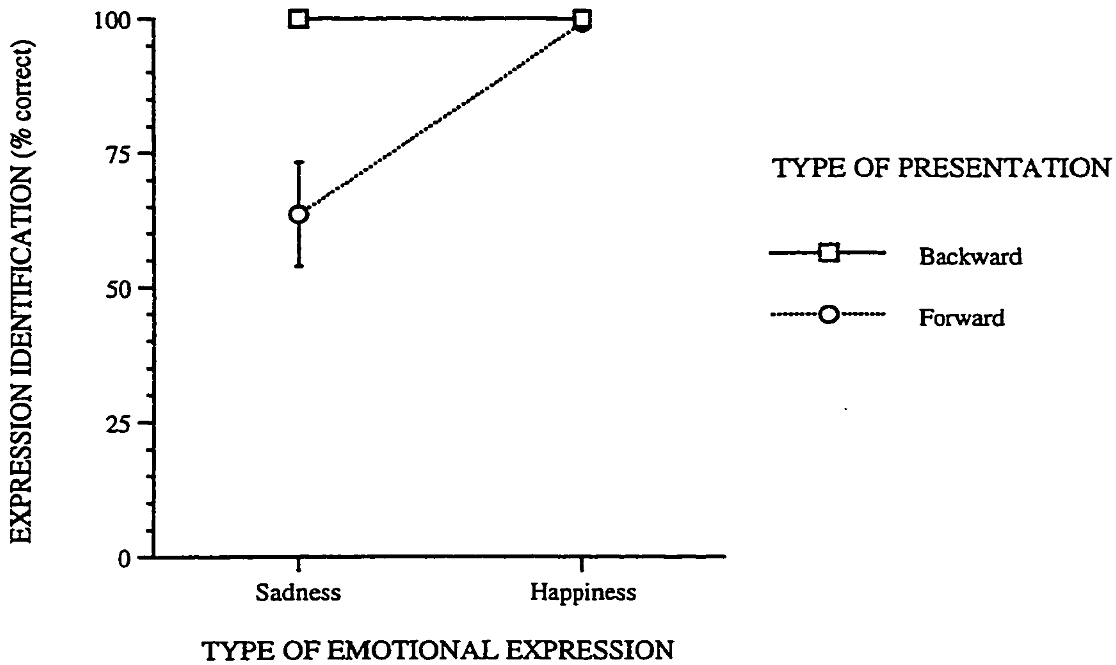

Figure 4.4. Identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 3.

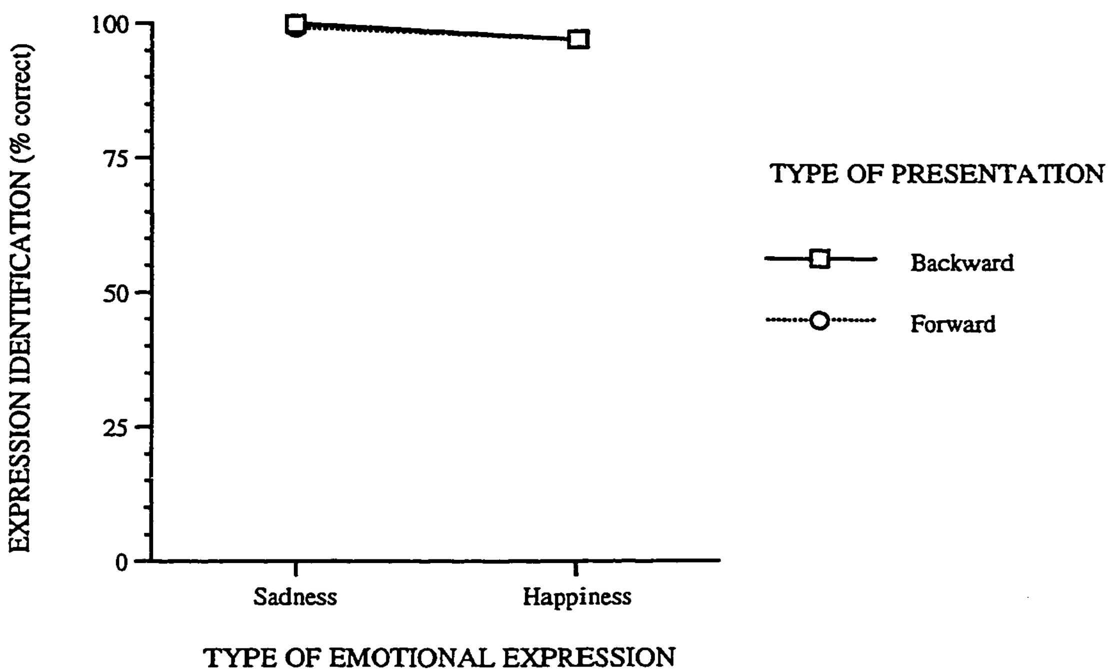

Figure 4.5. Identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 4.

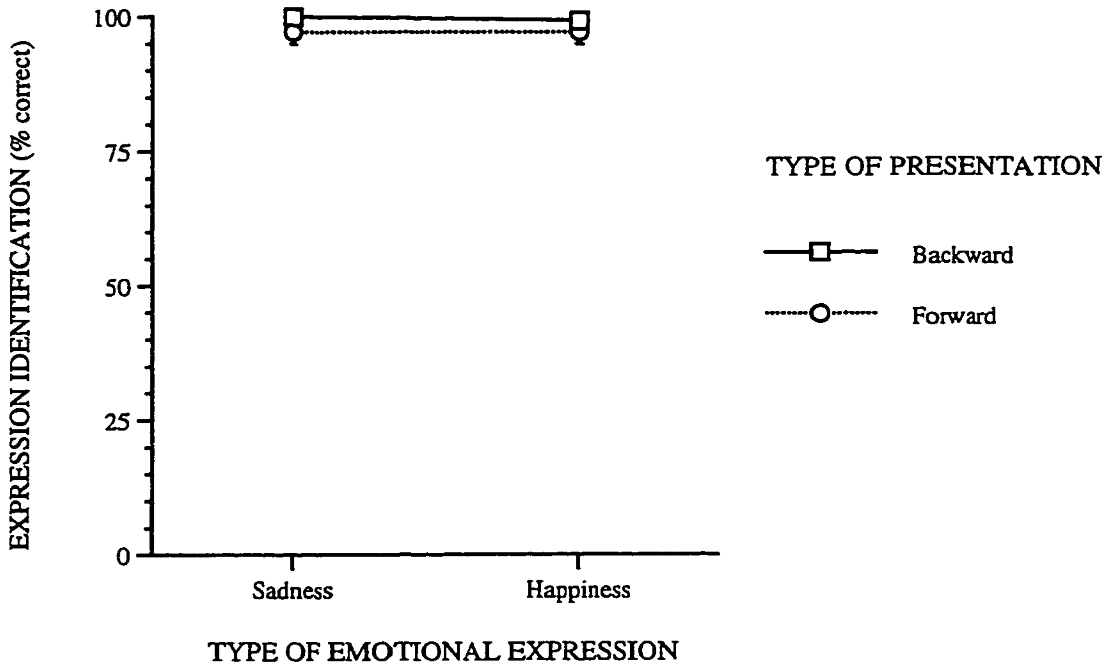

Figure 4.6. Identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 5.

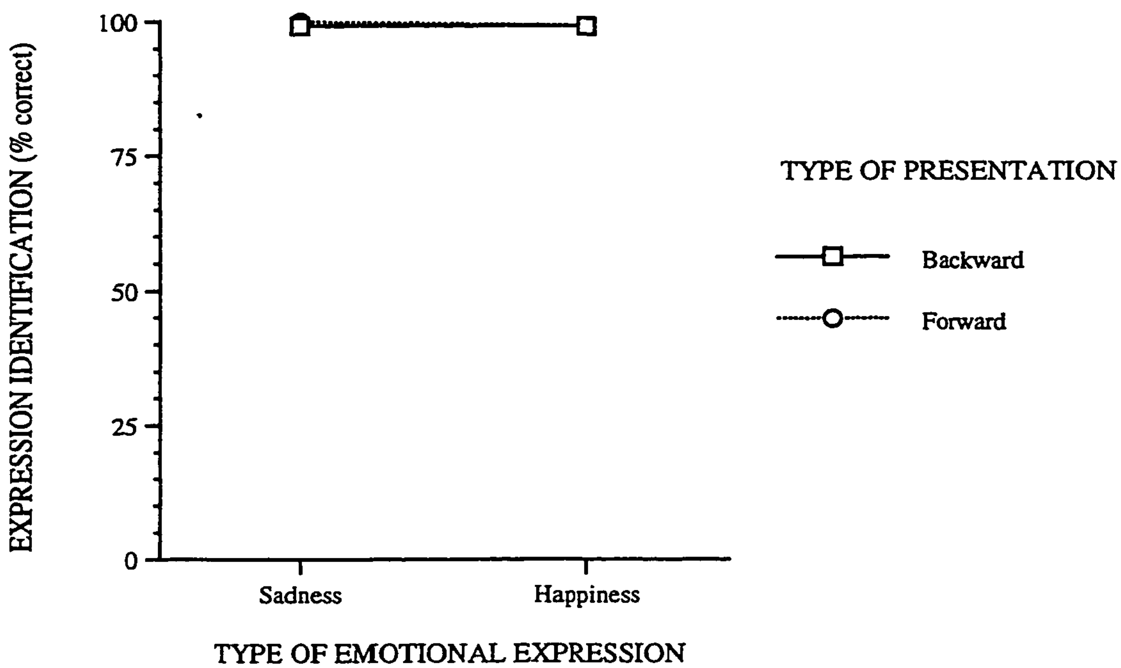

Figure 4.7. Identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 6.

direction in which the movie was played was not significant [main effect of Direction, $F(1, 13)=.565$, $p>.05$]. When movies were played forward or backward this resulted in about equal thresholds, 76.47 and 75.28 (1/60 sec), respectively.

All three two-way interactions were significant: Poser x Direction interaction [$F(5, 65)=35.243$, $p<.05$], Poser x Emotion interaction [$F(5, 65)=23.512$, $p<.05$], and Emotion x Direction interaction [$F(1, 13)=124.021$, $p<.05$], but are subsumed by the significant highest order interaction [Poser x Emotion x Direction interaction, $F(5, 65)=92.198$, $p<.05$]. The analysis of simple two-way interactions isolated this three-way effect. It was revealed that thresholds for correct identification of emotion type were dependent on the direction for all posers [Poser 1, $F(1, 65)=429.908$, $p<.05$; Poser 2, $F(1, 65)=48.577$, $p<.05$; Poser 3, $F(1, 65)=29.436$, $p<.05$; Poser 4, $F(1, 65)=14.220$, $p<.05$; and Poser 5, $F(1, 65)=20.649$, $p<.05$] except for Poser 6 [$F(1, 65)=.516$, $p>.05$].

A simple effects analysis was thereafter performed for each of the five significant simple interactions. The first analysis of the emotion x direction at Poser 1 revealed that this simple two-way interaction was present because direction of movie significantly affected the threshold for the happiness movie in one way [simple effect of Direction at Happiness for Poser 1, $F(1, 65)=55.156$, $p<.05$] and the sadness movie in another manner [simple effect of Direction at Sadness for Poser 1, $F(1, 65)=479.430$, $p<.05$]. For instance, the sadness sequences were identified earlier for forward (65.91, 1/60 sec) than backward (181.31, 1/60 sec) movies, whereas, happiness sequences were identified earlier in backward (100.77, 1/60 sec) rather than forward (139.91, 1/60 sec) movies.

The simple effect analysis of Emotion x Direction at Poser 2 demonstrated the same effect as Poser 1. The analysis indicated that this simple two-way interaction was present because direction of movie significantly affected the threshold for the happiness movie in one way [simple effect of Direction at Happiness for Poser 2, $F(1, 65)=16.306$, $p<.05$] and the sadness movie in another manner [simple effect of Direction at Sadness for Poser 2, $F(1, 65)=33.855$, $p<.05$]. Like for Poser 1, the sadness sequences were identified earlier for forward (107.22, 1/60 sec) than backward (137.88, 1/60 sec) movies, whereas, happiness sequences were identified earlier in backward (74.96, 1/60 sec) rather than forward (96.24, 1/60 sec) movies.

Poser 4's simple effect analysis of the Emotion x Direction simple interaction also demonstrated the same effect as Posers 1 and 2. The analysis indicated that this simple two-way interaction was present because direction of movie significantly affected the threshold for the happiness movie in one way [simple effect of Direction at Happiness for Poser 4, $F(1, 65)=6.755$, $p<.05$] and the sadness movie in another manner [simple effect of Direction at Sadness for Poser 4, $F(1, 65)=7.474$, $p<.05$]. Again, the sadness sequences were identified earlier for forward (60.38, 1/60 sec) than backward (74.79, 1/60 sec) movies, whereas, happiness sequences were identified earlier in backward (58.13, 1/60 sec) rather than forward (71.83, 1/60 sec) movies.

The simple effects analysis for Poser 5, demonstrated a partially similar effect to the above mentioned Posers. The direction of movie significantly affected the threshold for the happiness movies [simple effect of Direction at Happiness for Poser 5, $F(1, 65)=6.503$, $p<.05$] and the sadness movies [simple effect of Direction at Sadness for Poser 5, $F(1, 65)=80.578$, $p<.05$] in the same way, but more pronounced for the sadness. Here, both the sadness and happiness sequences were identified earlier for backward (28.23 and 65.27, 1/60 sec, respectively) than forward (75.54 and 78.71, 1/60 sec, respectively) movies.

Contrary to the previous simple effects, a different pattern was illustrated for Poser 3. The simple two-way interaction was present for Poser 3 because direction of movie significantly affected the threshold for the happiness movie in one way [simple effect of Direction at Happiness for Poser 3, $F(1, 65)=9.972$, $p<.05$] and the sadness movie in another manner [simple effect of Direction at Sadness for Poser 3, $F(1, 65)=20.385$, $p<.05$]. Note, however, that this pattern was different that for Posers 1, 2, 4, and 5. In this case, the sadness sequences were identified earlier for backward (57.19, 1/60 sec) than forward (80.98, 1/60 sec) movies, whereas, happiness sequences were identified earlier in forward (36.33, 1/60 sec) rather than backward (52.97, 1/60 sec) movies.

Generally, happiness movies played backward were identified earlier in the sequence, while the reverse was typically true for sadness movies (i.e. when played forward they were identified earlier in the sequence). This effect is illustrated in Figures 4.8 through 4.13.

4.4 Discussion

It is perhaps important, before attempting to discuss the results obtained, to define again the different measures that were examined in this experiment. Concerning the threshold results, one has to remember that it is defined as the point where the subjects, on average, press the key to stop the dynamic sequence, before making their identification judgment. The percentage of correct identification responses was therefore made after stopping the dynamic sequence. This identification judgment, consequently, does not correspond to the judgment of the emotional apex. Instead, this judgment is, associated with the exact moment at which the subjects stopped the dynamic sequence. This moment

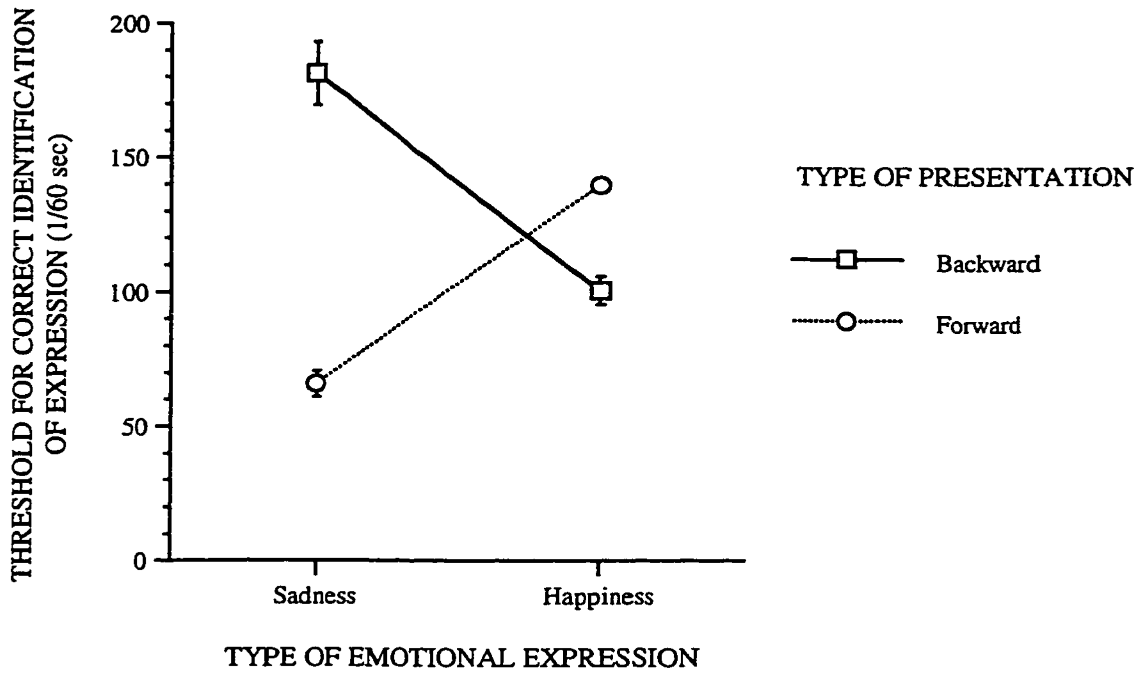

Figure 4.8. Threshold for correct identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 1.

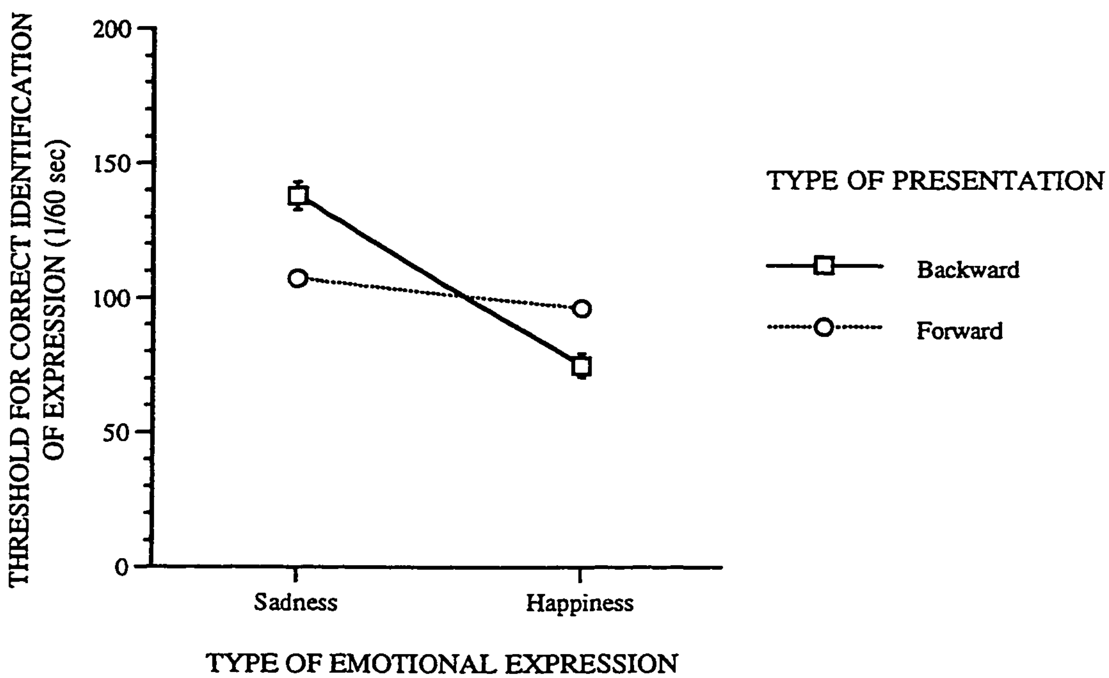

Figure 4.9. Threshold for correct identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 2.

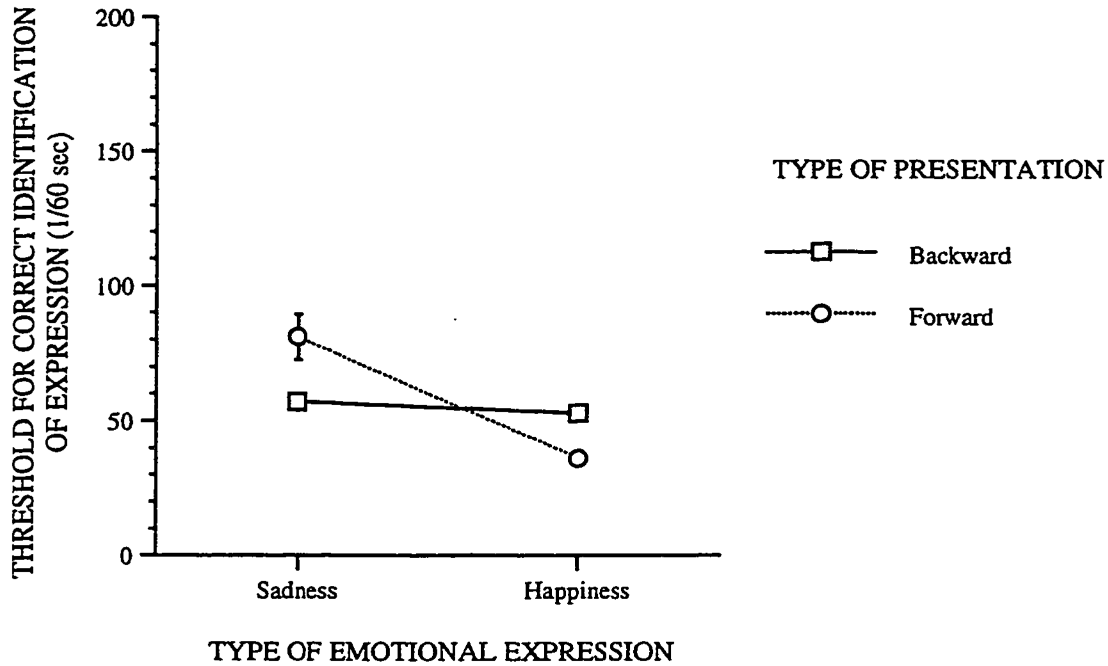

Figure 4.10. Threshold for correct identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 3.

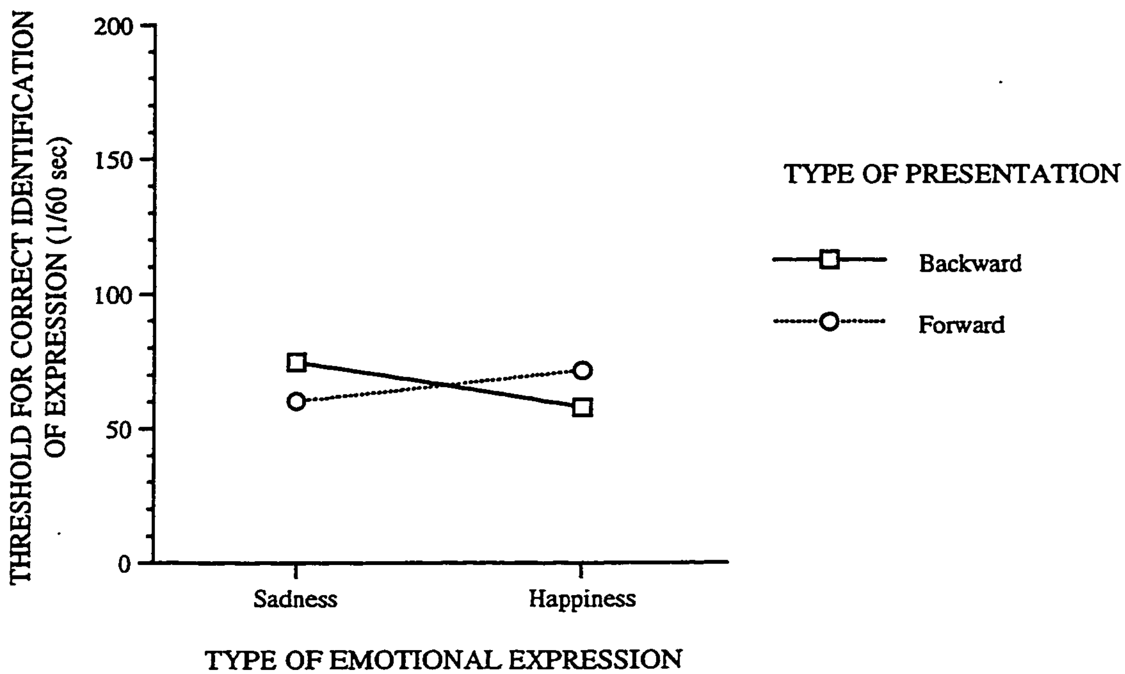

Figure 4.11. Threshold for correct identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 4.

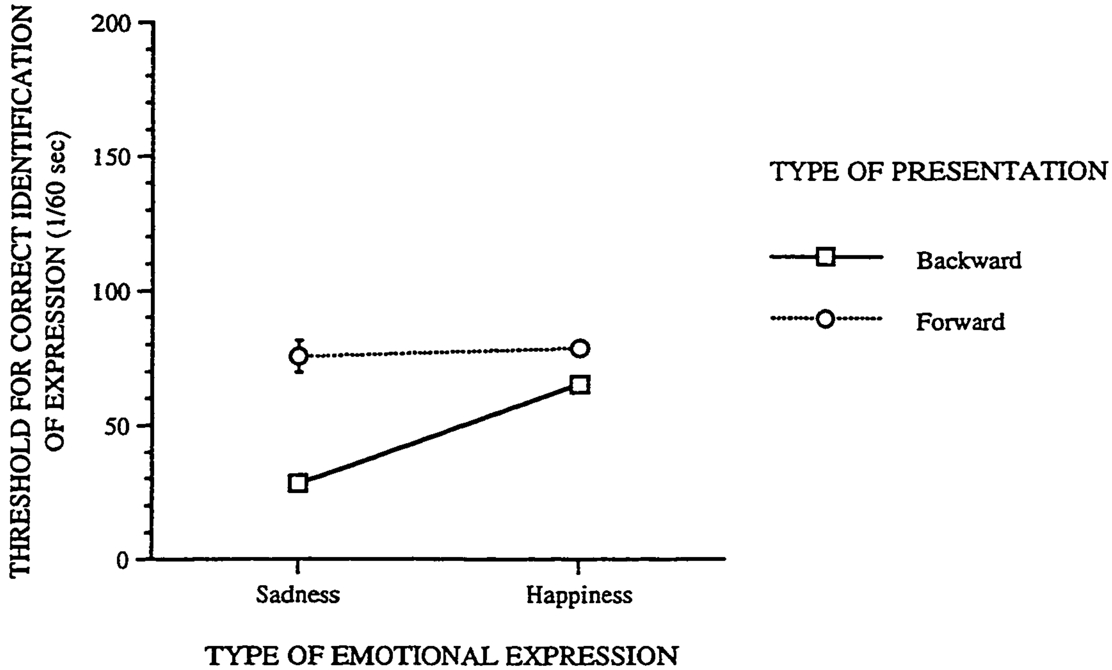

Figure 4.12. Threshold for correct identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 5.

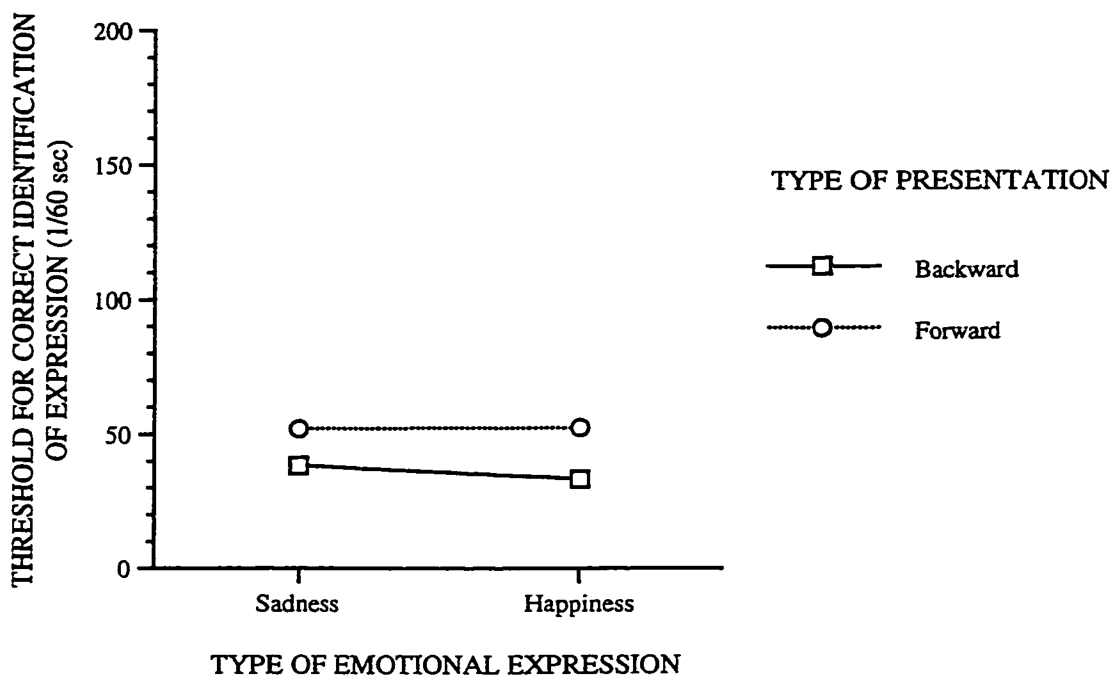

Figure 4.13. Threshold for correct identification of expression as a function of both the type of emotional expression and the type of presentation for Poser 6.

was defined in the instructions as the earliest moment in the dynamic sequence for which the subjects thought they could provide an accurate judgment of the emotion depicted.

The utilization of this procedure revealed that sequences were misjudged when insufficient information was presented. This interpretation is however, confounded by the presence of misleading visual signals in the sequence. We refer to this noise as pertaining to the motion of features that could be characteristic of a different emotional expression or as discussed by Ekman and Friesen (1984), could correspond to what they call "micro-expressions". Micro-expressions are very brief manifestations of a facial affect, that according to Ekman and Friesen (1984) may provide a signal to disambiguate felt from false emotional expressions. They support the idea that false emotional expressions may contain micro expressions that differentiate them from felt ones. This possibility was verified for poser 3 who obtained a significantly lower percentage of correct identifications in the forward condition while expressing sadness. The sequence was re-examined by the experimenter. It was revealed that the point of judgment identified included a micro-expression in the opposite direction to the target emotion. A tint of happiness was present before the expression unfolded into sadness.

The results suggest that the task was too easy. This might be explained by the fact that correct recognition judgments always occurred after the subject had decided that sufficient information was presented prior to the decision. This procedure could be corrected by the introduction of a different Psychophysical technique. The method of constant stimuli for finding thresholds would be an appropriate replacement. This would, however, render the procedure much longer.

EXPERIMENT 3

5.1. Introduction

The purpose of the third experiment was to examine the effect of variation in the temporal characteristics of dynamic emotional facial expressions on the judgment of the authenticity and intensity of the expressions. As aforementioned in the discussion on posed and spontaneous emotional facial expressions, several temporal aspects seem to play a role in the disambiguation of the emotional signal (Hess & Kleck, 1990; Gosselin & Kirouac 1994). Hess and Kleck (1990) compared elicited and deliberate emotional facial expressions using happiness and disgust. Their results indicated that the two types of expression have different temporal properties. Posed expressions were found to be longer and were more irregular. Other researchers have also reported differences showing that posed expressions are more asymmetrical with a more intense action on the left side of the face (Ekman, Hager & Friesen, 1981; Kowner; 1995; see also Skinner & Mullen, 1991 for a meta-analysis review). The timing and the coordination of the various regions of the face (brows, eyes, mouth) are usually different in posed expressions (Ekman & Friesen, 1984; Rinn, 1984; Hager & Ekman, 1985; Weiss, Blum & Gleberman, 1987). To summarize, posed expressions are more abrupt, the apex frozen, and the scope very intense or exaggerated. It seems that the typicality of posed expressions might affect the genuine aspect of an emotional expression.

Beside the difference that may exist between posed and spontaneous expressions in terms of their temporal characteristics, another important question deals with the sensitivity of the observer to these differences. The observer may be able to perceive differences in the intent. Gosselin and Kirouac (1994) using judgments of authenticity examined the effect of posed and spontaneous dynamic emotional facial expressions obtained from professional actors. The judgments of authenticity reveals that decoders were able to distinguish between posed and spontaneous expressions using facial signal alone. The authors, however, found that the decoders were significantly biased in responding toward spontaneous expressions. With the presence of this bias, the results cannot unequivocally support an advantage of spontaneous over posed emotional facial expressions.

Wallbott (1992) studied the degradation of the pictorial quality of the picture as well as the degradation of the temporal signal. Following degradation along the temporal continuum, Wallbott found that recognition rates were significantly affected with the biggest effect following the first step of degradation. The stimuli were based on a 25 frames per second recording. Degradations were performed by presenting the fifth of every frame, the seventh and the twenty-fifth. This degradation can be qualified as severe in comparison to the one proposed in this experiment. Consequently, one might propose that subtle degradation like the one used here would not affect recognition rate but would affect intensity and authenticity rating.

Based on these previous findings, this experiment further examined the judgment of authenticity using dynamic emotional facial expressions obtained from untrained posers when temporal variations are introduced in the dynamic sequences. The rationale behind the manipulation of the speed of presentation of the dynamic sequences was based on the fact that posed and spontaneous dynamic facial expressions possess subtle temporal information that can distinguish them from one another. It is therefore possible that temporal variations might perturb the perceived authenticity of the dynamic emotional facial expression. A judgment of intensity was also required from the observer. The rationale for this measure was that variations in speed may influence the perceived intensity of an expression. It was hypothesized that faster speed would produce higher ratings of perceived emotional intensity. The hypothesis for the judgment of authenticity was that any deviations from the normal speed of the dynamic sequences would produce lower ratings of authenticity.

5.2 Method

5.2.1 Subjects

Ten individuals participated in this experiment. All participants were recruited on a single basis through solicitation among, though not exclusively, the department of psychology population at Concordia University. Overall, the ratio of participants was biased towards fellow graduate students and both genders were recruited. The age of the participants varied between 21 and 52 years. Three of the subjects recruited for this experiment had also been solicited for the previous experiments. The subjects were informed of the research domain but were kept naive as to the purpose of the experiment.

5.2.2 Stimuli

The stimuli used in Experiment 2 were also utilized in this experiment. Poser 2 was, however, removed from the set. This decision was motivated by the fact that the sequences obtained from that poser were significantly longer than the ones obtained from the other posers which might in return bias the judgment of the observers. Short movie clips were constructed from the clips used in the second experiment. The movie clips, however, differed from the previous ones in their duration. Three different speeds were applied to the movies. The first one was normal, as it occurred in the original excerpts, played at the recording speed. The second one was half the speed of the original excerpts and therefore lasted twice as long. The sequence was constructed by doubling each frame within the movie. Finally, the third one was twice the speed of the original excerpts. This was accomplished by dropping one frame every two frames. Four different sequences for each poser were used and included depictions of the two target emotions and the two types of directions (forward and backward). Altogether, each poser had four different sequences to which three different speeds were applied for a total of 60 different excerpts (2x2x5x3). The total clip durations varied according to the poser and the speed of presentation.

5.2.3 Procedure

After signing the consent form (Appendix C), the subjects were tested individually in a quiet room, seated in front of the computer screen at a distance of 57 cm. At all times they were instructed to look at the screen following the initiation of each trial. The dynamic sequences were presented one by one in a randomized order. The following written instructions were given to each subject:

> During this experiment you will be asked to judge, how **real** and how **intense** the different emotions presented are. Since different individuals have somewhat different facial characteristics, as well as different ways to express their emotions, your task is to give a rating from 0 to 9 of how well each sequence conveys the intended emotion, while ignoring the person's identity or duration of the sequence. Concentrate on the realness and the intensity of the emotion.

After each sequence the subjects were presented with an on-screen dialogue box to enter their responses. The first task required from the subjects included a two alternatives forced choice judgment, where they had to indicate which emotions they thought was depicted, by depressing either the letter "S" (sadness) or "H (happiness) on the keyboard. The subsequent tasks were to first, rate the sequence's realness and second, rate the sequence's intensity, on a scale from 0 to 9 for both ratings (0 indicating low and 9 indicating high). The time allotted to make the judgments was determined by the subject's own pace. After both judgments where entered, the next trial was initiated by pressing the enter key on the keyboard. Each sequence was repeated 3 times in three separate blocks for a total of 180 trials. Each block lasted approximately 30 minutes yielding a total of about 90 minutes to complete the entire procedure.

5.2.4 Statistical design

The statistical design of Experiment 3 was a 5x2x2x3 repeated measures factorial analysis of variance (ANOVA), with Posers (5 levels), Direction of presentation (2 levels: backward and forward), type of Emotion (2 levels: sadness and happiness) and finally, Speed of the dynamic sequences (3 levels: normal, half-speed, and double-speed) as variables.

5.3 Results

For each of the 60 combinations of poser, expression, movie direction, and speed both the realness of the expression and the intensity of the expression were measured at each of the 3 repetitions, for each observer. Subject, and thereafter, group means were then computed for the realness and intensity data sets to yield two subsequent repeated measures analyses of variance (ANOVAs).

5.3.1 Realness of Expression Rating

The rating of realness of each emotional sequence was calculated for each subject per condition and a repeated measures ANOVA was conducted on the realness data to determine if it was dependent on the type of Poser (5 levels: poser 1, poser 2, poser 3, poser 4, and poser 5), the type of Emotion (2 levels: sadness and happiness), the Direction the movie was played in (2 levels: backward and forward), and the Speed at which the movie was played (3 levels: normal speed, half-speed, and double-speed).

The highest order interactions that were significant were the Poser x Direction x Emotion three-way interaction [$F(4, 36)=4.180$, $p<.05$], and the Emotion x Speed two-way interaction [$F(2, 18)=7.549$, $p<.05$]. All other effects were either non-significant or overridden by one or both of these two higher order interactions [main effect of Poser $F(4, 36)=5.850$ $p<.05$; main effect of Direction $F(1, 9)=8.344$, $p<.05$; main effect of Emotion $F(1, 9)=23.251$, $p<.05$; main effect of Speed $F(2, 18)=.835$, $p>.05$; Poser x Direction interaction $F(4, 36)=1.878$, $p>.05$; Poser x Emotion interaction $F(4, 36)=2.142$, $p>.05$; Direction x Emotion interaction $F(1, 9)=.487$, $p>.05$; Poser x Speed interaction $F(8, 72)=.688$, $p>.05$; Direction x Speed interaction $F(2, 18)=.666$, $p>.05$; Poser x Direction x Speed interaction $F(8, 72)=1.227$, $p>.05$; Poser x Emotion x Speed interaction $F(8, 72)=1.941$, $p>.05$; Direction x Emotion x Speed interaction $F(2, 18)=.837$, $p>.05$; Poser x Direction x Emotion x Speed interaction $F(8, 72)=.686$, $p>.05$].

The Poser x Direction x Emotion interaction was the highest order interaction found to be significant [Note that this interaction did not involve the speed factor. The effect of speed will be discussed later on]. In other words, the effect of playing direction depended on the type of emotion portrayed, and this interaction effect varied across different posers. Simple interaction analyses were conducted on this three-way interaction to isolate the effect. It was determined that this three-way interaction was due to the fact that there was a significant Direction x Emotion interaction for only one [Direction x Emotion for Poser 2 $F(1, 72)=20.607$, $p<.05$] of the five posers [Direction x Emotion for Poser 1 $F(1, 72)=2.779$, $p>.05$, Direction x Emotion for Poser 3 $F(1, 72)=.131$, $p>.05$, Direction x Emotion for Poser 4 $F(1, 72)=1.653$, $p>.05$, and Direction x Emotion for Poser 5 $F(1, 72)=.004$, $p>.05$].

Simple effects analysis was, thus, performed on the one significant simple interaction (for Poser 2). This analysis revealed that the Direction x Emotion simple interaction was significant because Direction produced a significant but different effect on each emotion [Direction at Sadness $F(1, 72)=14.060$, $p<.05$, and Direction at Happiness $F(1, 72)=7.130$, $p<.05$]. For instance, a backward sadness movie was perceived as more real than a forward sadness movie, 3.733 and 2.267, respectively, whereas, the reverse effect was found for the happiness movie clips. Forward happiness sequences (5.844) were perceived as more real than backward happiness sequences (4.800).

As shown in Figures 5.1 through 5.5, a similar effect was demonstrated for all posers for emotion type. That is, the happiness expression was consistently perceived as more real than the sadness expression, regardless of their original direction or poser. The only variability in this data set, as shown by the statistical analysis, was the effect of direction. Except for Poser 2, backward presentations were, contrary to expectation, rated as more real than forward presentations.

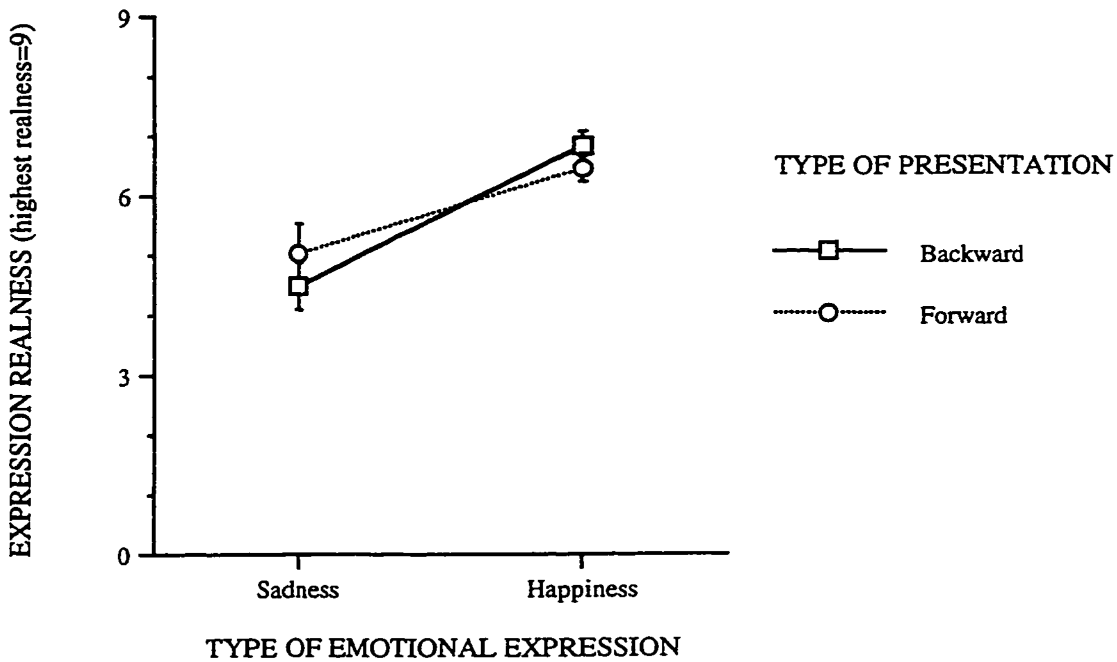

Figure 5.1. Realness of expression as a function of both the type of emotional expression and the type of presentation for Poser 1.

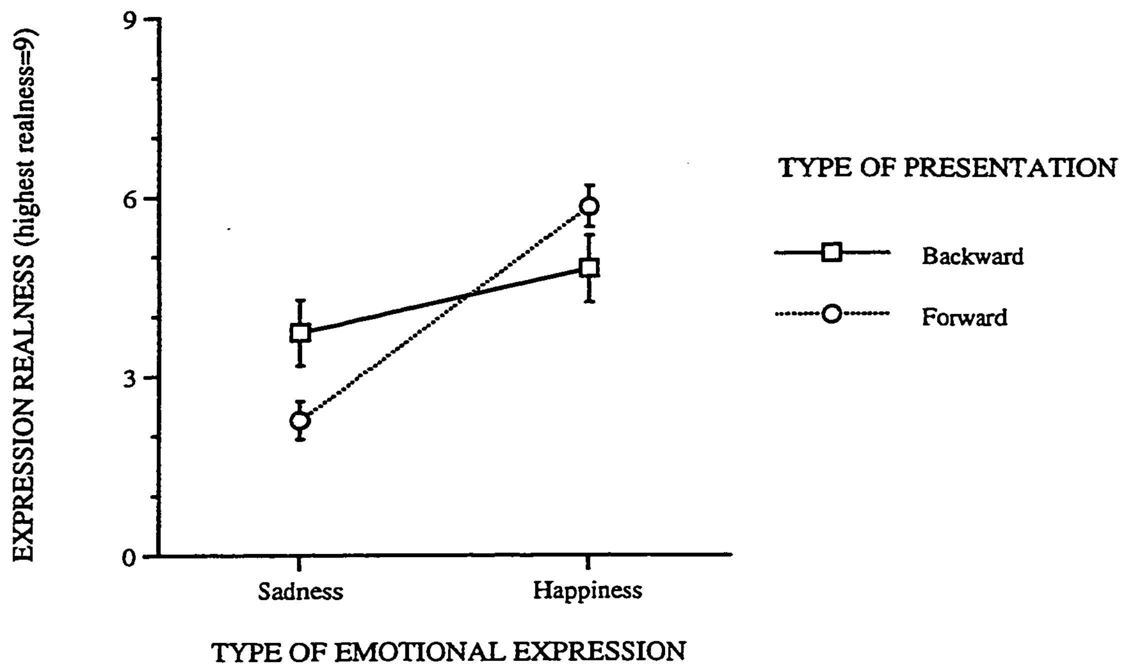

Figure 5.2. Realness of expression as a function of both the type of emotional expression and the type of presentation for Poser 2.

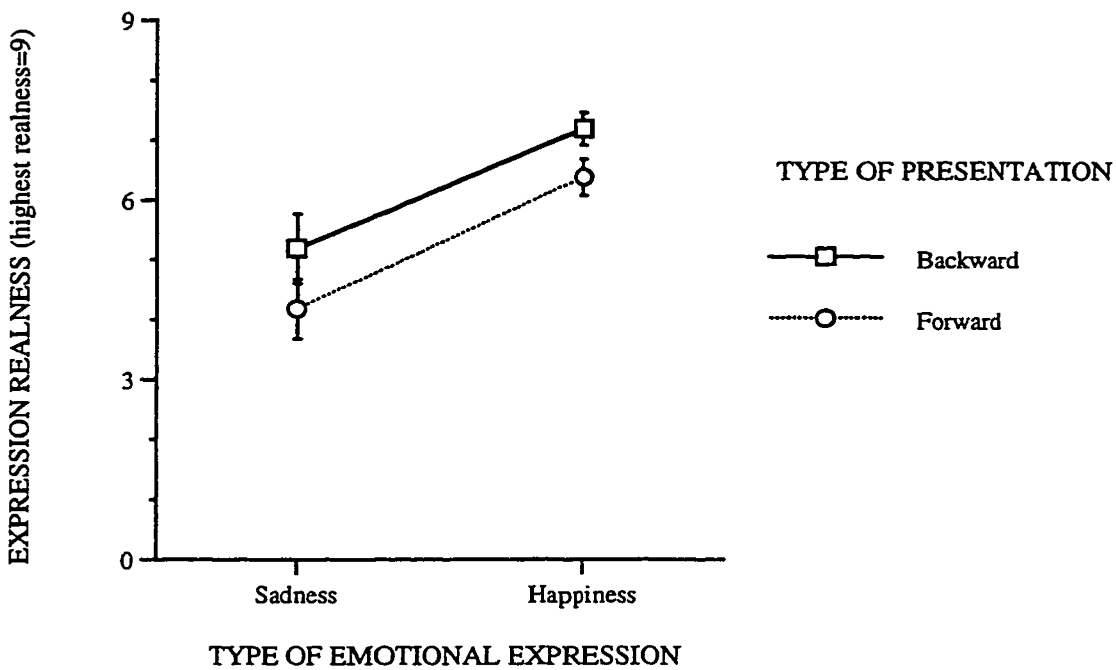

Figure 5.3. Realness of expression as a function of both the type of emotional expression and the type of presentation for Poser 3.

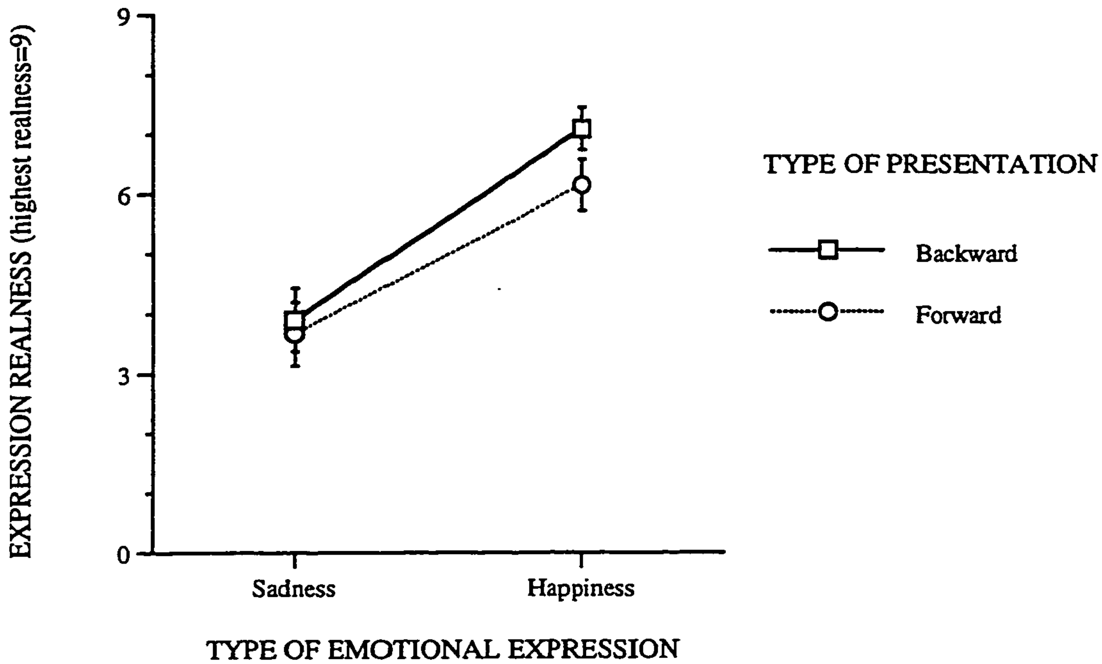

Figure 5.4. Realness of expression as a function of both the type of emotional expression and the type of presentation for Poser 4.

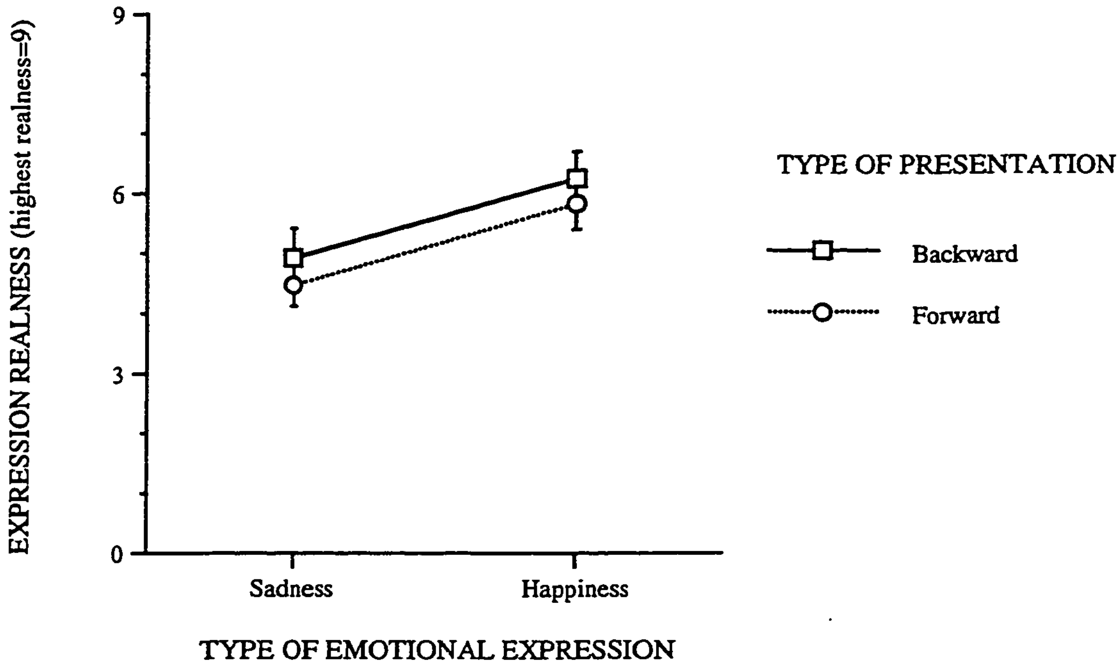

Figure 5.5. Realness of expression as a function of both the type of emotional expression and the type of presentation for Poser 5.

The highest order significant interaction involving the speed variable was the Emotion x Speed interaction. The effect of the speed at which the movie was played changed across the two emotions. Simple effects analysis was conducted and demonstrated that this interaction effect was due to a significant Speed effect for Happiness [$F(2, 18)=7.145$, $p<.05$] but not for Sadness [$F(2, 18)=1.938$, $p>.05$]. Despite the significant simple effect of Speed at Happiness, Tukey (hsd) pairwise comparisons illustrated no significant differences between (1) normal speed and half-speed, (2) normal speed and double-speed, or (3) half-speed and double-speed. The differences between each of these comparisons, though not large enough to be significant, must have combined to cause the simple effect.

Although not supported statistically, half-speed tended to increase realness ratings for happiness and decrease realness ratings for sadness while double-speed tended to decrease realness ratings for happiness and increase realness ratings for sadness (see Figure 5.6).

5.3.2 Intensity of Expression Rating

The rating of intensity of each emotional sequence was calculated for each subject per condition and a repeated measures ANOVA was conducted on the intensity data to determine if it was dependent on the type of Poser (5 levels: poser 1, poser 2, poser 3, poser 4, and poser 5), the type of Emotion (2 levels: sadness and happiness), the Direction the movie was played in (2 levels: backward and forward), and the Speed at which the movie was played (3 levels: normal speed, half-speed, and double-speed).

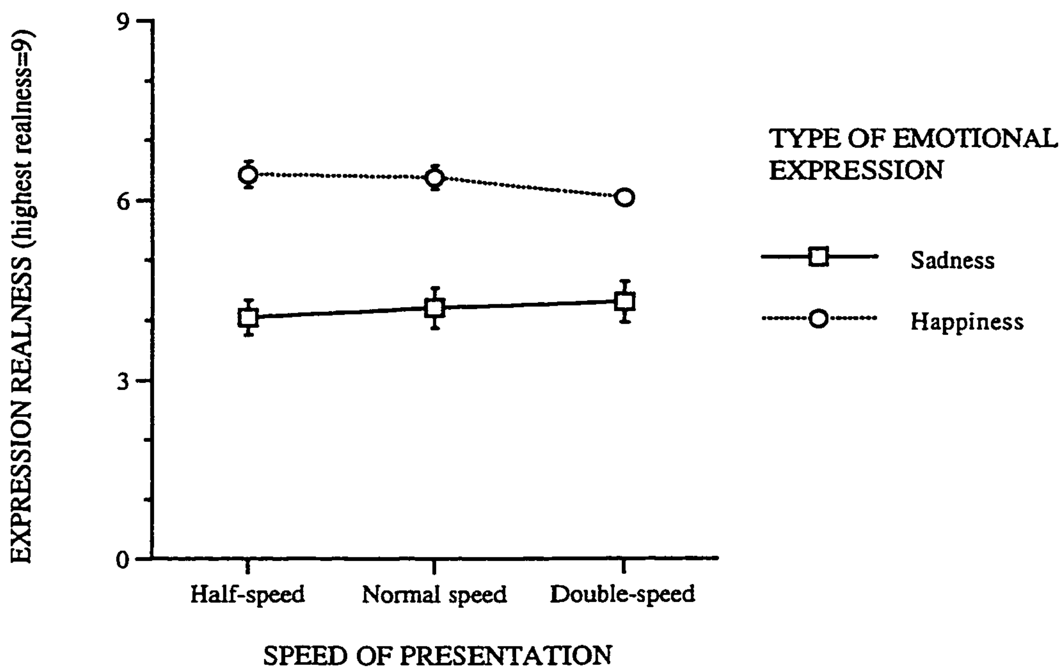

Figure 5.6. Realness of expression as a function of both the type of emotional expression and the speed of presentation.

The highest order interactions that were significant were the Poser x Direction x Emotion three-way interaction [$F(4, 36)=28.567$, $p<.05$], the Poser x Direction x Speed three-way interaction [$F(8, 72)=3.674$, $p<.05$], and the Emotion x Speed [$F(2, 18)=13.357$, $p<.05$]. All other effects were either non-significant or overridden by one or both of these two higher order interactions [main effect of Poser $F(4, 36)=6.563$ $p<.05$; main effect of Direction $F(1, 9)=62.221$, $p<.05$; main effect of Emotion $F(1, 9)=.401$, $p>.05$; main effect of Speed $F(2, 18)=1.480$, $p>.05$; Poser x Direction interaction $F(4, 36)=6.661$, $p<.05$; Poser x Emotion interaction $F(4, 36)=16.514$, $p<.05$; Direction x Emotion interaction $F(1, 9)=14.976$, $p<.05$; Poser x Speed interaction $F(8, 72)=1.050$, $p>.05$; Direction x Speed interaction $F(2, 18)=10.034$, $p<.05$; Poser x Emotion x Speed interaction $F(8, 72)=1.478$, $p>.05$; Direction x Emotion x Speed interaction $F(2, 18)=.507$, $p>.05$; Poser x Direction x Emotion x Speed interaction $F(8, 72)=.721$, $p>.05$].

As aforementioned, the Poser x Direction x Emotion interaction was one of the highest order interactions found to be significant [Note that this interaction was also significant in the realness data set]. In other words, the effect of playing direction depended on the type of emotion portrayed, and this interaction effect varied across different posers. Simple interaction analysis was thereafter conducted on this three-way interaction to isolate the effect. It was determined that this three-way interaction was due to the fact that there was a significant Direction x Emotion interaction for four [Direction x Emotion for Poser 2 $F(1, 72)=62.389$, $p<.05$; Direction x Emotion for Poser 3 $F(1, 72)=33.752$, $p<.05$; Direction x Emotion for Poser 4 $F(1, 72)=23.002$, $p<.05$; and Direction x Emotion for Poser 5 $F(1, 72)=11.221$, $p<.05$] of the five posers [Direction x Emotion for Poser 1 $F(1, 72)=.010$, $p>.05$]. Simple effects analysis was, thus, performed on these four significant simple interactions.

This analysis revealed that the Direction x Emotion simple interaction for Poser 2 was significant because Direction produced a significant effect on Sadness [$F(1, 72)=125.168$, $p<.05$] but not on Happiness [$F(1, 72)=.0003$, $p>.05$] movies. To illustrate, a backward sadness movie was perceived as more intense than a forward sadness movie (7.311 and 3.756, respectively), whereas forward and backward happiness sequences were perceived as equally intense (5.606 and 5.611, respectively).

The simple effect analysis on Poser 3 demonstrated the reverse effect. Direction of the movie clip was significantly different for happiness [Direction at Happiness $F(1, 72)=72.178$, $p<.05$] but not sadness [Direction at Sadness $F(1, 72)=.078$, $p>.05$] sequences. For example, a backward happiness movie was perceived as more intense than a forward happiness movie (6.878 and 4.178, respectively), whereas forward and backward sadness sequences were perceived as equally intense (6.344 and 6.433, respectively).

This analysis for Poser 4 revealed that the Direction x Emotion simple interaction was significant because Direction produced the same effect on each emotion [Direction at Sadness $F(1, 72)=4.623$, $p<.05$, and Direction at Happiness $F(1, 72)=79.795$, $p<.05$], but to a greater degree for the happiness sequences. For instance, backward movies were always perceived as more intense regardless of emotion, but the difference was more pronounced for happiness movie clips. Perceived intensity values for sadness sequences were 6.911 and 7.594 for forward and backward presentations, respectively. Perceived intensity values for happiness sequences were 4.244 and 7.083 for forward and backward presentations, respectively.

The simple effect analysis for Poser 5 demonstrated the same effect for Poser 3. Direction of the movie clip was significantly different for happiness [Direction at

Happiness $F(1, 72)=22.775$, $p<.05$] but not sadness [Direction at Sadness $F(1, 72)=.001$, $p>.05$] sequences. For example, a backward happiness movie was perceived as more intense than a forward happiness movie (7.133 and 5.617, respectively), whereas forward and backward sadness sequences were perceived as equally intense (5.544 and 5.556, respectively).

As shown in Figures 5.7 through 5.11, contrary to the realness data, the Poser x Direction x Emotion interaction was more complicated, dependent on several variables. That is, the happiness expression was sometimes more intense and sometimes less intense than sadness, which at times was dependent on the original direction, and always dependent on the poser.

As previously mentioned, another significant three-way interaction in the intensity data set was the Poser x Direction x Speed interaction. A similar pattern of analyses was conducted on this interaction. First of all, simple interaction analysis illustrated that this particular three-way interaction was significant because there was a significant simple Direction x Speed interaction for only one [Direction x Speed interaction at Poser 5 $F(1, 72)=13.482$, $p<.05$] of the five posers [Direction x Speed interaction at Poser 1 $F(1, 72)=.314$, $p>.05$; Direction x Speed interaction at Poser 2 $F(1, 72)=1.101$, $p>.05$; Direction x Speed interaction at Poser 3 $F(1, 72)=1.498$, $p>.05$; and Direction x Speed interaction at Poser 4 $F(1, 72)=1.543$, $p>.05$].

Simple effects analysis conducted on this simple Direction x Speed interaction at Poser 5 indicated that the effect of Speed was significant but different at each Direction [simple effect of Speed at Forward $F(1, 72)=6.030$, $p<.05$ and simple effect of Speed at Backward $F(1, 72)=7.495$, $p<.05$]. Thereafter, Tukey (hsd) pairwise comparisons were performed to isolate these simple effects. For forward movies, normal speed was not

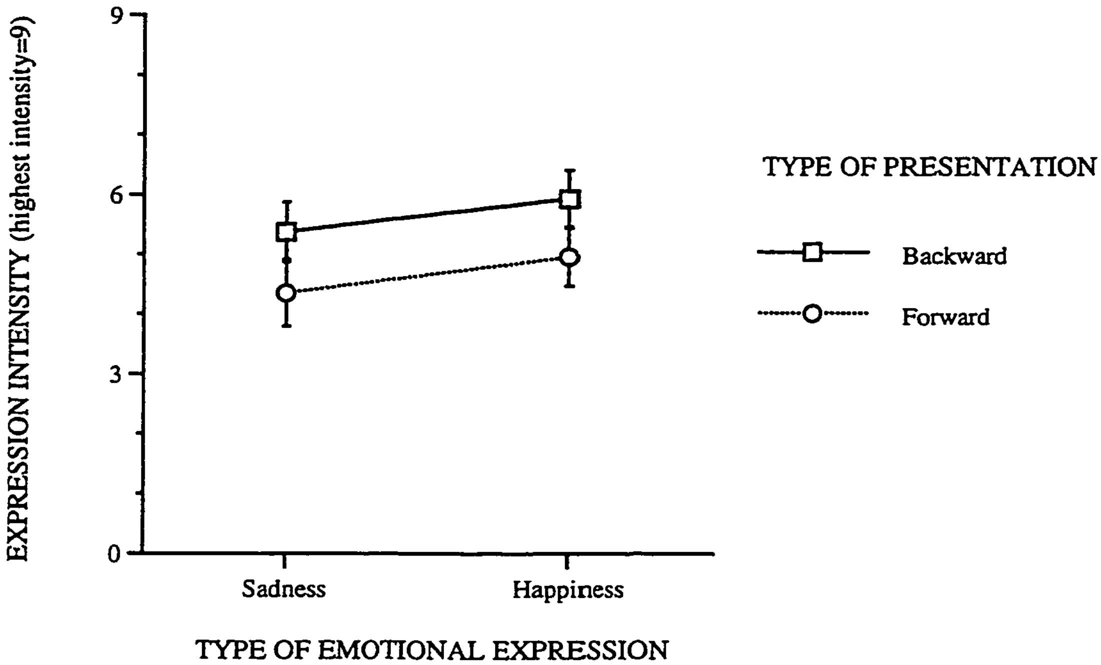

Figure 5.7. Intensity of expression as a function of both the type of emotional expression and the type of presentation for Poser 1.

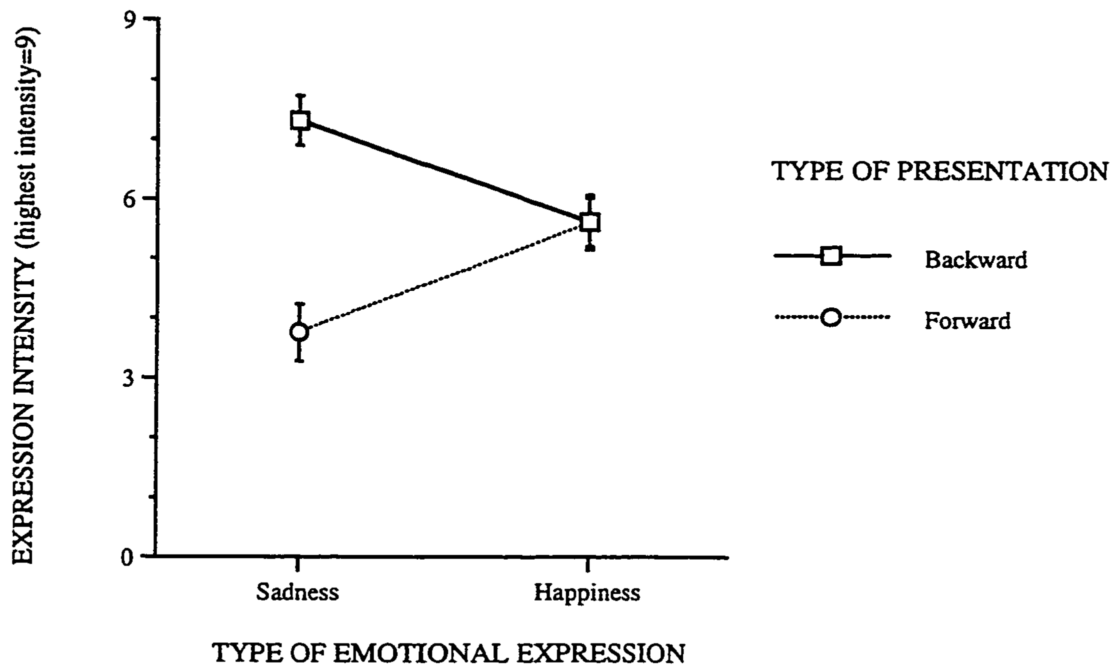

Figure 5.8. Intensity of expression as a function of both the type of emotional expression and the type of presentation for Poser 2.

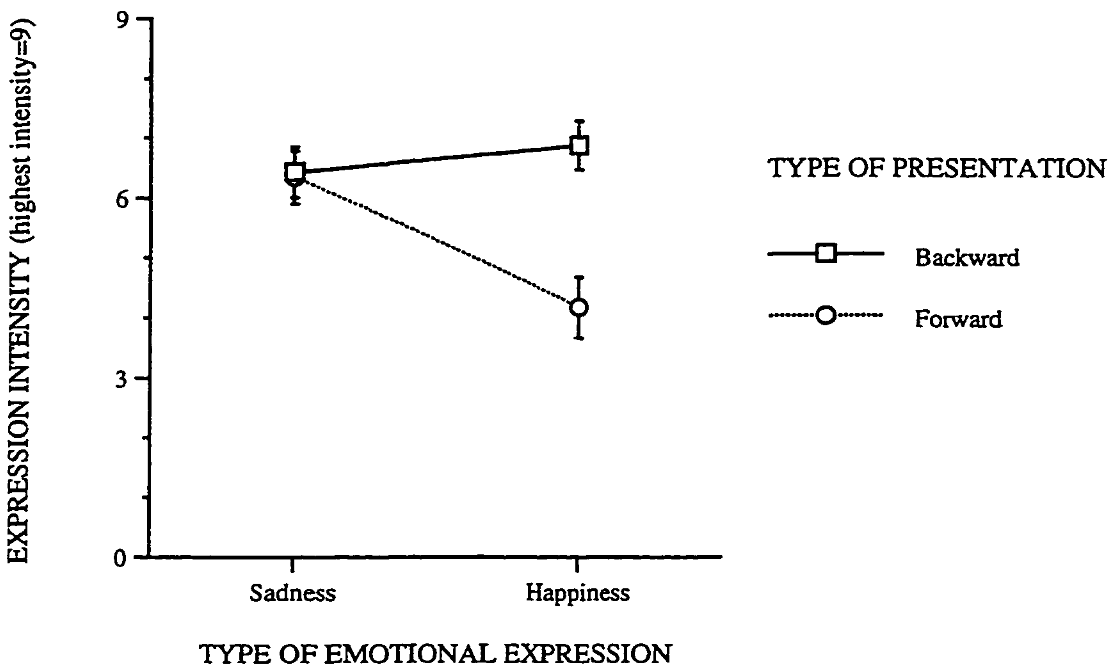

Figure 5.9. Intensity of expression as a function of both the type of emotional expression and the type of presentation for Poser 3.

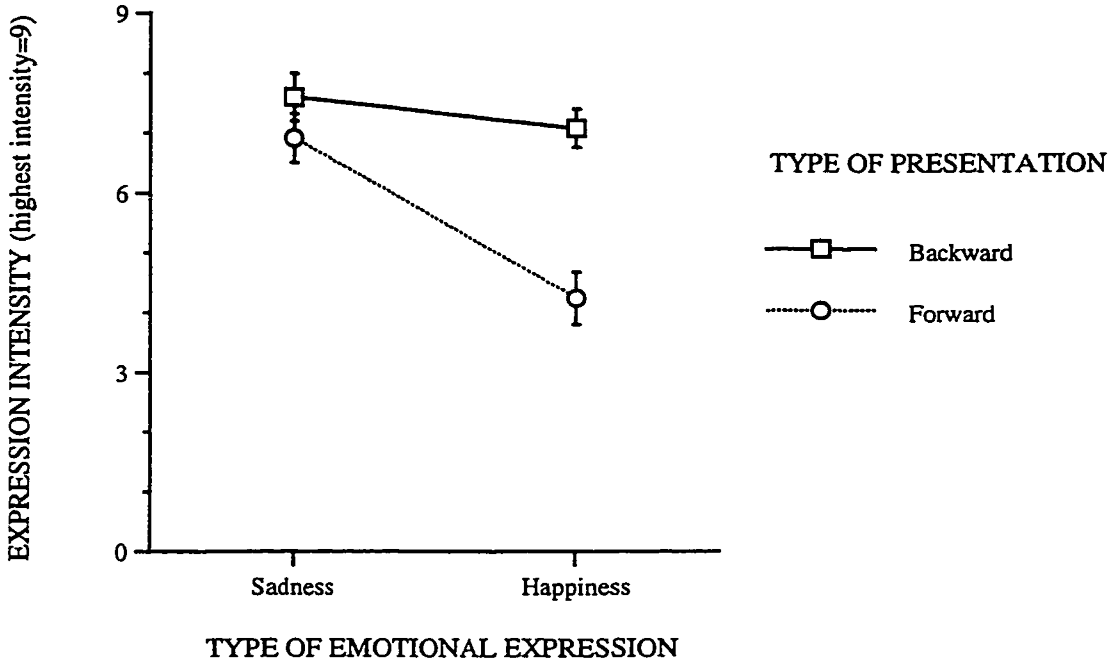

Figure 5.10. Intensity of expression as a function of both the type of emotional expression and the type of presentation for Poser 4.

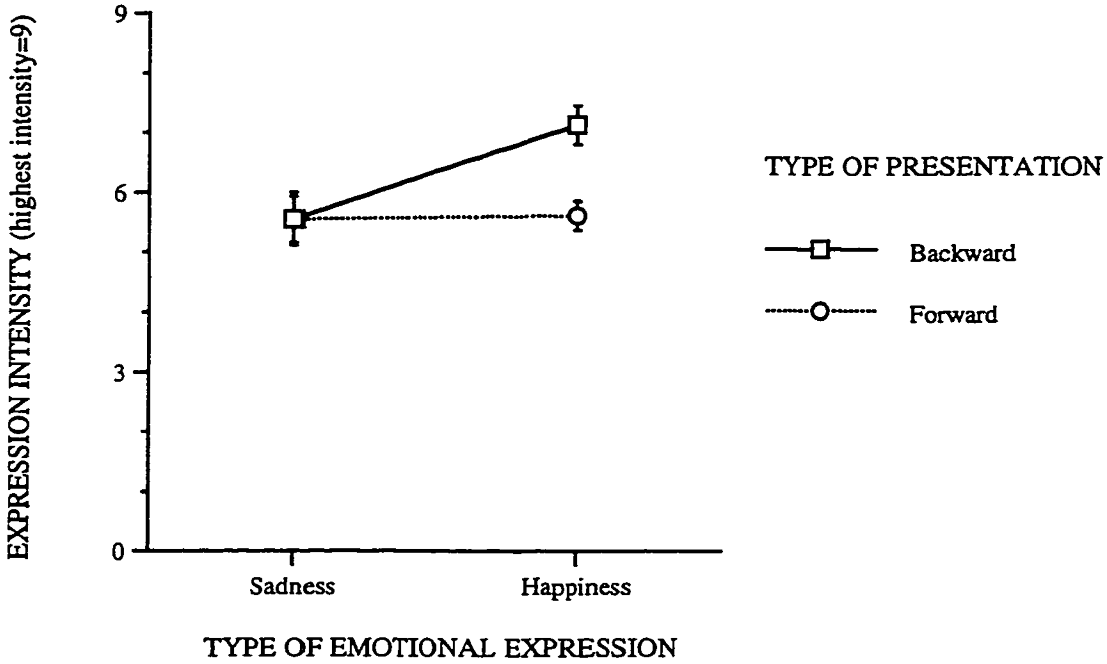

Figure 5.11. Intensity of expression as a function of both the type of emotional expression and the type of presentation for Poser 5.

significantly different from half-speed or double-speed, but half-speed was different from double-speed. For backward movies, the same pattern was observed (i.e. only half-speed and double-speed differed significantly). Despite the same pattern of significant pairwise comparisons, the effect was opposite. Half-speed tended to increase ratings of intensity for forward movies while decreasing the intensity ratings of backward movies. Furthermore, double-speed tended to have the reverse effect, in that it decreased ratings of intensity for forward movies (to yield lower than normal ratings) while it increased intensity ratings for backward movies (to produce higher than normal ratings).

Last of all, the remaining interaction of interest, the Emotion x Speed two-way interaction, was first analyzed via simple effects. This analysis indicated that the Emotion x Speed interaction was a result of a significant simple effect of Speed at Happiness [$F(2, 18)=7.423$, $p<.05$] and a non-significant simple effect of Speed at Sadness [$F(2, 18)=3.167$, $p>.05$]. Thereafter, Tukey (hsd) pairwise comparisons were performed to isolate the Speed at Happiness simple effect. Half-speed was found to be significantly different from double-speed for the happiness sequences. Despite their trend, half-speed did not differ significantly from normal speed and likewise, normal speed did not differ from double-speed. More specifically, half-speed increased intensity ratings compared to normal speed, while double-speed decreased intensity ratings compared to normal speed.

Also contrary to the realness data, the effect of speed was more complicated and messy for intensity of emotion ratings, dependent on several variables. That is, the speed at which the movie was played sometimes interacted with the original direction of the movie but always depended on the poser (as shown in Figures 5.12 to 5.16). Speed also interacted with the type of emotion portrayed in the sequence. This effect was more clear. Increasing the speed of the sequence increased intensity rating of sadness expressions

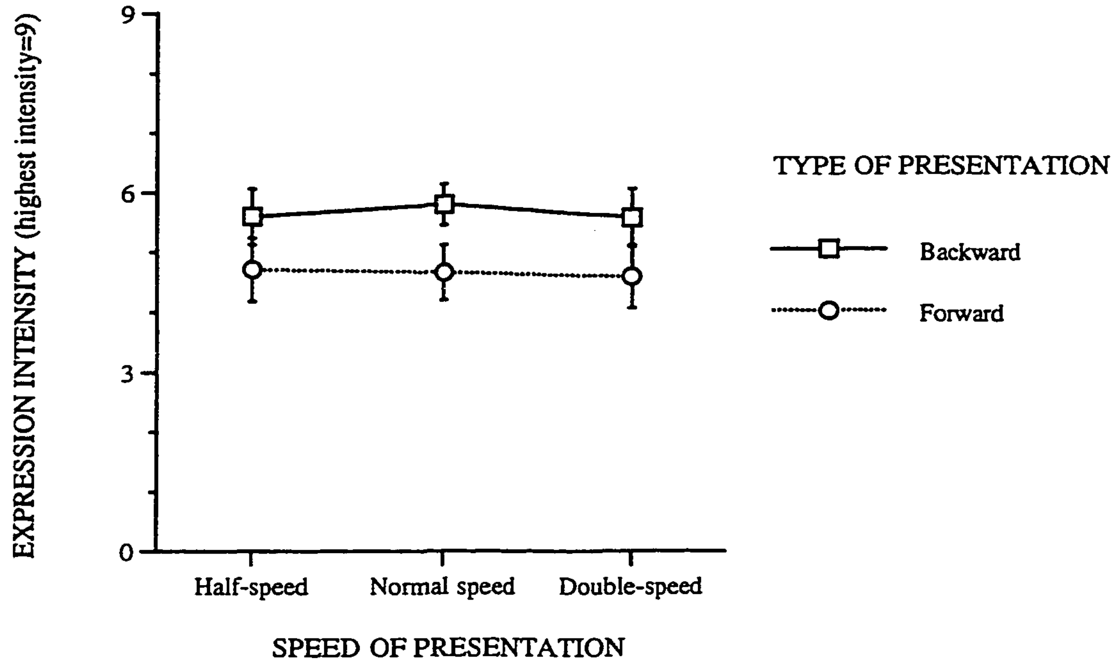

Figure 5.12. Intensity of expression as a function of both the speed of presentation and the type of presentation for Poser 1.

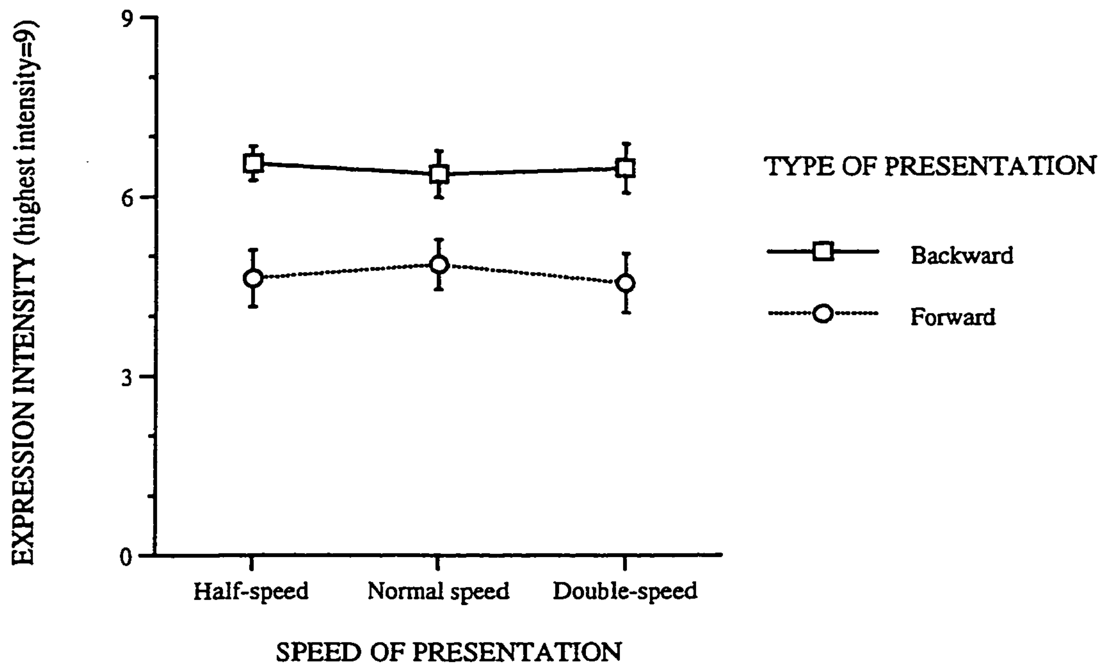

Figure 5.13. Intensity of expression as a function of both the speed of presentation and the type of presentation for Poser 2.

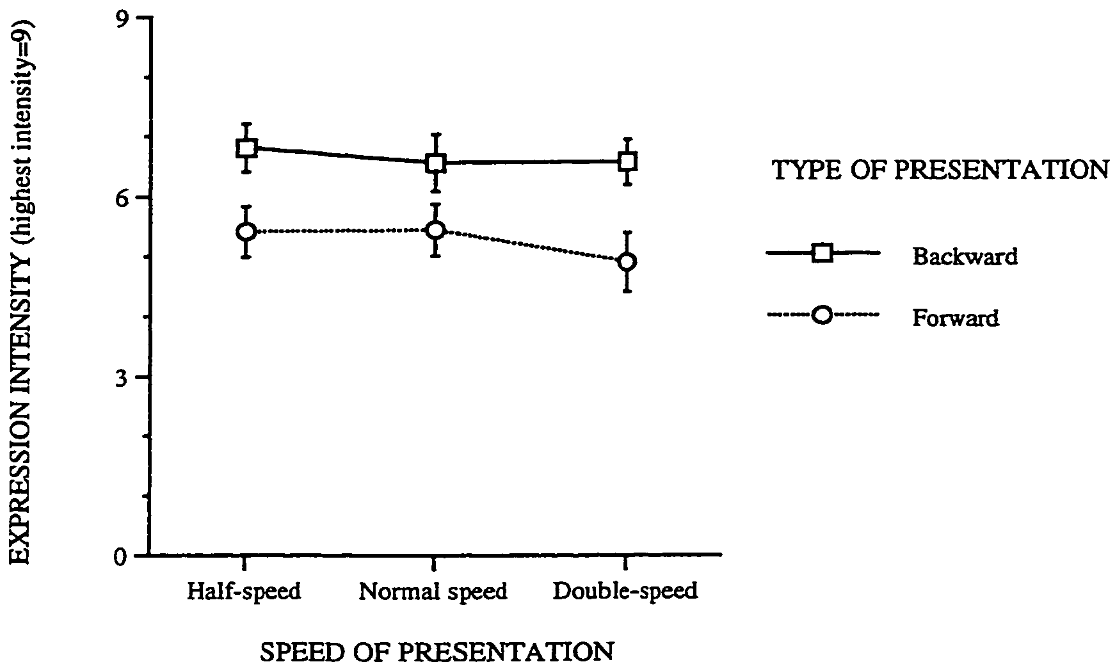

Figure 5.14. Intensity of expression as a function of both the speed of presentation and the type of presentation for Poser 3.

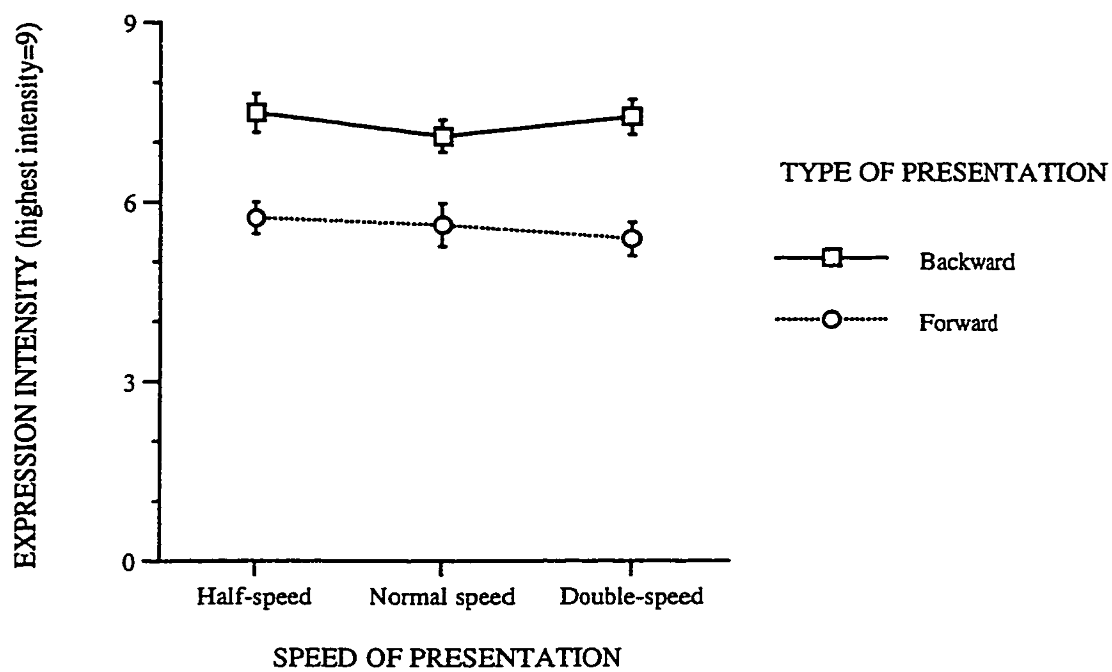

Figure 5.15. Intensity of expression as a function of both the speed of presentation and the type of presentation for Poser 4.

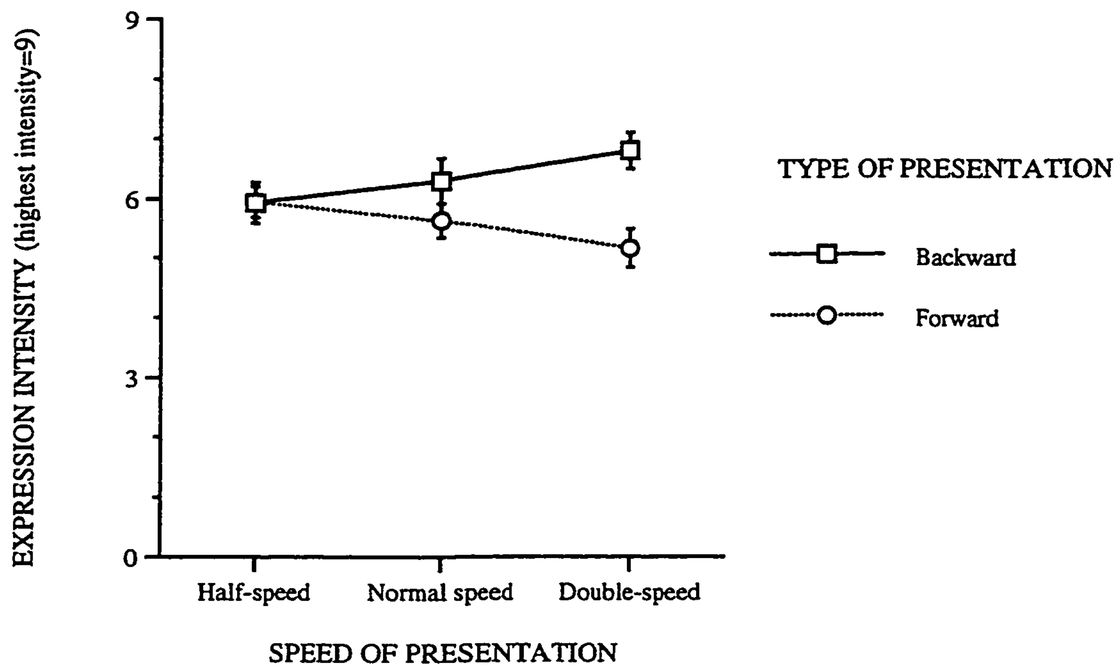

Figure 5.16. Intensity of expression as a function of both the speed of presentation and the type of presentation for Poser 5.

(though not statistically) while it decreased the intensity rating of happiness expressions (significant effect). This is illustrated in Figure 5.17.

5.4 Discussion

This experiment was designed to examine the effect of variation in the temporal characteristics of dynamic emotional facial expressions on the judgment of the authenticity and intensity of the expressions. The results supported in part the hypothesis according to which any deviations from the normal speed of the dynamic sequences would produce lower ratings of authenticity. However, this effect proved to be complex. The analysis on the rating of authenticity showed a dissociation between the two emotions. First, the happiness sequences always received a rating more authentic than the sadness sequences, regardless of their original direction or poser. The superiority of backward ratings over forward presentations is consistent with the results obtained in the previous experiments.. Backward presentations were again found to be rated as more real than forward presentations with the exception of Poser 2 which would account for the three-way interaction reported in the previous section.

A dissociation between the two emotions was also identified with the speed variation. Half-speed sequences tended to increase authenticity ratings for happiness and decrease authenticity ratings for sadness while double-speed tended to decrease authenticity ratings for happiness and increase authenticity ratings for sadness. One reason which suggests that this effect though weak might be veridical is supported by the inverted relationship along the speed axis for both happiness and sadness. There is no clear explanation which could account for this observation so far. Some insights may reside in the microgenesis of the expressive sequence. One could also propose that the meaning of

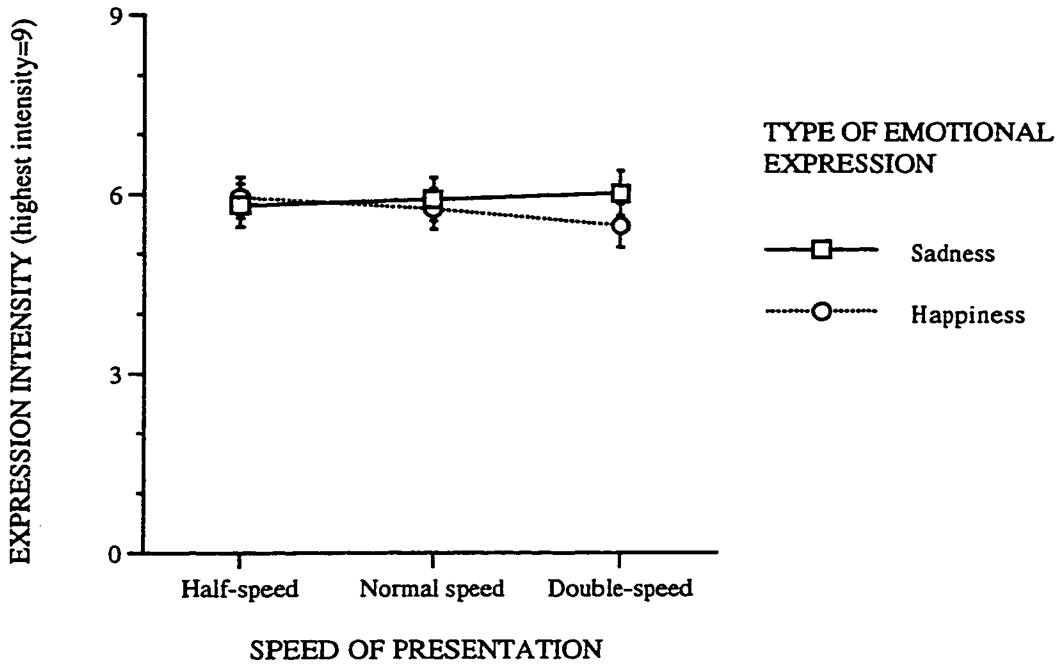

Figure 5.17. Intensity of expression as a function of both the type of emotional expression and the speed of presentation.

this effect would lie in the fact that a slow progression of the features over time accentuates the perception of realness in happiness displays while the opposite occurs for sadness. One explanation which could account for both types of effect at once would be the introduction of a concept where authenticity is linked with a particular speed, an ideal speed of progression. The ideal speed would correspond to a normalized temporal frequency in which the feature displacement at the time of recording would be combined with the speed of presentation. This idea cannot be tested a posteriori with the design and methodology employed here, but it would certainly deserve full attention in the future.

The analysis of the intensity ratings revealed a complicated pattern of results. The happiness sequences were sometimes more intense and sometimes less intense than sadness. None of the effects were consistent across posers. Therefore, the hypothesis that faster speed would produce higher rating of perceived emotional intensity was not supported. These results suggest that the intensity judgment as it might be predicted could be highly dependent on the feature configuration in the face (see Wallbott, 1992 for a similar view). This is mainly supported by the difference observed across posers which would also perhaps underline a difference in their feature configurations. In considering the variation in intensity that may exist before the manipulations are introduced, it would be interesting to try to equate the intensity of the stimuli in the future.

Contrary to the authenticity judgment, the effect of speed depended on the poser and direction. To simplify, the speed at which the movie was played sometimes interacted with the original direction of the movie but always depended on the poser. Poser 5 accounted by himself for the interaction. For this reason, it might be more cautious to attribute this effect to random factors instead of postulating causes for a single stimulus among six others. The replication of this effect would therefore be necessary before attempting to explain or search for a cause.

The two types of measures collected revealed an effect of the temporal factors on the perception of the emotion. One effect that is worth mentioning deals with the authenticity and intensity ratings which both were affected by the increase of the playback speed. Doubling the speed increased the perceived authenticity of the sadness expression at the same time as it increased the perceived intensity of the same expression. This finding suggests that the increase in speed accentuates the authenticity as well as the intensity. Happiness expressions were also affected in an opposite manner. Doubling the speed reduced the perceived authenticity of the happiness expression at the same time as it reduced the perceived intensity of the same expression. On the basis of these results, the happiness sequences would be perceived as less genuine and less intense when presented too fast. Sadness would, on the other hand, gain in intensity and be more genuine with faster presentation. One possibility to explain this pattern of results would be to refer to the concept of active and passive emotions (Ekman, 1984; Wallbott, 1992). Happiness as an active emotional expression would possess a characteristic time course which according to these observations would differ from the one postulated for sadness.

Interestingly, Hess and Kleck's (1990) comparison of elicited and deliberate emotional facial expressions using happiness and disgust revealed an effect of temporal properties. Their results indicated that the two types of expression have different temporal properties. In the present case, the authenticity judgment was more affected than the judgment of intensity. Intensity was only marginally affected by the temporal factors. This would suggest that the judgment of intensity would rely less on the temporal factors present in the emotional sequence. It could be that the information necessary to assess the intensity of an emotion is directly linked to the spatial displacement of the features in the face rather than to the speed at which the emotion develops.

As shown in the past, posed and spontaneous dynamic facial expressions possess subtle temporal information that can distinguish them from one another. Researchers argue that the typicality of posed expressions might affect the genuine aspect of an emotional expression (Ekman, Hager & Friesen, 1981; Kowner; 1995; Skinner & Mullen, 1991; Ekman & Friesen, 1984; Rinn, 1984; Hager & Ekman, 1985; Weiss, Blum & Gleberman, 1987; Hess and Kleck, 1990; Gosselin & Kirouac, 1994). The judgment of authenticity in this experiment, however, seems not to have suffered from the utilization of posed expressions. This observation is supported by the high rating of authenticity obtained with the happiness sequences. One might argue that the judgment reflects a different set of standards as the one required when judging the authenticity among posed and spontaneous expressions (Gosselin & Kirouac, 1994).

EXPERIMENT 4

6.1. Introduction

The purpose of the fourth experiment was to compare the mode of presentation (i.e. static and dynamic) in order to estimate the relative contribution of each mode, using a two alternative forced choice procedure. As discussed before only few studies have compared static and dynamic emotional facial expressions. For example, Lemay, Kirouac and Lacouture (1995) found the dimensionallity axes were similar for both modes of presentation. Interestingly, categorical judgments were easier when dynamic stimuli were presented. The authors proposed that dynamic presentations are more easily judged because they possess temporal information (movement of the facial features over time). Similar findings were also obtained by Landry (1993). The importance of the temporal information is also supported by Russell and Fehr (1987), who have shown that the context surrounding an expression may affect the judgment of this expression.

Other researchers reported an advantage for dynamic over static emotional facial expressions (Dubé, von Grünau & Kwas, 1995). Dynamic facial expressions were identified with more accuracy than static depictions of the same expression. The difference between the two Psychophysical functions suggests that the visual information present in emotional facial expressions varies in strength when dynamic and static comparisons are made. These results support the idea that clues present in frames preceding the final, or static depiction, provide important information for the disambiguation of the emotional expression.

Recently, Thornton and Kourtzi (1997) also reported an advantage of dynamic over static depictions of human faces. The results indicated that subjects' performance was identical for dynamic and static primes in the same person/same emotion condition. However, a dynamic advantage was found when the person was the same but the expression was different. No difference was found for the other conditions. The authors interpreted the results as evidence for a modulation of identity performance as a consequence of the type of information which is presented at the time of encoding. Dynamic information would produce a representation that facilitates matching of identity when expressions are different.

Based on these previous findings, this experiment further examined the processing of static and dynamic emotional facial expressions. The rationale behind this manipulation was to replicate previous findings using untrained posers and to modify the methodology as to increase the generalizability of the results. Dubé et al. (1995) reported two difficulties associated with their stimuli. The first one was that only two posers were utilized. The second one was that posers had great difficulties to depict a neutral affect. Therefore, it appears of great importance to obtain emotional facial expressive sequences which possess a true neutral phase.

Consequently, four posers were used, instead of two. Their representativeness was verified by the judgment performance obtained on these sequences in experiment 2. Contrary to Landry (1993) static stimuli always had the same spatial content as the dynamic ones such that the apex of the dynamic sequence was always the same as the static sequence. In both the studies by Dubé et al.(1995) and Thornton and Kourtzi (1997), stimuli were constructed according to this rule. There is, however, one inconvenience with this choice of procedure. It might be possible that the results be biased in favor of the static representation and, therefore, a stronger advantage for dynamic might occur if this bias could be removed. It was hypothesized that dynamic information present in a sequence would lead to higher recognition rates than a static sequence which corresponds to the dynamic apex of the same excerpt.

6.2 Method

6.2.1 Subjects

Ten individuals participated in this experiment. All participants were recruited on a single basis through solicitation among, though not exclusively, the department of psychology population at Concordia University. Overall, the ratio of participants was biased towards fellow graduate students and both genders were recruited. The age of the participants varied between 21 and 52 years. Some of the subjects recruited for this experiment had also been solicited for the previous experiments. The subjects were informed of the research domain but were kept naive as to the purpose of the experiment.

6.2.2 Stimuli

The stimuli used in this experiment were selected among the dynamic sequences used in Experiment 2. Poser 4 was, however, removed from the set because the sequences obtained from that poser were significantly longer than the ones obtained from the other posers which might in return bias the judgment of the observers. From each poser two sequences were selected out of the possible four (see Section 5.2.2), one depicting happiness, the other sadness. In addition, this selection had to satisfy the following constraints: (1) the chosen segments' recognition rates had to be high, and (2) the standard deviation of the recognition threshold had to be low. Short movie clips were then constructed from these sequences in the following manner. The original sequence was modified so as to terminate either (1) at the previously established threshold, T, or (2) at T minus 6, 12, and 18 frames, or (3) at T plus 6 and 12 frames. The six frame interval was derived from an estimation of the time necessary to press the response key. This estimate was thought to be equal to 200 ms, which after conversion into frames per second, corresponded to six frames. The T plus 12 frames condition was dropped since pilot studies demonstrated a ceiling effect. This left 10 different sequences which were used for each of the five posers in the T, T+6, and T-6, conditions. Exceptions had to be made for conditions T-12 and T-18 where four sequences (out of the twenty) were dropped due to the brevity of the movie clips for certain posers. Thus a total of 46 dynamic stimuli was left. The total clip duration varied according to the poser and the condition. Forty six static stimuli were also constructed by simply extracting the last frame from each dynamic sequence and duplicating it in order to yield an equal number of frames to its dynamic counterpart. Consequently, both types of stimuli (dynamic and static) always had the same duration and the identical last frame.

6.2.3 Procedure

The subjects were first asked to sign a consent form (Appendix C) and then were tested individually in a quiet room, seated in front of the computer screen at a distance of 57 cm. At all times they were instructed to look at the screen following the initiation of each trial. All trials were presented one at a time in a randomized order, however, the dynamic and static sequences were divided into two separate blocks. The two blocks were counterbalanced among the 10 subjects. A typical trial consisted of a sequence (static or dynamic), followed by a checkerboard mask which lasted for a second. Thereafter, the subjects were presented with an on-screen dialogue box to enter their responses. The subject's first task was a two alternative forced choice judgment, where they had to indicate which emotion they thought was depicted, by depressing either the letter "S" (sadness) or "H" (happiness) on the keyboard. A subsequent task was also required where the subject had to assess the certainty of their judgment, on a scale from 0 to 9. The time allotted to make the judgments was determined by the subject's own pace. After both responses were entered, the next trial was initiated by pressing the enter key on the keyboard. Each sequence was repeated 20 times for a total of 920 static and 920 dynamic sequences. Each block lasted approximately 60 minutes yielding a total of about 2 hours to complete the entire experiment.

6.2.4 Statistical design

Consequently, the statistical design of Experiment 4 was a 2x2x5 repeated measures factorial analysis of variance (ANOVA), where the first variable corresponded to the type of Sequence (2 levels: dynamic and static), the second one corresponded to type of Emotion (2 levels: sadness and happiness), and the third one consisted of the amount of Information present in the sequence (5 levels: T-18, T-12, T-6, T, and T+6). [note: this design was modified for posers 3, 5, and 6 who lacked one or two levels of the "amount of information" variable. More specifically, a 2x2x3 ANOVA was run for poser 3 while 2x2x4 ANOVAs were run for posers 5 and 6.]

6.3 Results

For each of the approximately 100 combinations of poser, expression, type of sequence, and amount of information, both the percent correct identification of the expression and the salience of the expression were measured at each of the 20 repetitions, for each observer. Subject, and thereafter, group means were then computed for each of the percent correct and saliency data sets. Not all five posers were able to yield movie clips with five levels of information content and furthermore, within a particular poser's sequences the happiness and sadness movies may have produced different levels of information content. It was therefore necessary to conduct separate analyses of variance (ANOVAs) for each poser *and* for each expression within each poser. Two subsequent series of repeated measures were thus run on the data, one series for the percent correct data and another series for the saliency rating data.

6.3.1 Percent Correct Identification of Expression

6.3.1.1 Poser 1

The percent correct identification of each emotional sequence was calculated for each subject per condition for Poser 1 sequences and analyses were performed separately for the happiness and sadness sequences. To determine if the percent correct data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (5 levels: T-18, T-12, T-6, T, and T+6) repeated measures ANOVAs were conducted.

The ANOVA for the *happiness expression* revealed that percent correct identification of expression was dependent on the type of sequence [main effect of Sequence $F(1, 9)=11.009$, $p<.05$], as well as the amount of information content [main effect of Information $F(4, 36)=60.929$, $p<.05$]. The main effects, however, interacted with each other yielding a significant Sequence x Information interaction effect [$F(4, 36)=9.048$, $p<.05$]. Simple effects analysis was thus performed and isolated the interaction to be caused by dynamic sequences having a significantly higher percent correct than static sequences for all levels of information content except T and T+6, i.e. the threshold and above threshold levels [Sequence at T-18 $F(1, 9)=11.695$, $p<.05$, Sequence at T-12 $F(1, 9)=12.228$, $p<.05$, Sequence at T-6 $F(1, 9)=6.084$, $p<.05$, Sequence at T $F(1, 9)=3.857$, $p>.05$, Sequence at T+6 $F(1, 9)=3.273$, $p>.05$]. For instance the values were, respectively for dynamic and static sequences, 48% and 21% for T-18, 54.5% and 25.5% for T-12, 63% and 44% for T-6, 100% and 98.5% for T, and finally 98% and 100% for T+6. Note also that as the amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence. Figure 6.1 demonstrates this effect.

The ANOVA for the *sadness expression* revealed that percent correct identification of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.280$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=33.151$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=.447$, $p>.05$]. Tukey (hsd) pairwise comparisons were thus performed on the significant main effect of information content and it was determined that all pairwise comparisons were significant except T versus T+6, likely due to a ceiling effect. As illustrated by Figure 6.2, respectively for dynamic and static sequences, mean percent correct were 61% and 70.5% for T-18, 76% and 80.5% for T-12, 88% and 89.5% for T-6, 98.5% and 99% for T, and finally 99.5% and 98% for T+6. Note also that as the

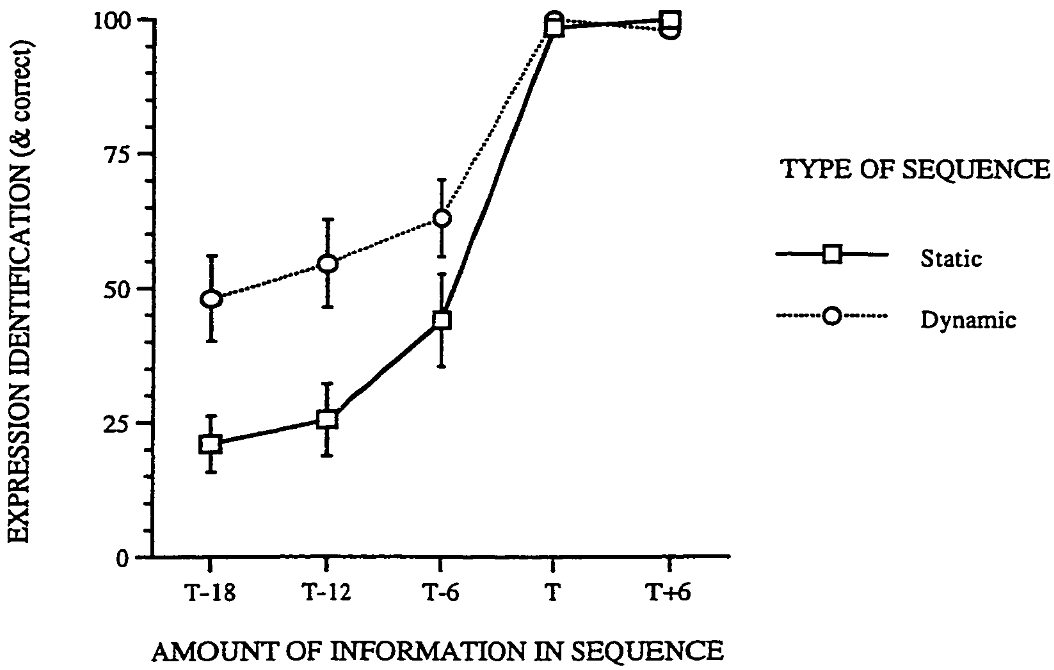

Figure 6.1. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 1's static and dynamic happiness sequences.

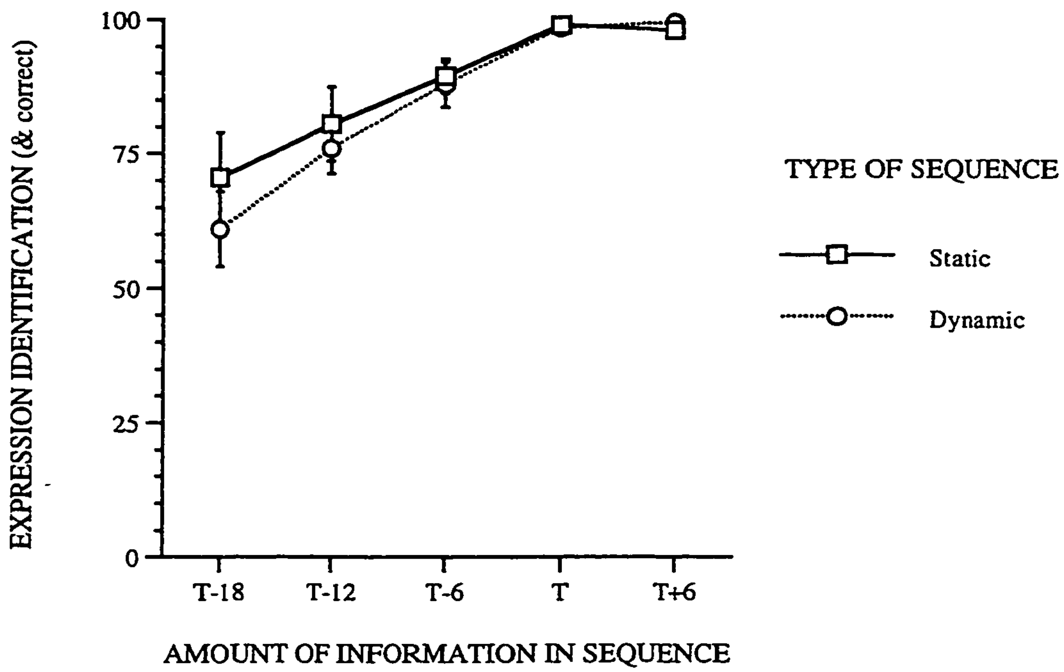

Figure 6.2. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 1's static and dynamic sadness sequences.

amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence.

6.3.1.2 Poser 2

The percent correct identification of each emotional sequence was calculated for each subject per condition for Poser 2 sequences and analyses were performed separately for the happiness and sadness sequences. To determine if the percent correct data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (4 levels: T-12, T-6, T, and T+6 for happiness; 5 levels: T-18, T-12, T-6, T, and T+6 for sadness) a 2 x 4 and a 2 x 5 repeated measures ANOVA were conducted on happiness and sadness data, respectively.

The ANOVA for the *happiness expression* revealed that percent correct identification of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.902$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(3, 27)=279.074$, $p<.05$]. The main effects did not interact with each other yielding a non-significant Sequence x Information interaction effect [$F(3, 27)=.766$, $p>.05$]. Pairwise comparisons (Tukey hsd) of the Information main effect indicated that for this poser T-12 yielded a significantly lower percent correct than all other levels of information. The remaining pairwise comparisons were not significant, and as can be seen in Figure 6.3, this was due to a ceiling effect. For instance the values were, respectively for dynamic and static sequences, 30% and 23.5% for T-12, 99% and 89.5% for T-6, 98% and 99.5% for T, and finally 100% and 100% for T+6. As the amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence.

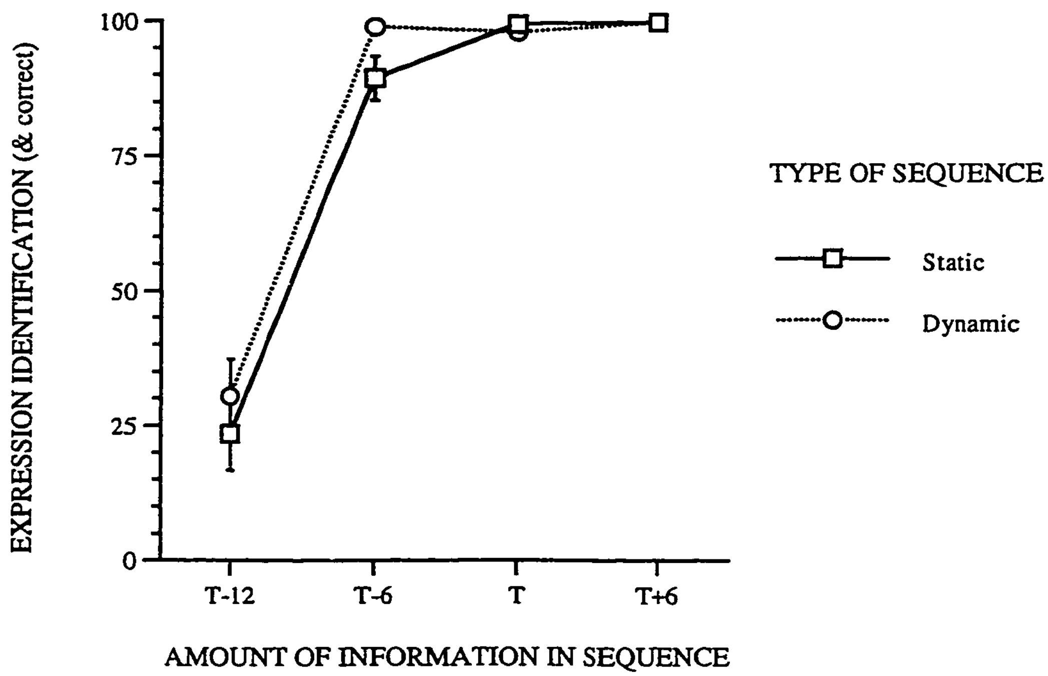

Figure 6.3. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 2's static and dynamic happiness sequences.

The ANOVA for the *sadness expression* revealed that percent correct identification of expression was also not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.153$, $p>.05$], nor on the amount of information content [main effect of Information $F(4, 36)=2.202$, $p>.05$]. Likewise, the Sequence x Information interaction was not significant [$F(4, 36)=.469$, $p>.05$]. As illustrated by Figure 6.4, however, the type of sequence did affect the percent correct identification as demonstrated by superior identification rates for static sequences for T-18, T-12, and T-6 (i.e. the below threshold content) and the superior identification for dynamic sequences for the T and T+6 movies (i.e. the above threshold content). Respectively for dynamic and static sequences, mean percent correct were 92.5% and 96% for T-18, 94% and 96% for T-12, 96.5% and 98.5% for T-6, 99.5% and 98.5% for T, and finally 99% and 98.5% for T+6. Again, as the amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence.

6.3.1.3 Poser 3

The percent correct identification of each emotional sequence was calculated for each subject per condition for Poser 3 sequences and analyses were performed separately for the happiness and sadness sequences. To determine if the percent correct data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (5 levels: T-18, T-12, T-6, T, and T+6) repeated measures ANOVAs were conducted.

The ANOVA for the *happiness expression* revealed that percent correct identification of expression was again not dependent on the type of sequence [main effect of Sequence $F(1, 9)=1.876$, $p>.05$], but was dependent on the amount of information

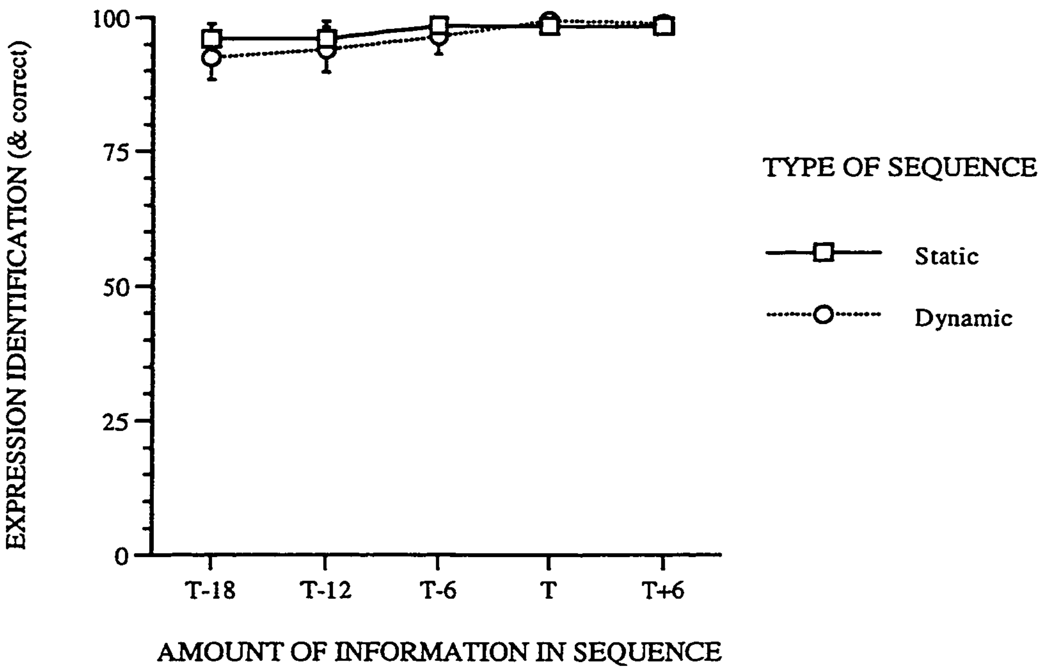

Figure 6.4. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 2's static and dynamic sadness sequences.

content [main effect of Information $F(4, 36)=22.651$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=1.336$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons for the Information main effect were conducted. The T-18 movie was not significantly different from the other two below threshold conditions (i.e. T-12 and T-1). Likewise, T-12 did not lead to significantly different percent correct than T-6. The remaining pairwise comparisons were, on the other hand, all significantly different. Despite the non-significant effect of type of sequence, Figure 6.5 indicated that dynamic sequences were consistently identified better than static versions. For instance the values were, respectively for dynamic and static sequences, 70.5% and 61.5% for T-18, 78% and 56% for T-12, 91% and 65% for T-6, 100% and 88.5% for T, and finally 99.5% and 99% for T+6. Indeed, as the amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence.

The ANOVA for the *sadness expression* revealed that percent correct identification of expression was again not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.244$, $p>.05$], yet was dependent on the amount of information content [main effect of Information $F(4, 36)=2.555$, $p<.05$]. The Sequence x Information interaction was again not significant [$F(4, 36)=.958$, $p>.05$]. Pairwise comparisons (Tukey hsd) of the Information main effect indicated that T-12 differed significantly from T (i.e. T yielded a higher percent correct). All other comparisons were non-significant. As illustrated in Figure 6.6, however, the type of sequence did affect the percent correct identification for above threshold information content, with superior identification for dynamic sequences. Respectively for dynamic and static sequences, for example, mean percent correct were 96% and 96.5% for T-18, 93.5% and 92% for T-12, 94.5% and 95.5% for T-6, 98.5% and 97.5% for T, and finally 99.5% and 93.5% for T+6. As previously demonstrated, as

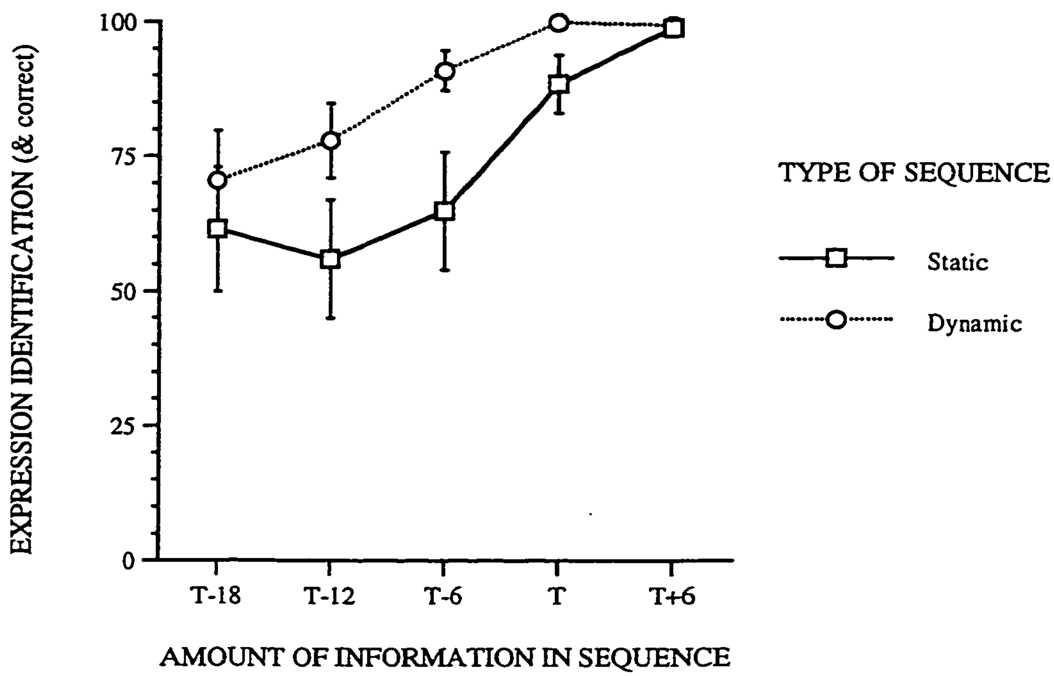

Figure 6.5. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 3's static and dynamic happiness sequences.

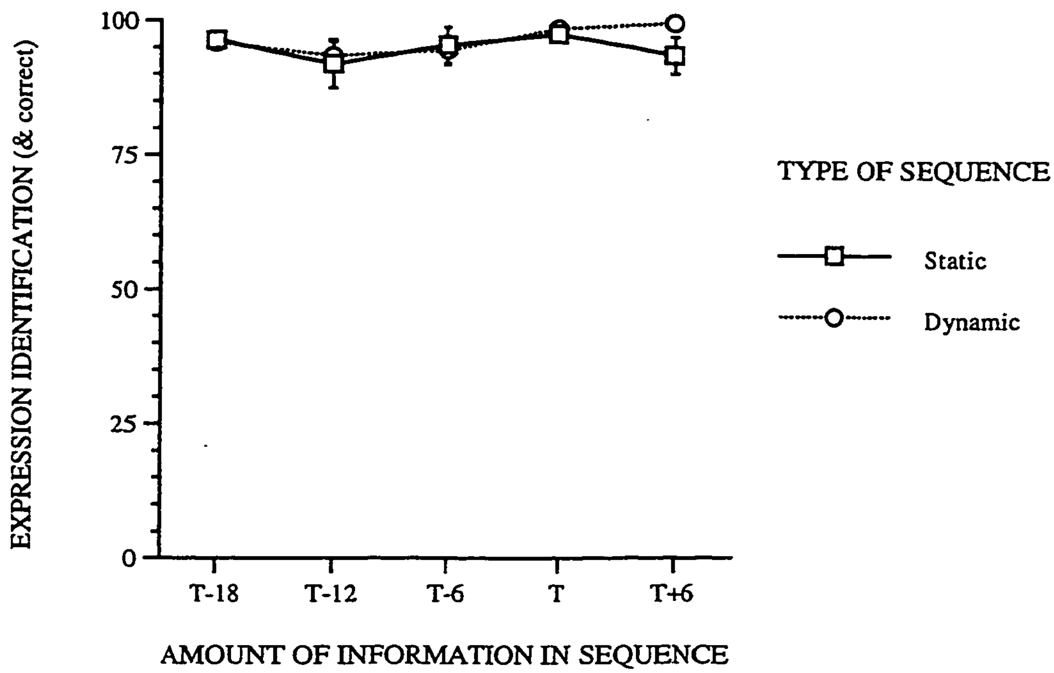

Figure 6.6. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 3's static and dynamic sadness sequences.

the amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence.

6.3.1.4 Poser 4

The percent correct identification of each emotional sequence was calculated for each subject per condition for Poser 4 sequences and analyses were performed separately for the happiness and sadness sequences. To determine if the percent correct data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (5 levels: T-18, T-12, T-6, T, and T+6 for happiness; 3 levels: T-6, T, and T+6 for sadness) a 2 x 5 and a 2 x 3 repeated measures ANOVA were conducted for the happiness and sadness data sets, respectively.

The ANOVA for the *happiness expression* revealed that percent correct identification of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=1.782$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=43.168$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=1.268$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons for the Information main effect were conducted. T-18 was found to yield significantly lower percent correct compared to all other information content movies. T-12 produced significantly lower percent correct identification than T and T+6, but not T-6. T-6 was not found to give significantly lower identification than T nor T+6, and likewise, T did not differ significantly from T+6. As can be seen in Figure 6.7, contrary to the statistics, the dynamic sequences tended to yield better identification of emotion with, for instance, 64% and 44% for T-18, 82% and 75% for T-12, 95% and 82.5% for T-6, 100% and 91.5% for T, and finally 99.5% and 97.5%

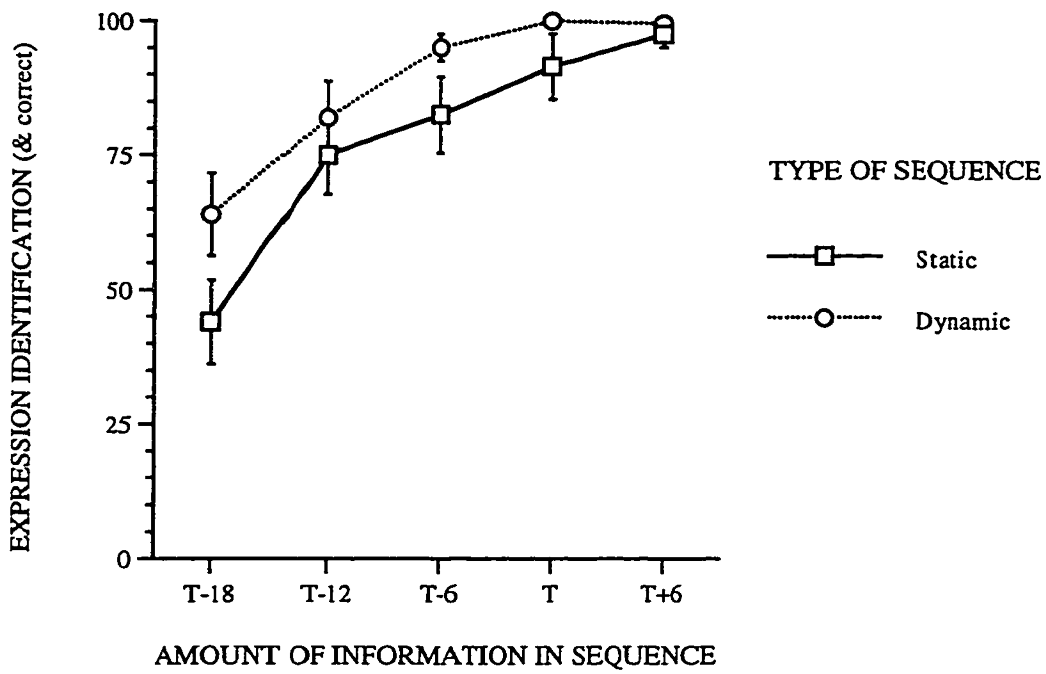

Figure 6.7. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 4's static and dynamic happiness sequences.

for T+6, respectively for dynamic and static sequences. Indeed, as the amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence.

The ANOVA for the *sadness expression* revealed that percent correct identification of expression was also not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.802$, $p>.05$], nor on the amount of information content [main effect of Information $F(2, 18)=.162$, $p>.05$]. Likewise, the Sequence x Information interaction was not significant [$F(2, 18)=.904$, $p>.05$]. A ceiling effect is the likely reason why no significant effects were demonstrated. As illustrated in Figure 6.8, however, the type of sequence did have a slight effect on the percent correct identification for below threshold information content movies, as demonstrated by superior identification for dynamic sequences for T-6. Respectively for dynamic and static sequences, for instance, mean percent correct were 100% and 98% for T-6, 99% and 99.5% for T, and finally 99.5% and 99.5% for T+6. As the amount of information increased so did the percent correct identification of emotion for static depictions only, the dynamic being at ceiling.

6.3.1.5 Poser 5

The percent correct identification of each emotional sequence was calculated for each subject per condition for Poser 5 sequences and analyses were performed separately for the happiness and sadness sequences. To determine if the percent correct data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (4 levels: T-12, T-6, T, and T+6 for happiness; 5 levels: T-18, T-12, T-6, T, and T+6 for sadness) a 2 x 4 and a 2 x 5 repeated measures ANOVA were conducted for the happiness and sadness data sets, respectively.

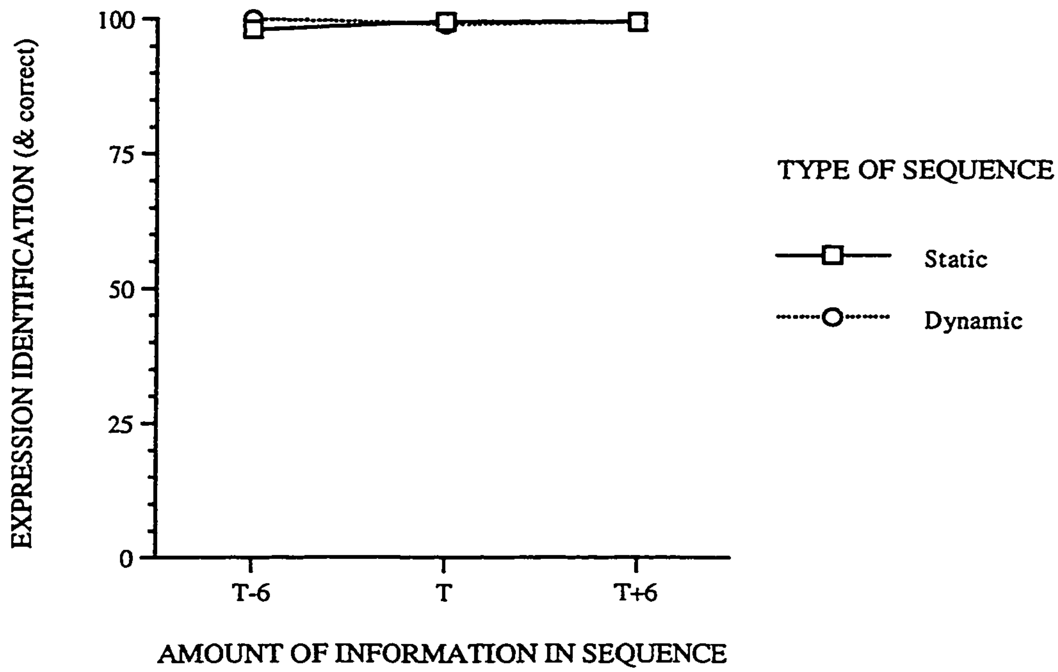

Figure 6.8. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 4's static and dynamic sadness sequences.

The ANOVA for the *happiness expression* revealed that percent correct identification of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=1.295$, $p>.05$], nor on the amount of information content [main effect of Information $F(3, 27)=.873$, $p>.05$]. Likewise, the Sequence x Information interaction was not significant [$F(3, 27)=1.145$, $p>.05$]. As illustrated in Figure 6.9, however, the type of sequence did slightly affect the percent correct identification as demonstrated by superior identification for static sequences for T-12, T-6 and T (i.e. the below threshold content) and the superior identification for dynamic sequences for the T+6 movies (i.e. the above threshold content). Respectively for dynamic and static sequences, mean percent correct were 93.5% and 99% for T-12, 96.5% and 99.5% for T-6, 96.5% and 99% for T, and finally 100% and 98.5% for T+6. This was caused by a ceiling effect for static sequences and an effect of information content for dynamic sequences (as the amount of information increased so did the percent correct identification of emotion).

The ANOVA for the *sadness expression* revealed that percent correct identification of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=1.873$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=16.718$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=.573$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons were conducted for the Information main effect. T-18 was found to yield significantly lower percent correct compared to all other information content movies. T-12 produced significantly lower percent correct identification than T and T+6, but not T-6. T-6 was not found to give significantly lower identification than T nor T+6, and likewise, T did not differ significantly from T+6. As can be seen in Figure 6.10, contrary to the statistics, the dynamic sequences tended to yield better identification of emotion with, for instance, 87.5% and 79.5% for T-18, 93% and 90.5% for T-12, 98% and 92% for T-6, 99.5% and 97% for T, and finally 100% and 98% for T+6, respectively for dynamic

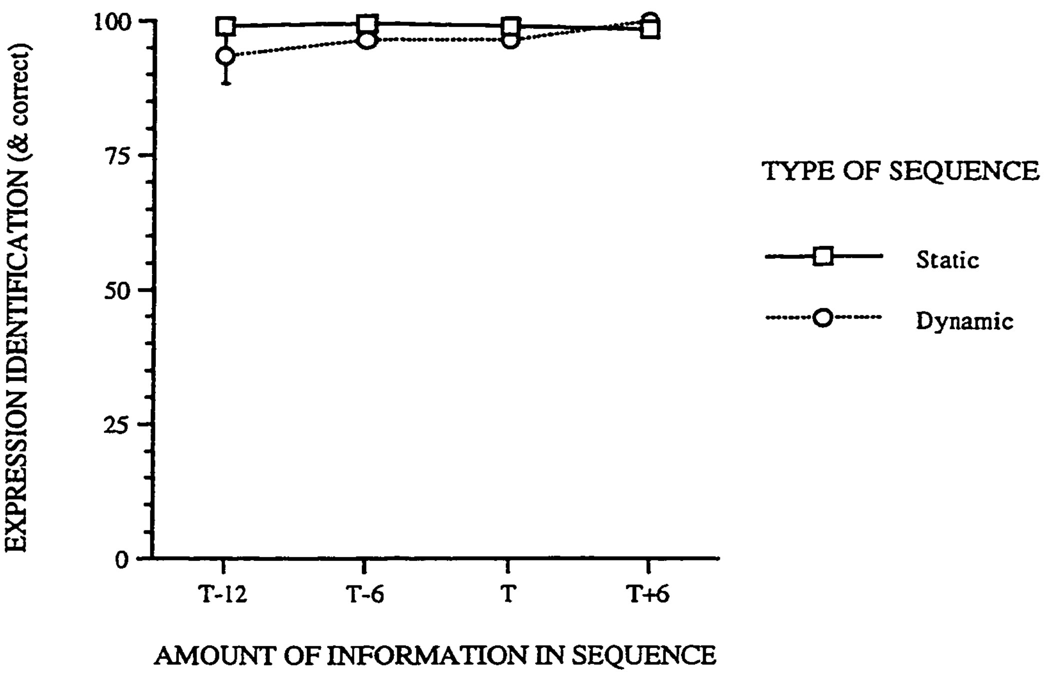

Figure 6.9. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 5's static and dynamic happiness sequences.

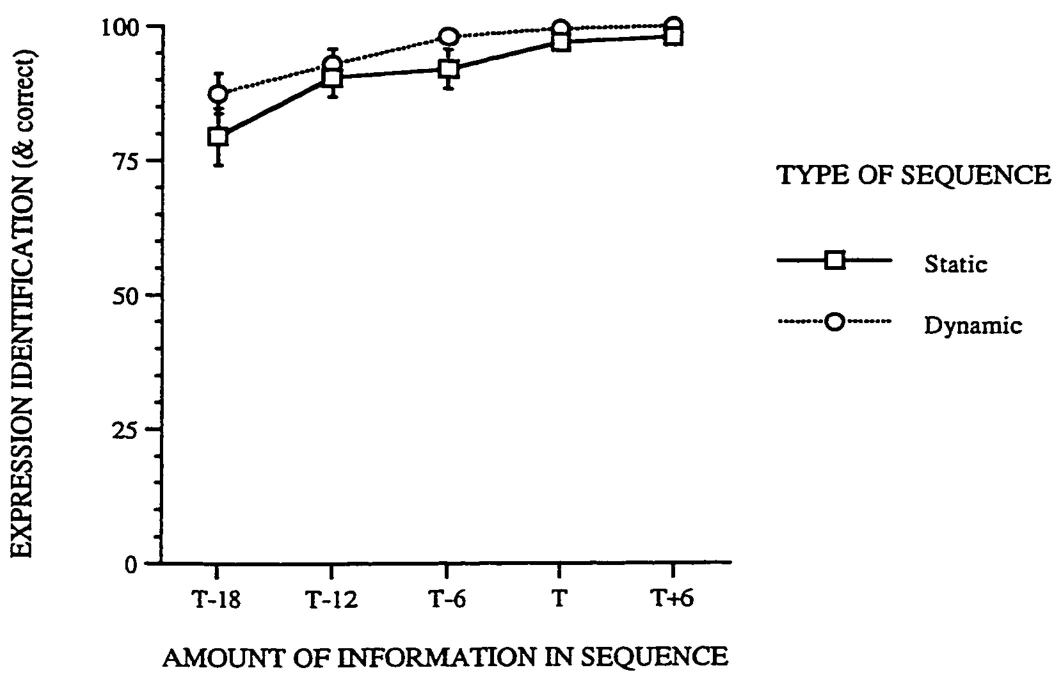

Figure 6.10. Identification of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 5's static and dynamic sadness sequences.

and static sequences. Indeed, as the amount of information increased so did the percent correct identification of emotion, regardless of the type of sequence.

Summary

In conclusion, as was typically observed for all posers, as the amount of information increased in the movie clip, so did the percent correct identification of emotion. In addition, and despite the lack of significance, there does indeed seem to be a trend for a difference in the percent correct identification of emotion dependent on the type of sequence used. As observed with all observers, regardless of emotion, there does seem to be a dynamic superiority in identification rates and the fact that this was non-significant most of the time is likely due to ceiling effects.

6.3.2 Saliency of Expression Rating

6.3.2.1 Poser 1

The saliency of expression rating of each emotional sequence was calculated for each subject per condition for Poser 1, and analyses were performed separately for the happiness and sadness sequences. To determine if the saliency rating data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (5 levels: T-18, T-12, T-6, T, and T+6) repeated measures ANOVAs were conducted.

The ANOVA for the *happiness expression* revealed that saliency of expression rating was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=1.417$, $p>.05$], but was dependent on the amount of information content [main effect of

Information $F(4, 36)=120.268$, $p<.05$]. The main effects did not interact with each other yielding a non-significant Sequence x Information interaction effect [$F(4, 36)=.460$, $p>.05$]. Tukey (hsd) pairwise comparison analysis was thus performed to isolate the main effect of Information. T-18 was not found to differ significantly from the other two below threshold information movies (i.e. T-12 and T-1), but did yield significantly lower saliency rates compared to T and T+6. Likewise, T-12 did not differ from T-6, but did produce lower saliency rates than T and T+6. T-6 also gave significantly lower rates than T and T+6. T, however, did not differ from T+6. Despite the lack of a significant main effect of type of sequence, as illustrated in Figure 6.11, there was again a dynamic superiority for saliency ratings. For instance, respectively for dynamic and static sequences, the values were 1.60 and .85 for T-18, 1.66 and 1.16 for T-12, 2.08 and 1.06 for T-6, 6.52 and 6.02 for T, and finally 7.49 and 6.50 for T+6. Note also that as the amount of information increased so did the rating of saliency, regardless of the type of sequence.

The ANOVA for the *sadness expression* revealed that saliency of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.018$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=48.003$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=.649$, $p>.05$]. Tukey (hsd) pairwise comparisons were thus performed on the significant main effect of information content, and it was determined that all pairwise comparisons were significant except T-18 versus T-12 and T versus T+6. As illustrated in Figure 6.12, static and dynamic sequences did not differ. Respectively for dynamic and static sequences, ratings of saliency were 2.39 and 2.32 for T-18, 2.66 and 2.79 for T-12, 3.37 and 3.55 for T-6, 4.35 and 4.76 for T, and finally 4.96 and 4.76 for T+6. Note also that as the amount of information increased so did the saliency rating, regardless of the type of sequence.

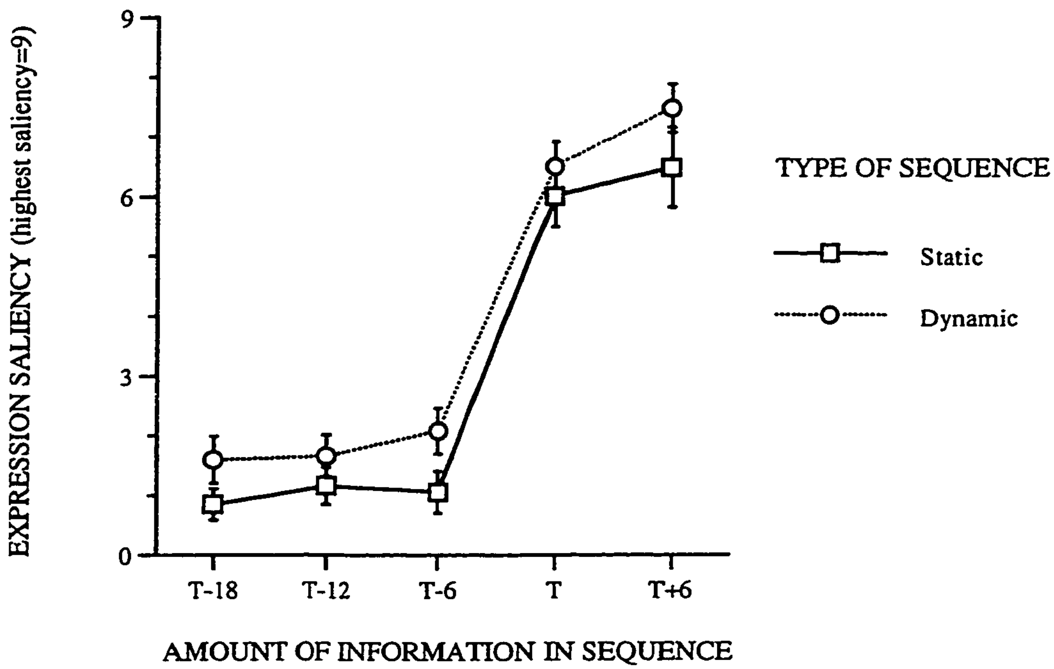

Figure 6.11. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 1's static and dynamic happiness sequences.

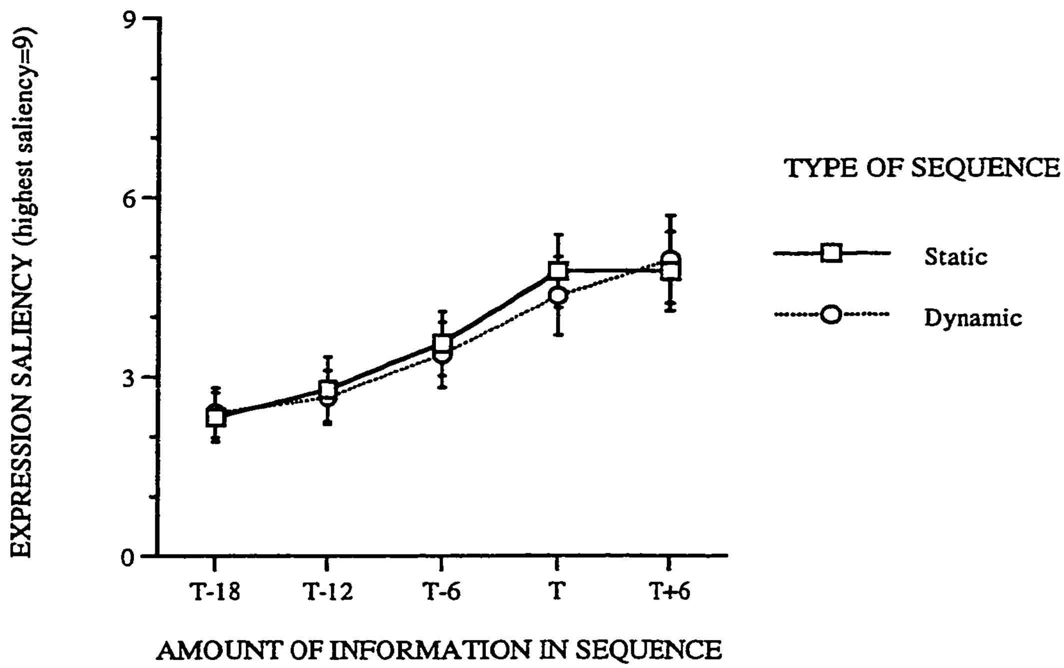

Figure 6.12. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 1's static and dynamic sadness sequences.

6.3.2.2 Poser 2

The saliency rating of each emotional sequence was calculated for each subject per condition for Poser 2, and analyses were performed separately for the happiness and sadness sequences. To determine if the saliency rating data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (4 levels: T-12, T-6, T, and T+6 for happiness; 5 levels: T-18, T-12, T-6, T, and T+6 for sadness) a 2 x 4 and a 2 x 5 repeated measures ANOVA were conducted on happiness and sadness data, respectively.

The ANOVA for the *happiness expression* revealed saliency rating of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.209$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(3, 27)=97.801$, $p<.05$]. The main effects did not interact with each other yielding a non-significant Sequence x Information interaction effect [$F(3, 27)=1.268$, $p>.05$]. Pairwise comparisons (Tukey hsd) of the Information main effect indicated that for this poser all pairwise comparisons were significant. Again, saliency rates were consistently higher for dynamic sequences in spite of a non-significant main effect. As shown in Figure 6.13, respectively for dynamic and static sequences, the values were 2.07 and 1.62 for T-12, 4.70 and 3.25 for T-6, 5.49 and 4.22 for T, and finally 6.12 and 5.03 for T+6. As the amount of information increased so did the saliency rating of emotion, regardless of the type of sequence.

The ANOVA for the *sadness expression* revealed that saliency of expression was also not dependent on the type of sequence [main effect of Sequence $F(1, 9)=1.898$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=50.089$, $p<.05$]. However, the Sequence x Information interaction

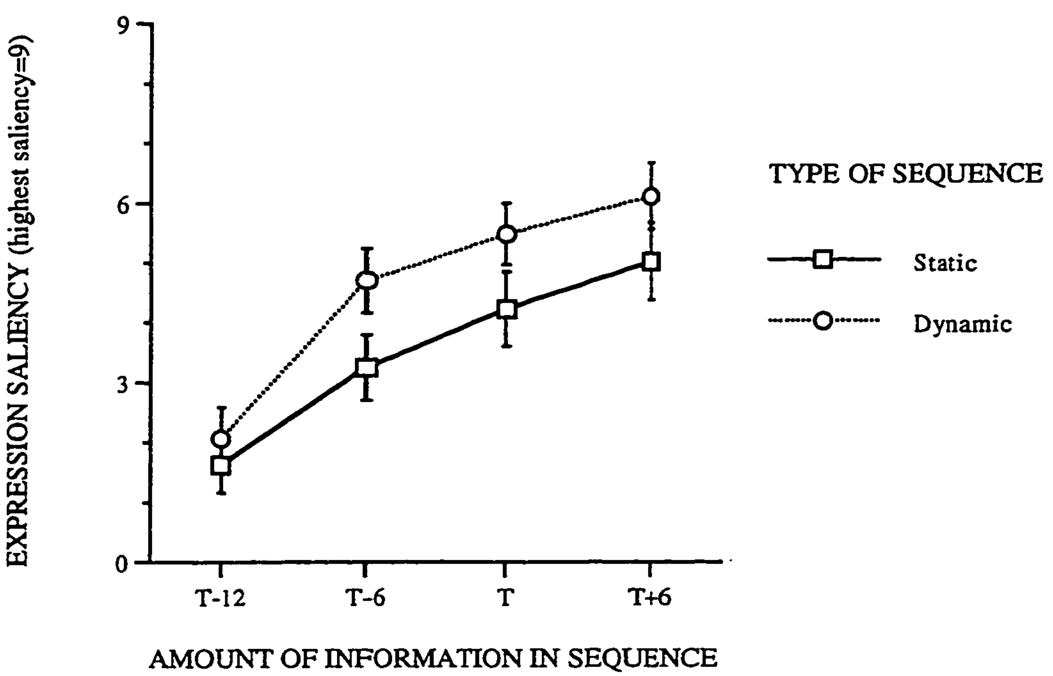

Figure 6.13. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 2's static and dynamic happiness sequences.

was not significant [$F(4, 36)=1.264$, $p>.05$]. Tukey (hsd) analysis revealed that T-18 was not different from T-12, T-6 did not differ from T, and T did not differ from T+6. All other comparisons were significant. As illustrated in Figure 6.14, however, the type of sequence did affect the saliency rating, and contrary to previous findings, there was a superior saliency for static sequences. Respectively for dynamic and static sequences, mean saliency rates were 3.49 and 4.70 for T-18, 3.87 and 5.03 for T-12, 4.71 and 5.48 for T-6, 4.93 and 5.89 for T, and finally 5.15 and 6.17 for T+6. Again, as the amount of information increased so did the saliency rates of emotion, regardless of the type of sequence.

6.3.2.3 Poser 3

The saliency rate of each emotional sequence was calculated for each subject per condition for Poser 3, and analyses were performed separately for the happiness and sadness sequences. To determine if the saliency rate data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (5 levels: T-18, T-12, T-6, T, and T+6) repeated measures ANOVAs were conducted.

The ANOVA for the *happiness expression* revealed saliency rate of expression was again not dependent on the type of sequence [main effect of Sequence $F(1, 9)=2.353$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=97.768$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=2.080$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons were conducted for the Information main effect. The T-18 movie was not significantly different from the T-12 condition. Likewise, T-12 did not lead to significantly different ratings than T-6. The remaining pairwise comparisons were all

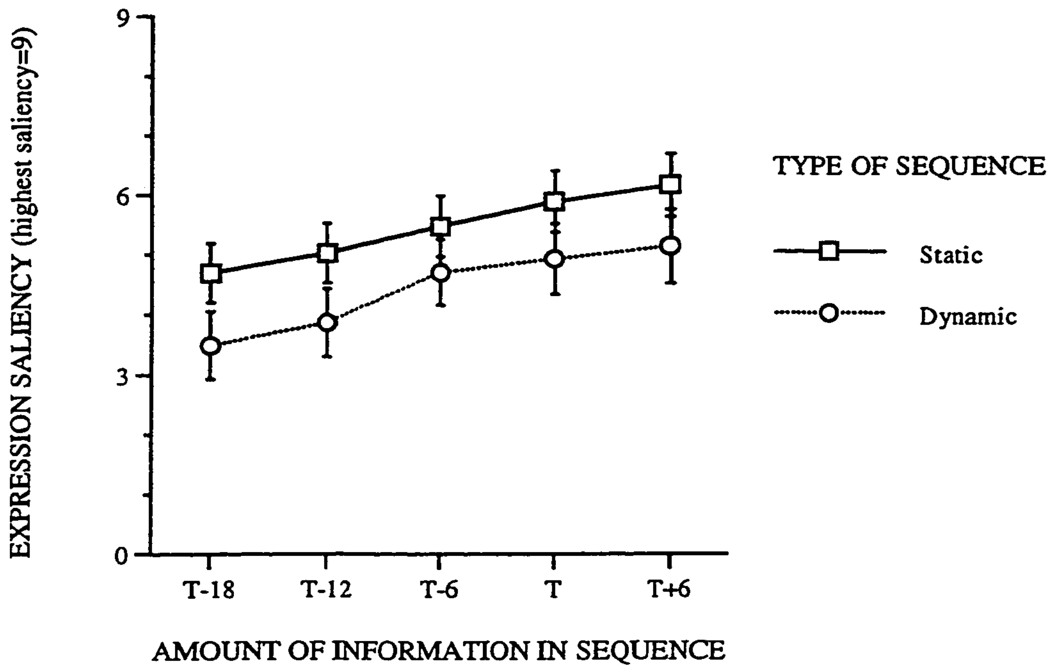

Figure 6.14. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 2's static and dynamic sadness sequences.

significantly different. Despite the non-significant effect of type of sequence, Figure 6.15 indicated that dynamic sequences were consistently rated higher in saliency than static versions. For instance, respectively for dynamic and static sequences, the values were 2.34 and 1.65 for T-18, 3.37 and 1.83 for T-12, 3.96 and 2.55 for T-6, 6.24 and 4.29 for T, and finally 7.55 and 6.59 for T+6. Indeed, as the amount of information increased so did the saliency rating of emotion, regardless of the type of sequence.

The ANOVA for the *sadness expression* revealed that saliency rating of expression was again not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.059$, $p>.05$], yet was dependent on the amount of information content [main effect of Information $F(4, 36)=47.173$, $p<.05$]. These two main effects, however, interacted [Sequence x Information interaction $F(4, 36)=5.332$, $p<.05$]. Simple effects analysis was thus performed and isolated the interaction to be caused by dynamic sequences having a significantly higher percent correct than static sequences only for T+6 [Sequence at T-18 $F(1, 9)=$, $p>.05$, Sequence at T-12 $F(1, 9)=$, $p>.05$, Sequence at T-6 $F(1, 9)=$, $p>.05$, Sequence at T $F(1, 9)=$, $p>.05$, Sequence at T+6 $F(1, 9)=$, $p<.05$]. For instance, respectively for dynamic and static sequences, the values were 3.28 and 3.26 for T-18, 3.68 and 3.57 for T-12, 3.89 and 4.08 for T-6, 4.86 and 5.06 for T, and finally 5.47 and 4.12 for T+6. Note also that as the amount of information increased so did the saliency rating of emotion, regardless of the type of sequence (except for static T+6). Figure 6.16 demonstrates this effect.

6.3.2.4 Poser 4

The saliency rate of each emotional sequence was calculated for each subject per condition for Poser 4, and analyses were performed separately for the happiness and

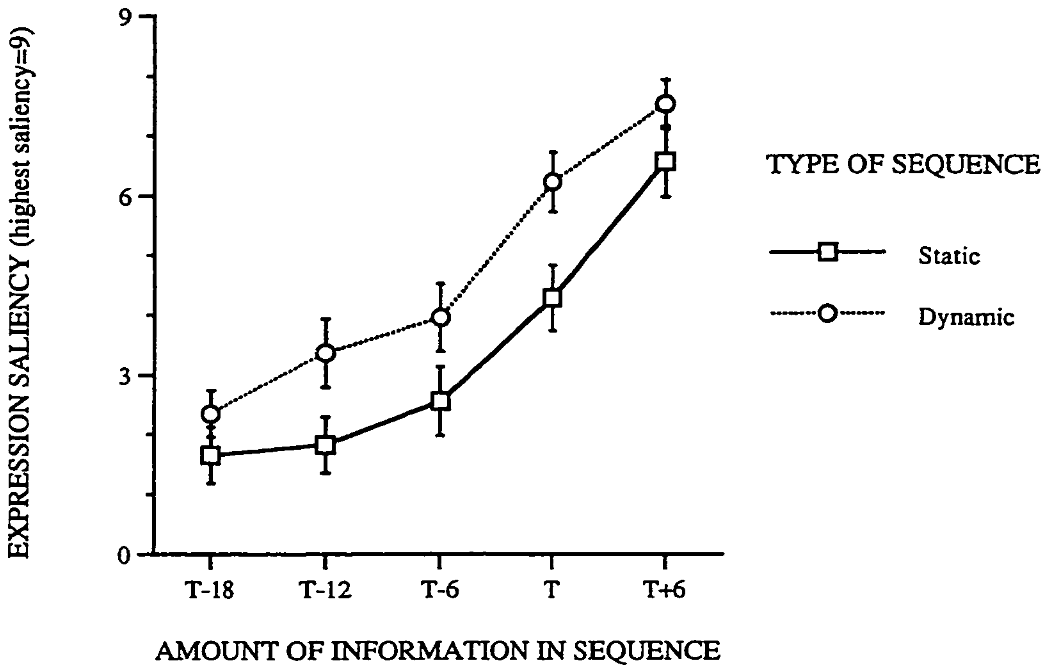

Figure 6.15. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 3's static and dynamic happiness sequences.

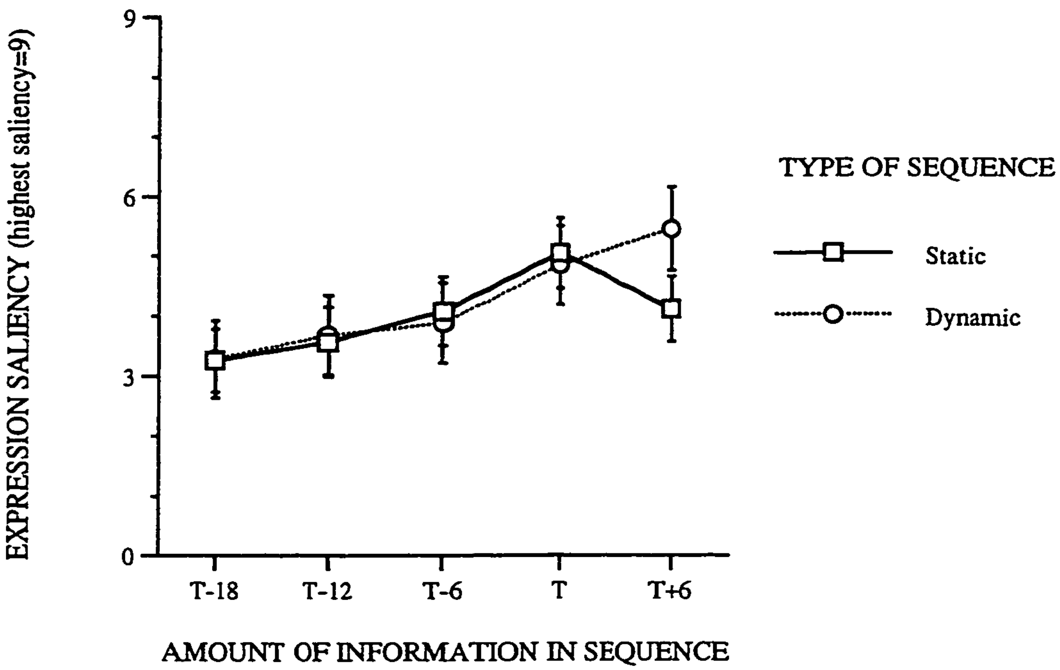

Figure 6.16. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 3's static and dynamic sadness sequences.

sadness sequences. To determine if the saliency rate data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (5 levels: T-18, T-12, T-6, T, and T+6 for happiness; 3 levels: T-6, T, and T+6 for sadness) a 2 x 5 and a 2 x 3 repeated measures ANOVA were conducted for the happiness and sadness data sets, respectively.

The ANOVA for the *happiness expression* revealed that saliency rate of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.579$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=52.082$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=.770$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons were conducted for the Information main effect. T-18 was not different from T-12, and in addition, T-12 did not differ from T-6. The remaining comparisons did reach significance. As can be seen in Figure 6.17, contrary to the statistics, the dynamic sequences tended to yield better saliency ratings of emotion with values of 1.92 and 1.50 for T-18, 2.67 and 2.19 for T-12, 3.35 and 2.49 for T-6, 4.82 and 3.85 for T, and finally 5.39 and 4.99 for T+6, respectively for dynamic and static sequences. Indeed, as the amount of information increased so did the saliency rating of emotion, regardless of the type of sequence.

The ANOVA for the *sadness expression* revealed that saliency ratings of expression were also not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.009$, $p>.05$], but were dependent on the amount of information content [main effect of Information $F(2, 18)=99.242$, $p<.05$]. The Sequence x Information interaction was not significant [$F(2, 18)=.570$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons were conducted for the Information main effect. All pairwise comparisons were significant. As can be seen in Figure 6.18, static and dynamic

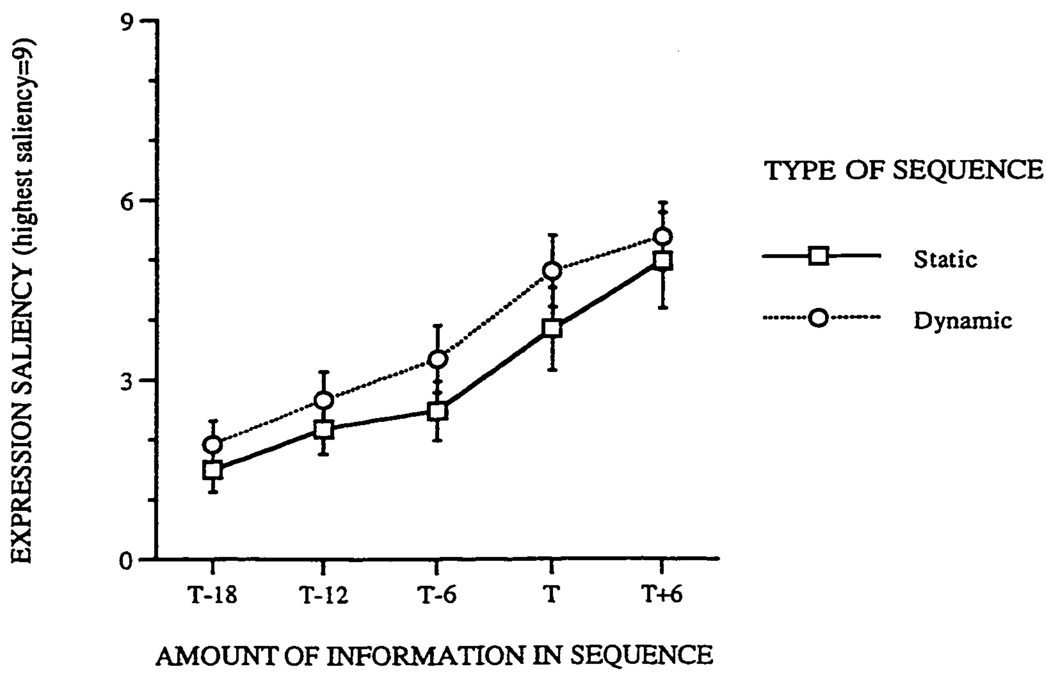

Figure 6.17. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 4's static and dynamic happiness sequences.

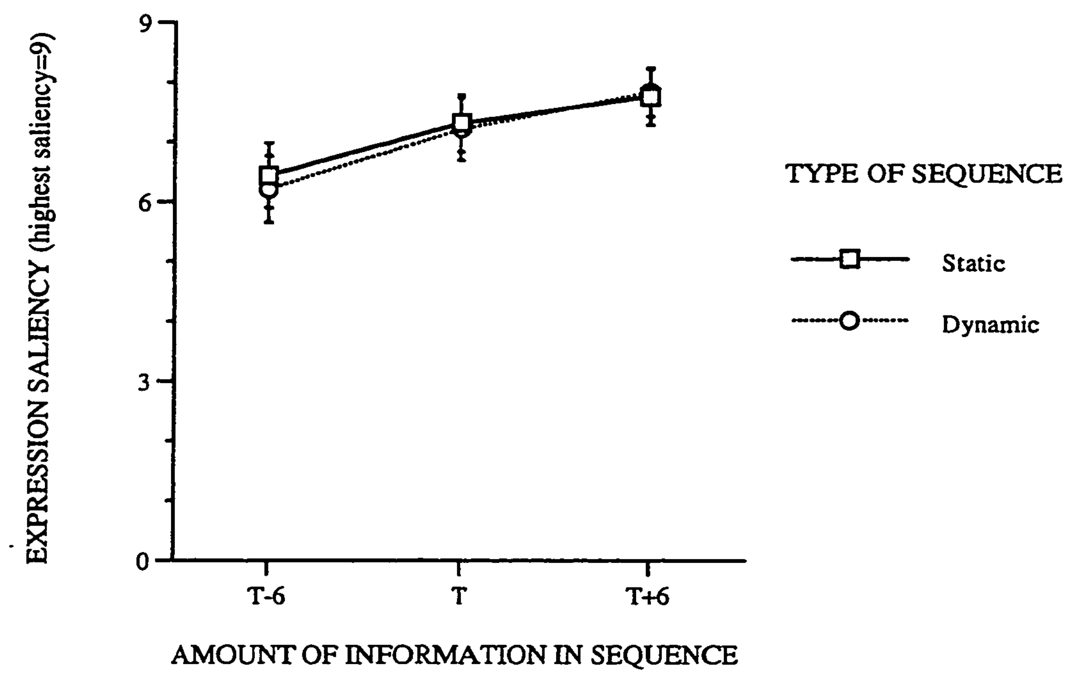

Figure 6.18. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 4's static and dynamic sadness sequences.

depictions did not differ for this expression for this poser: 6.21 and 6.44 for T-6, 7.22 and 7.32 for T, and finally 7.84 and 7.77 for T+6, respectively for dynamic and static sequences. Interestingly, the saliency ratings for this poser's expression were very high and thus perhaps the lack of separation between the type of sequence is due to a ceiling effect. As typically observed, as the amount of information increased so did the saliency rating of emotion, regardless of the type of sequence.

6.3.2.5 Poser 5

The saliency rate of each emotional sequence was calculated for each subject per condition for Poser 5, and analyses were performed separately for the happiness and sadness sequences. To determine if the saliency rate data were dependent on the type of Sequence (2 levels: static and dynamic), and the amount of Information (4 levels: T-12, T-6, T, and T+6 for happiness; 5 levels: T-18, T-12, T-6, T, and T+6 for sadness) a 2 x 4 and a 2 x 5 repeated measures ANOVA were conducted for the happiness and sadness data sets, respectively.

The ANOVA for the *happiness expression* revealed that saliency rate of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.393$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(3, 27)=18.668$, $p<.05$]. The Sequence x Information interaction was not significant [$F(3, 27)=2.067$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons were conducted for the Information main effect. T-12 did not differ from T-6 nor T. All other comparisons were significant. As can be seen in Figure 6.19, static and dynamic depictions did differ and contrary to the tendency, static movies yielded superior saliency rates. The values were 3.68 and 4.24 for T-12, 3.58 and 4.01 for T-6, 4.10 and

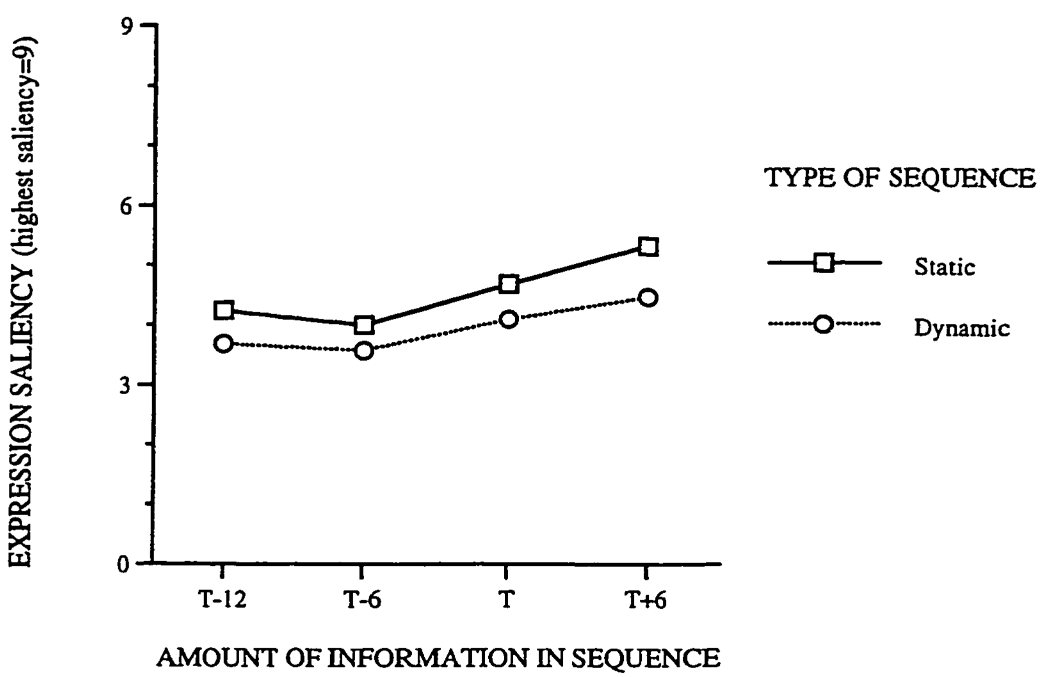

Figure 6.19. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 5's static and dynamic happiness sequences.

4.69 for T, and finally 4.48 and 5.34 for T+6, respectively for dynamic and static sequences. As typically observed, as the amount of information increased so did the saliency rating of emotion, regardless of the type of sequence.

The ANOVA for the *sadness expression* revealed that saliency rate of expression was not dependent on the type of sequence [main effect of Sequence $F(1, 9)=.130$, $p>.05$], but was dependent on the amount of information content [main effect of Information $F(4, 36)=160.477$, $p<.05$]. The Sequence x Information interaction was not significant [$F(4, 36)=.718$, $p>.05$], and thus posthoc analyses comprised of Tukey (hsd) pairwise comparisons were conducted for the Information main effect. T-18 was not found to yield significantly lower saliency rates compared to T-12 and likewise, T was not significantly lower than T+6. The remaining comparisons were significant. As can be seen in Figure 6.20, contrary to the statistics, the dynamic sequences tended to yield better saliency rates with values of 3.15 and 3.35 for T-18, 3.65 and 3.42 for T-12, 4.55 and 3.93 for T-6, 5.62 and 5.28 for T, and finally 6.00 and 5.55 for T+6, respectively for dynamic and static sequences. As the amount of information increased so did the saliency rate of emotion, regardless of the type of sequence.

Summary

In conclusion, similar to the percent correct identification data, it was generally observed across posers that as the amount of information in a sequence increased, so did the saliency rate. Again like the percent correct data, despite the lack of significance, there does seem to be a trend for a difference in the saliency rate of emotion dependent on the type of sequence used. As observed with the majority of posers, regardless of emotion, there does seem to be a dynamic superiority in saliency rate.

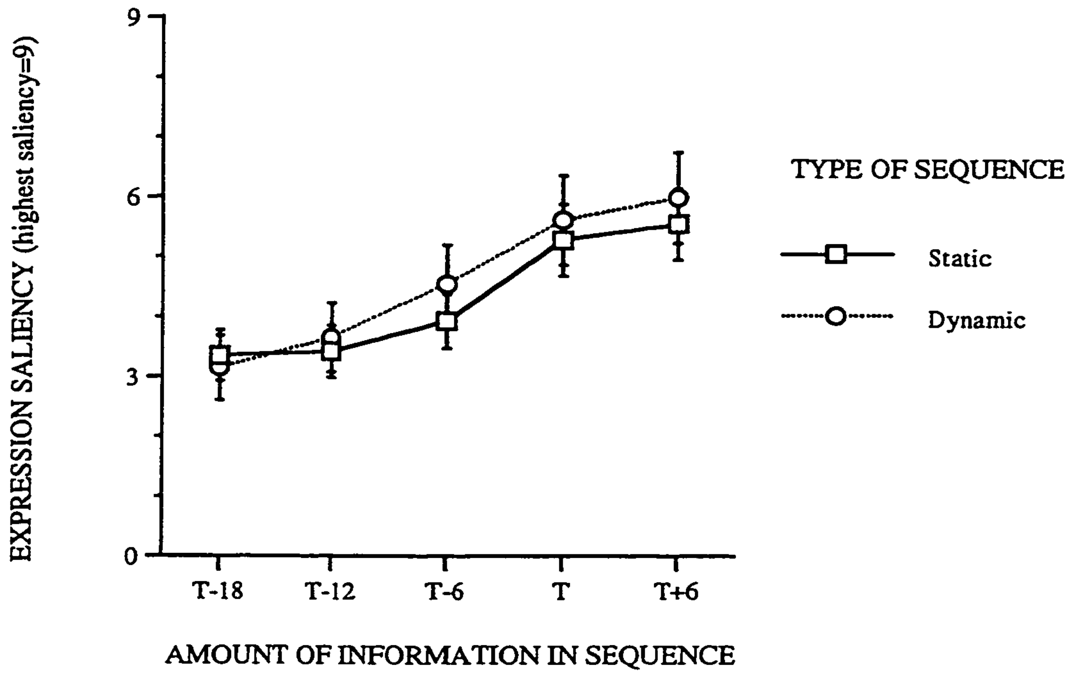

Figure 6.20. Saliency of expression as a function of the amount of information (# frames below, at and above threshold) for Poser 5's static and dynamic sadness sequences.

6.4 Discussion

This experiment was designed to compare the type of mode of presentation (i.e. static and dynamic) in order to estimate the relative contribution of each mode, using a two alternative forced choice procedure. The results failed to support the hypothesis according to which dynamic information present in a sequence would lead to higher recognition rates in comparison with static sequences. The analysis of the percentage of correct identification of emotion dependent on the type of sequence did not show a significant increase in the recognition of dynamic sequences over static ones. It is, however, important to stress that all observers, regardless of the emotion portrayed exhibited an increase in their identification rates for dynamic in comparison to static sequences. A similar observation was made for the judgment of saliency. Despite the lack of significance, there was a trend in the saliency rate of emotion dependent on the type of sequence used. The majority of the observers, regardless of emotion, judged the dynamic sequences as more salient than static ones.

There are several factors that might be responsible for the lack of effect reported. Among them it is important to address the ceiling effect that was encountered for some sequences. The experiment was designed to lead to psychometric functions which would correspond to the discrimination capacity of the observer as a function of the information present in the stimuli. However, the sadness sequences lead to an easy and sometimes perfect identification judgment even when little information was presented, that is, below the pre-established threshold. Three out of the five posers elicited recognition rates around 100% despite the varying amount of information in the stimuli. A similar, but limited, performance was also found in the happiness sequences. One poser out of five showed this effect in performance.

The explanation for both types of sequence is most likely to be related to the same factor. This factor deals with the existence of a neutral phase or by extension a neutral state of emotionality. It seems that the sadness sequences failed to portray a true neutral state. Consequently even with the least amount of information in the stimulus the observers where able to judge the expression segment as pertaining to the right emotion. This raises two major questions. The first being the possibility that the posers were involuntarily disclosing information as to the underlying emotion. This explanation would also suggest that involuntary disclosure might arise in the happiness sequences as well. Though one poser seems to have produced this effect, it is highly unlikely that involuntary disclosure can be the main factor because the effect on sadness was too severe. The second question relates to the possibility that the sadness expression in its weak form might contains a great deal of features similar to the ones found with the neutral expression. Despite the fact that this explanation might be possible there is no evidence in the present study to support this claim.

One could question the veracity of the neutral phase in this manipulation. As already reported in the past, Dubé et al. (1995) found that posers have great difficulties to depict a neutral affect. The importance to obtain emotional facial expressive sequences which possess a true neutral phase remains for this a paradigm. The lack of a veridical neutral phase might be enough to suggest that neutrality when attempted is biased towards the perception of sadness.

Beside the presence of a ceiling effect that might have interfered with the power of the treatment, a second factor might have reduced the effect size and therefore have affected the treatment effect. In this experiment and contrary to Landry (1993) who found a significant advantage of dynamic over static stimuli, the static stimuli always had the same spatial content as the dynamic stimuli. Therefore, the apex of the dynamic sequence was always the same as all of the static sequence. Dubé et al.(1995), as well as Thornton and Kourtzi (1997) constructed their stimuli according to this rule. One might argue that there is, however, one inconvenience with this choice of procedure. In considering the summation process in the temporal domain, the static aspect becomes more heavily represented. Consequently, the static representation becomes biased in the information load it conveys over time. A stronger effect favoring the dynamic presentation might occur if this bias could be removed. This would increase the treatment effect and perhaps produce a significant advantage of dynamic over static stimuli. Wallbott (1992) stressed this possibility in his explanation of the discrepancies he obtained between two of his experiments. For example, Wallbott (1991) found little effect of information degradation when the stimuli were presented statically for 10 seconds. On the other hand, in Wallbott (1992) a strong effect of degradation was found when the stimulus duration was 2 seconds and the stimuli were dynamic.

In considering past literature surrounding this question, the results obtained in this experiment stress the importance of temporal factors in the perception and decoding of emotional facial expressions. The dimensionallity axes for dynamic and static presentations are similar (Lemay, Kirouac and Lacouture, 1995). These authors also showed that categorical judgments were easier when dynamic stimuli were presented. This was interpreted as being the result of the ease that temporal information produced in judging dynamic presentations. The importance of temporal information in a similar context is also supported by other researchers (Landry, 1993; Russell and Fehr, 1987). Russell and Fehr (1987) have shown in a series of experiments that the context surrounding an expression may affect the judgment of this expression (see also Feenan & Snodgrass, 1990 for similar effects).

To conclude dynamic facial expressions were often identified with more accuracy than static depictions of the same expression. The difference between the two Psychophysical functions suggest that the visual information present in emotional facial expressions varies in strength when dynamic and static comparisons are made. These results support the idea that information present in frames preceding the final, or static depiction, provide important information for the disambiguation of the emotional expression. Furthermore, the difficulty experienced with the sadness sequences suggest that the expression of neutrality may contain a great deal of sadness. This is related to the idea that confusions arise at the boundary between emotions (Etcoff & Magee, 1992; Calder, Young, Perrett, Etcoff & Rowland, 1996). A similar confusion might also arise at the boundary between one emotion and neutrality. This would suggest that the categorical boundary between sadness and neutrality is somewhat blurry.

EXPERIMENT 5

7.1. Introduction

The results obtained in Experiment 4 showed that dynamic sequences are perceived with greater accuracy than static ones when the same amount of information is presented (i.e. the static depiction is the apex frame of the dynamic sequence) and that the amount of information is restrained. This suggests that after a certain amount of information is presented no further benefit is gained from additional information. It would seem that at this point any further details become redundant for both the static and dynamic decisions. Before that stage, the superiority of dynamic expressions may be due to the contextual information preceding the required judgment. Experiment 5 further explored this hypothesis via a priming or adaptation paradigm.

Interestingly, Thornton and Kourtzi (1997) have proposed that dynamic information may lead to a better perceptual representation than static information. It is possible to think that this argument might be tested using an adaptation paradigm. Consequently, the presentation of dynamic information would produce a stronger effect on the following test stimulus. An adaptation paradigm was actually utilized by Prkachin and Prkachin (1994) who directly tested the idea of the existence of feature detectors which are especially tuned to faces. Their rationale was based on the physiological observations made with monkeys which were described in section 1.3.1. With this paradigm, they found that the adapted emotional expression (static adaptation and test) led to a reduced level of correct identification whereas other emotional expressions were facilitated. The judged magnitude of the emotion was also reported to be less for the adapted emotions as opposed to the non-adapted ones. They interpreted their results as evidence for the existence of a specific system responsible for the processing of facial expressions.

Within this context, it might be proposed that adaptation to dynamic emotional facial expressions could produce a stronger adaptation effect when compared with static emotional facial expressions. Based on these previous findings and interpretations, the present experiment further examined the processing of static and dynamic emotional facial expressions. It was hypothesized that dynamic information present in a sequence would lead to a higher adaptation effect than static information. It was also hypothesized, based on the results obtained in Experiment 1, that happiness and sadness might be affected differently.

7.2 Method

7.2.1 Subjects

Twelve individuals participated in this experiment. All participants were recruited on a single basis through solicitation among, though not exclusively, the department of psychology population at Concordia University. Overall, the ratio of participants was biased towards fellow graduate students and both genders were recruited. The age of the participants varied between 21 and 52 years. Some of the subjects recruited for this experiment had also been solicited for the previous experiments. The subjects were informed of the research domain but were kept naive as to the purpose of the experiment.

7.2.2 Stimuli

7.2.2.1 Adaptation stimuli

The stimuli used in this experiment were selected from the dynamic sequences used in Experiment 2. Because an adaptation paradigm was employed, only two posers of each gender were utilized (posers 3 and 5 were removed from the set), in order to achieve a reasonable length of testing. From each poser, two sequences were selected out of the possible four (see section 4.2.2), one depicting happiness, the other sadness. In addition, this selection had to satisfy the following constraints (1) the chosen segments' recognition rates had to be high, and (2) the standard deviation of the recognition threshold had to be low. The original sequences were used, in addition to, newly constructed static versions. The static stimuli were constructed by presenting the last frame from each dynamic sequence for a duration equal to the original dynamic sequence. This procedure ensured an equal duration of stimulation for the two types of sequences. Altogether, four different sequences were used for each of the four posers, two were static and two were dynamic. Thus, there was a total of 16 stimuli, which varied in duration according to the poser and the condition. These eight dynamic and eight static stimuli served as adapting stimuli and were tested in two separate blocks.

7.2.2.2 Test stimuli

A composite stimulus was made by morphing the 2 last frames of the happiness and sadness sequences (from the same poser) with each other, via a transparency algorithm over a total of 30 frames. This process was repeated for all posers. Thereafter, this morphed stimulus, which by definition is dynamic, was employed to extract three different frames per sequence to create the test stimuli. These three frames corresponded to the middle point of the movie (i.e. the presumed ambiguous point), 5 frames before the middle point (i.e. biased towards sadness), and 5 frames after the middle point (i.e. biased towards happiness). The morphed stimuli were, therefore, ambiguous depictions, sometimes biased toward sadness or happiness, dependent on the strength of the original combined depictions, and the location of the selected frame in the morphed movie. The test stimuli were, consequently, all static (unlike the dynamic and static adaptation stimuli). Three test stimuli were composed per poser, yielding 12 test stimuli.

7.2.3 Procedure

The subjects first signed the consent form (Appendix C) and then were tested individually in a quiet room, seated in front of the computer screen at a distance of 57 cm. At all times they were instructed to look at the screen following the initiation of each trial. All trials were presented one at a time in a randomized order but the dynamic and static adaptation sequences were divided into two separate blocks. The two blocks were counterbalanced among the 12 subjects. A typical trial consisted of an adapting sequence (static or dynamic), followed by 300 ms of a blank interval, after which a test stimulus would appear. Thereafter, the subjects were immediately presented with an on-screen dialogue box to enter their responses. The subject's first task was a two alternative forced choice judgment, where they had to indicate which emotion they thought was depicted in the test stimulus, by depressing either the letter "S" (sadness) or "H" (happiness) on the keyboard. A subsequent task was also required where the subject had to assess the certainty of their previous judgment, on a scale from 0 to 9 (where 0 referred to uncertain and 9 referred to highly certain). The time allotted to make the judgments was determined by the subject's own pace. After both responses were entered, the next trial was initiated by pressing the enter key on the keyboard. Each sequence was repeated 10 times for a total of 360 static and 360 dynamic sequences. Each block lasted approximately 60 minutes yielding a total of about 2 hours to complete the entire experiment.

7.2.4 Statistical design

The statistical design of Experiment 5 was a 2x4x3x3 repeated measures factorial analysis of variance (ANOVA), where the first variable corresponded to the type of Adaptation Sequence (2 levels: dynamic and static), the second one corresponded to the Poser (4 levels), the third to the type of Adaptation (3 levels: baseline, happiness, and sadness), and the fourth one consisted of the type of Test stimulus (3 levels: ambiguous, biased towards happiness, and biased towards sadness).

7.3 Results

For each of the approximately 72 combinations of sequence, poser, adaptation, and test stimulus, both the identification of the expression and the certainty of the expression were measured at each of the 10 repetitions, for each observer. Subject, and thereafter, group means were then computed for each of the identification and certainty data sets. Since the baseline (i.e. no adaptation condition) was run both prior to and following the adaptation conditions, a dependent t-test was conducted on the pre- and post-adaptation data to determine if the time of testing factor was significant. This was done for each sequence type and each dependent measure separately, thus yielding four dependent two-tailed t-tests. Following this set of analyses, analyses of variance (ANOVAs) were conducted for each sequence type *and* for each dependent measure to investigate the effect of adaptation. For instance, upon determining which data would represent the baseline data (see t-test results below), two three-way ANOVAs were performed separately on the identity and certainty data yielded from the dynamic sequences, with Poser (4 levels), the type of Adaptation (3 levels: baseline, happiness, and sadness), and the type of Test stimulus (3 levels: ambiguous, biased towards happiness, and biased towards sadness) as repeated measures variables. Two additional repeated measures ANOVAs with the identical design were thereafter utilized on the static sequence data. Four t-tests and four ANOVAs were thus run on the data for this experiment.

7.3.1 Static Sequences

7.3.1.1 Identification of Expression

The subjects' identification response consisted of either an "s" for smile or an "f" for frown. For the purpose of analyses, this alphabetical response was converted into a sign response. The frown response was converted into a "-1" whereas the smile response was changed into a "+1". This conversion was determined for each static emotional sequence for each subject per condition and a dependent t-test was conducted on the baseline identification data to determine if it was affected by the time of testing (i.e. the baseline condition was run both pre- and post-adaptation).

The two-tailed dependent t-test indicated that the baseline run prior to adaptation conditions did not differ from the baseline which was run following the adaptation conditions. The lack of difference between the two baseline conditions ($t(11)=1.322$, p>.05) suggests that there should be little if any carryover effects within the adaptation conditions, allowing for more reliable data and conclusions. It was therefore decided to collapse across these two baseline measures and use this combined data as the baseline or "no adaptation" data in the following ANOVA.

Next, a three-way analysis of variance was performed to examine the effect of Poser, Adaptation, and Test stimulus on the identification of the emotion. The three-way interaction was indeed significant [Poser x Adaptation x Test $F(12, 132)=3.993$, $p<.05$]. All other effects were significant but overridden by this higher order interaction [main effect of Poser $F(3, 33)=9.682$, $p<.05$; main effect of Adaptation $F(2, 22)=26.184$, $p<.05$; main effect of Test $F(2, 22)=293.018$, $p<.05$; Poser x Adaptation interaction $F(6, 66)=2.909$, $p<.05$; Poser x Test interaction $F(6, 66)=5.687$, $p<.05$; Adaptation x Test interaction $F(4, 44)=8.088$, $p<.05$].

The Poser x Adaptation x Test interaction was the highest order interaction found to be significant. In other words, the effect of emotional adaptation on identity response depended on the type of emotion portrayed in the test stimulus, and this interaction effect varied across different posers. Simple interaction analysis was thereafter conducted on this three-way interaction to isolate the effect. The analysis, however, failed to clarify the effect since all two-way simple interactions were found to be significant [Adaptation x Test at Poser 1 $F(4, 132)=18.955$, $p<.05$; Adaptation x Test at Poser 2 $F(4, 132)=45.159$, $p<.05$; Adaptation x Test at Poser 3 $F(4, 132)=15.701$, $p<.05$; Adaptation x Test at Poser 4 $F(4, 132)=16.733$, $p<.05$]. It was, thus, necessary to perform simple effects analysis due to the significant simple interactions and to isolate the three-way interaction effect.

Simple effects analysis (Adaptation at Test) for Poser 1's significant simple interaction revealed that the Adaptation x Test simple interaction was significant because Adaptation produced a significant effect for the Ambiguous and Sadness Test stimuli but not for the Happiness Test stimulus [Adaptation at Ambiguous $F(2, 132)=6.468$, $p<.05$; Adaptation at Sadness $F(2, 132)=38.571$, $p<.05$; Adaptation at Happiness $F(2, 132)=.119$, $p>.05$]. There were more than two levels of adaptation, and therefore, Tukey (hsd) pairwise comparisons were obligatory for the final understanding of this simple interaction effect. For the Ambiguous Test, only the happiness and sadness adaptation conditions were significantly different (i.e. happiness did not differ from baseline, and sadness did not differ from baseline). This was true despite the obvious trend. For instance, the baseline for the ambiguous test stimulus for this poser was perceived to be more happy (+.8167). Following the happiness adaptation, however, there was a reliable reduced identification of happiness compared to the baseline (.7667 compared to .8167, respectively), while sadness adaptation reliably led to an (maximal) increase in identification of happiness compared to the baseline (1.0 compared to .8167, respectively). Next, for the Sadness Test, all pairwise comparisons were significant. The baseline for the sadness test stimulus for this poser was perceived to be -.5. Following the happiness adaptation there was a reliable increase in identification of sadness compared to the baseline (-.8 compared to -.5, respectively), while sadness adaptation reliably led to a decrease in identification of sadness compared to the baseline (-.2 compared to -.5, respectively). Taken together, these two sets of Tukey pairwise comparisons indicate that for Poser 1, identification of the baseline is significantly adaptable for ambiguous and sadness test stimuli, i.e. happiness adaptation produced less perceived happiness (or more perceived sadness) and sadness adaptation produced less perceived sadness (or more perceived happiness). It is important to note that the same adaptation effect was observed for the happiness test stimulus but due to smaller mean differences did not reach significance. It was this that caused the significant two-way simple interaction for Poser 1. This effect is shown in Figure 7.1.

Simple effects analysis (Adaptation at Test) for Poser 2's significant simple interaction revealed the identical effect. The Adaptation x Test simple interaction was significant because Adaptation produced a significant effect for the Ambiguous and Sadness Test stimuli but not for the Happiness Test stimulus [Adaptation at Ambiguous $F(2, 132)=101.111$, $p<.05$; Adaptation at Sadness $F(2, 132)=33.611$, $p<.05$; Adaptation at Happiness $F(2, 132)=1.071$, $p>.05$]. There were more than two levels of adaptation, and therefore again, Tukey (hsd) pairwise comparisons were obligatory for the final understanding of this simple interaction effect. For the Ambiguous Test, all pairwise comparisons were found to be significantly different and revealed the same effect as with Poser 1's data. For instance, the baseline for the ambiguous test stimulus for this poser was perceived to be slightly happy (+.1667). Following the happiness adaptation, however, there was a reliable reduced identification of happiness compared to the baseline (-.2333 compared to .1667, respectively), while sadness adaptation reliably led to an increase in identification of happiness compared to the baseline (.7333 compared to .1667, respectively). Next, for the Sadness Test, all except one of the pairwise comparisons were significant (despite the trend, happiness adaptation did not differ significantly from baseline level). The baseline for the sadness test stimulus for this poser was perceived to be -.7333. Following the happiness adaptation there was a reliable increase in identification of sadness compared to the baseline (-.9167 compared to -.7333, respectively), while sadness adaptation reliably led to a decrease in identification of sadness compared to the baseline (-.3667 compared to -.7333, respectively). Taken together, these two sets of Tukey pairwise comparisons indicate that like Poser 1, identification of the baseline is significantly adaptable for ambiguous and sadness test stimuli for Poser 2 as well, i.e. happiness adaptation produced less perceived happiness (or more perceived sadness) and

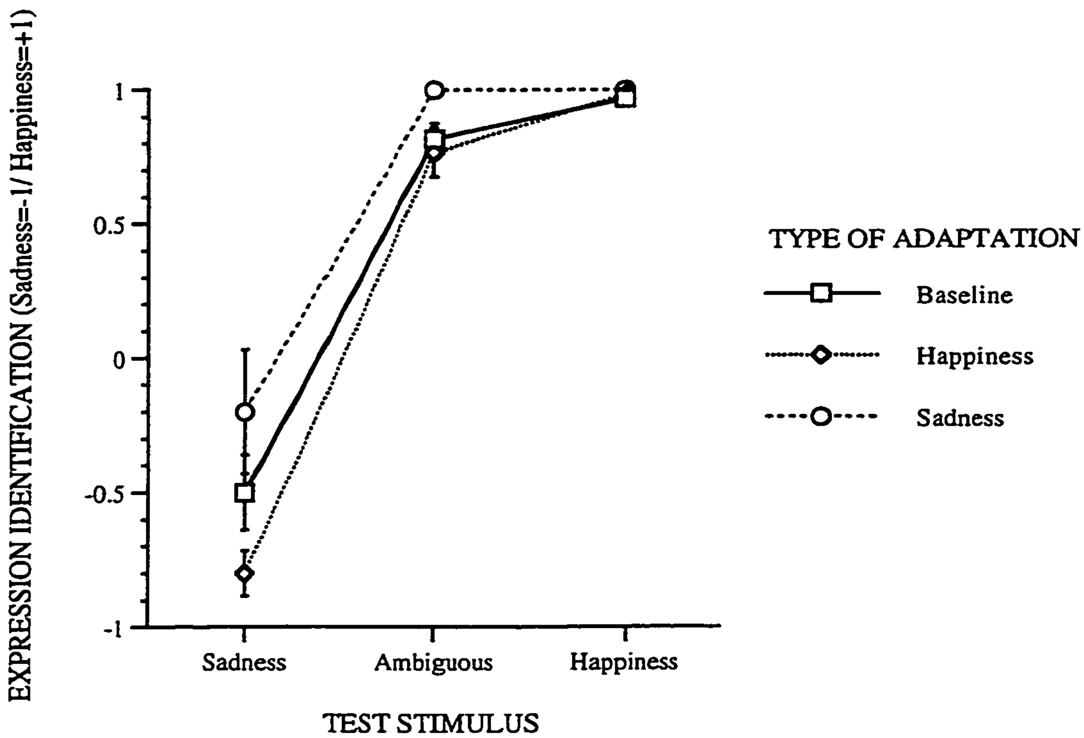

Figure 7.1. Identification of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 1.

sadness adaptation produced less perceived sadness (or more perceived happiness). It is important to note again, that the same adaptation effect was observed for the happiness test stimulus but again due to smaller mean differences it did not reach significance. It was this that caused the significant two-way simple interaction for Poser 2. This effect is shown in Figure 7.2.

Simple effects analysis (Adaptation at Test) for Poser 3's significant simple interaction revealed the same general effect (i.e. same overall adaptation effect) with some minor differences in patterns of significance. In this case, the Adaptation x Test simple interaction was significant because Adaptation produced a significant effect for the Ambiguous and Happiness Test stimuli but not for the Sadness Test stimulus [Adaptation at Ambiguous $F(2, 132)=36.786$, $p<.05$; Adaptation at Happiness $F(2, 132)=5.278$, $p<.05$; Adaptation at Sadness $F(2, 132)=1.905$, $p>.05$]. There were more than two levels of adaptation, and therefore again, Tukey (hsd) pairwise comparisons were obligatory for the final understanding of this simple interaction effect. For the Ambiguous Test, all except one of the pairwise comparisons were found to be significantly different (i.e. despite the trend, sadness adaptation did not differ significantly from baseline) and revealed the same adaptation effect as with the previous posers' data. For instance, the baseline for the ambiguous test stimulus for this poser was perceived to be neutral (0). Following the happiness adaptation, however, there was a reliable increased identification of sadness compared to the baseline (-.4500 compared to 0, respectively), while sadness adaptation led to a small although reliable increase in identification of happiness compared to the baseline (.1 compared to 0, respectively). Next, for the Happiness Test, despite the trend, the pairwise comparisons did not reach significance. The baseline for the Happiness test stimulus for this poser was perceived to be .8000. Following the happiness adaptation there was a reliable decrease in identification of happiness compared to the baseline (.7833 compared to .8000, respectively), while sadness adaptation reliably led to an increase in

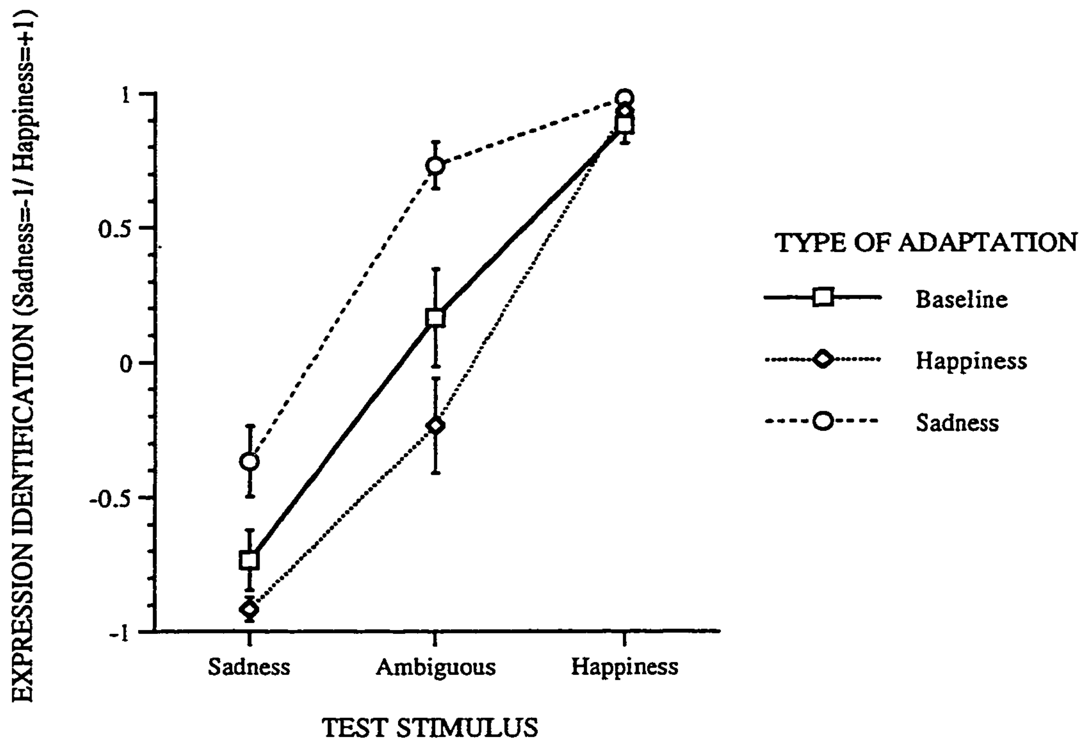

Figure 7.2. Identification of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 2.

identification of happiness compared to the baseline (.9833 compared to .8000, respectively). Taken together, these two sets of Tukey pairwise comparisons indicate that like Posers 1 and 2, identification of the baseline is significantly adaptable. The only difference between this poser's data and the previous posers is that although all three posers demonstrate the same adaptation effect (for all three test stimuli), Posers 1 and 2 do not show a *significant* effect for the Happiness Test stimulus and Poser 3 does not demonstrate a *significant* effect for the Sadness Test stimulus. Thus, it was the fact that the Sadness Test stimulus was not significantly affected by adaptation while Ambiguous and Happiness Test stimuli were, that caused the significant two-way simple interaction for Poser 3. This effect is shown in Figure 7.3.

Finally, the simple effects analysis (Adaptation at Test) for Poser 4's significant simple interaction consistent with the previous three posers, revealed the same general adaptation effect which likewise demonstrated some minor differences in patterns of significance. In this case, the Adaptation x Test simple interaction was significant because Adaptation produced a significant effect for the Ambiguous Test stimulus only [Adaptation at Ambiguous $F(2, 132)=34.563$, $p<.05$; Adaptation at Sadness $F(2, 132)=2.063$, $p>.05$; Adaptation at Happiness $F(2, 132)=.992$, $p>.05$]. There were more than two levels of adaptation, and therefore again, Tukey (hsd) pairwise comparisons were obligatory for the final understanding of this simple interaction effect. For the Ambiguous Test, all except one of the pairwise comparisons were found to be significantly different (i.e. despite the trend, happiness adaptation did not differ significantly from baseline) and revealed the same adaptation effect as with the previous posers' data. For instance, the baseline for the ambiguous test stimulus for this poser was perceived to be slightly happy (.1500). Following the happiness adaptation, however, there was a small but reliable decreased identification of sadness compared to the baseline (.1333 compared to .1500, respectively), while sadness adaptation led to a large increase in identification of happiness compared to

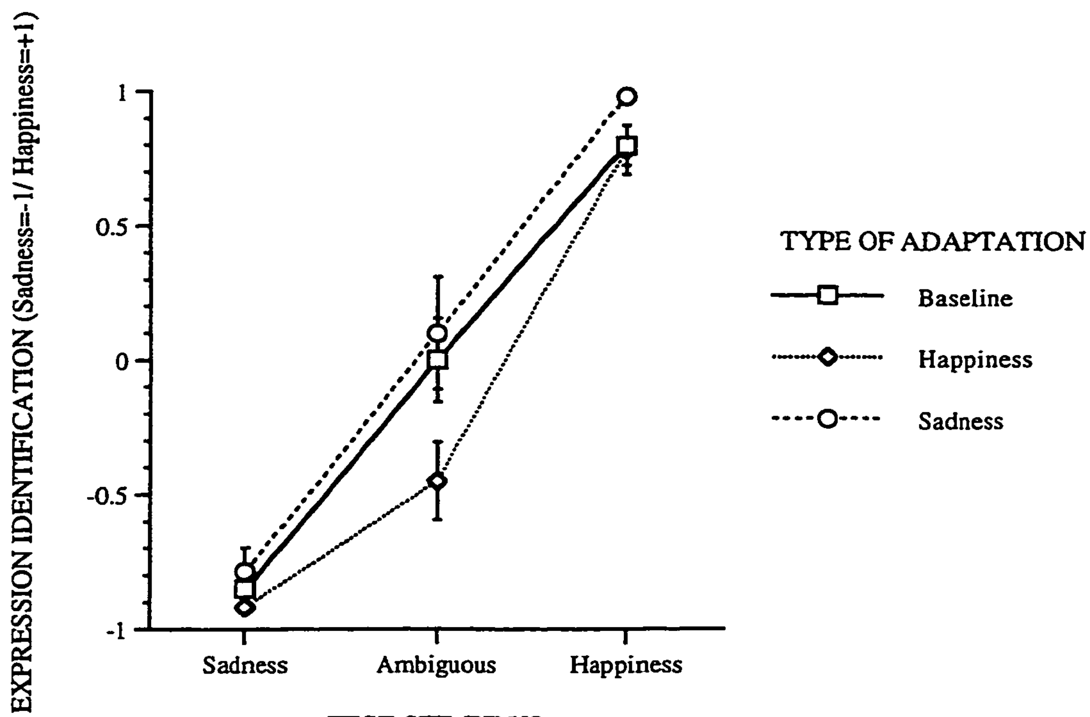

Figure 7.3. Identification of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 3.

the baseline (.6333 compared to .1500, respectively). The Tukey pairwise comparisons indicate that like Posers 1, 2 and 3, identification of the baseline is significantly adaptable. Contrary to the obvious trend in the data, this was only statistically true for the Ambiguous Test stimulus (see Figure 7.4).

In summary, all four posers (two female and two male) demonstrated the same general adaptation effects. That is, adaptation to happiness decreases perceived happiness (or increases perceived sadness) and adaptation to sadness decreases perceived sadness (or increases perceived happiness). The only difference between the posers data is that the adaptation effect was not always significant for all three types of Test stimuli. For example, the Ambiguous Test stimuli were consistently significantly affected by adaptation for all posers. The Sadness and Happiness Test stimuli were, on the other hand, not always significantly affected by adaptation. It is important, however, to stress that despite the lack of consistent significant adaptation effects with the Happiness and Sadness Test stimuli, the effect remained present and clear for all posers. It was thus a simple lack of statistical power of the experiment which caused the lack of significance for all Test stimuli.

7.3.1.2 Intensity of Expression

The subjects' intensity response consisted of a numeric rating between 0 and 9, whereby 0 represented zero intensity and 9 indicated very high intensity. For an accurate comprehension of the possible adaptation effects, it was deemed necessary to know the identity response in addition to the intensity rating for the analyses. If a baseline intensity response was, for example, 2.4 (sadness) prior to adaptation and 2.3 (happiness) following adaptation to sadness, one can understand the need for the identity of emotion

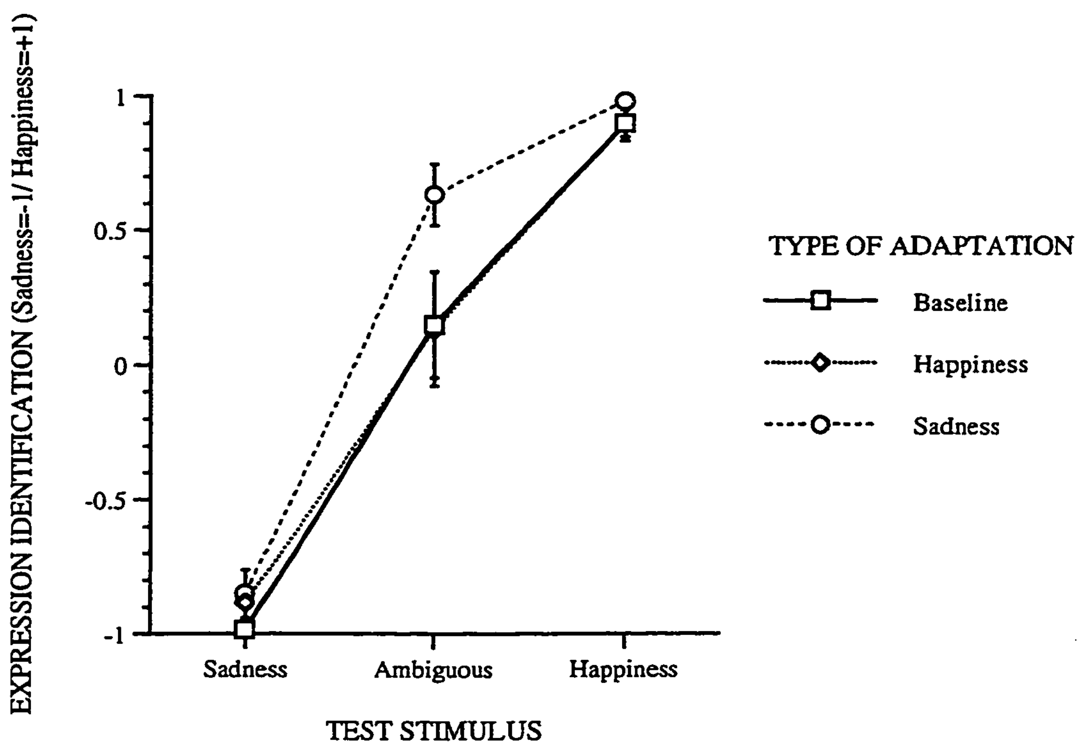

Figure 7.4. Identification of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 4.

response in lieu of the intensity rating alone for a veridical conclusion. The researcher may have, for instance, mistakenly concluded that adaptation had no effect or only a marginal reduction of intensity (of .1). To accomplish this, each intensity rating was multiplied by its identity value. As previously mentioned, a "+1.0" represented a smile response while a "-1.0" represented a frown response. This conversion was determined for each static emotional sequence for each subject per condition. Thus one would correctly conclude that there was indeed a substantial adaptation effect judged by the complete reduction in intensity of the frown (e.g. from -2.4 to 0) to the extent of becoming a moderate intensity smile of (e.g. from 0 to +2.3). Thereafter, similarly to the identity data set, a dependent t-test was conducted on the baseline intensity data to determine if they were affected by the time of testing (i.e. the baseline condition was run both pre- and post-adaptation).

Like the identity data, the two-tailed dependent t-test indicated that the baseline run prior to adaptation conditions did not differ from the baseline which was run following the adaptation conditions ($t(11)=1.767$, $p>.05$). The lack of difference between the two baseline conditions suggests that there should be little if any carryover effects within the adaptation conditions, allowing for more reliable data and conclusions. It was therefore decided to collapse across these two baseline measures and to use these combined data as the baseline or "no adaptation" data in the following ANOVA.

Next, a three-way analysis of variance was performed to examine the effect of Poser, Adaptation, and Test stimulus on the intensity of the emotion. As with the identity data, the three-way interaction was indeed significant [Poser x Adaptation x Test $F(12, 132)=4.236$, $p<.05$]. All other effects were either non-significant or overridden by this higher order interaction [main effect of Poser $F(3, 33)=12.685$, $p<.05$; main effect of Adaptation $F(2, 22)=25.777$, $p<.05$; main effect of Test $F(2, 22)=171.416$, $p<.05$; Poser x Adaptation interaction $F(6, 66)=2.061$, $p>.05$; Poser x Test interaction $F(6, 66)=5.158$, $p<.05$; Adaptation x Test interaction $F(4, 44)=5.597$, $p<.05$].

The Poser x Adaptation x Test interaction was the highest order interaction found to be significant. In other words, the effect of emotional adaptation on intensity rating depended on the type of emotion portrayed in the test stimulus, and this interaction effect varied across different posers. Simple interaction analysis was thereafter conducted on this three-way interaction to isolate the effect. The analysis, however, failed to clarify the effect since all two-way simple interactions were found to be significant [Adaptation x Test at Poser 1 $F(4, 132)=20.364$, $p<.05$; Adaptation x Test at Poser 2 $F(4, 132)=35.450$, $p<.05$; Adaptation x Test at Poser 3 $F(4, 132)=11.440$, $p<.05$; Adaptation x Test at Poser 4 $F(4, 132)=19.099$, $p<.05$]. It was, thus, necessary to perform simple effects analyses due to the significant simple interactions and to isolate the three-way interaction effect.

Simple effects analysis (Adaptation at Test) for Poser 1's significant simple interaction revealed that Adaptation produced a significant effect for all three test stimuli [Adaptation at Ambiguous $F(2, 132)=22.679$, $p<.05$; Adaptation at Sadness $F(2, 132)=66.927$, $p<.05$; Adaptation at Happiness $F(2, 132)=3.402$, $p<.05$]. There were more than two levels of adaptation, and therefore, Tukey (hsd) pairwise comparisons were obligatory for the final understanding of this simple interaction effect. For the Ambiguous Test, all except one of the pairwise comparisons were significant (happiness adaptation did not differ significantly from baseline, despite its trend). For instance, the baseline intensity for the ambiguous test stimulus for this poser was perceived to be happy (+4.4083). Following the happiness adaptation, however, there was a reliable reduced intensity of happiness compared to the baseline (3.7333 compared to 4.4083, respectively), while sadness adaptation reliably led to an increase in intensity of happiness compared to the baseline (5.7667 compared to 4.4083, respectively). Next, for the Sadness Test, all pairwise comparisons were significant. The baseline for the sadness test stimulus for this poser was perceived to be -3.4667. Following the happiness adaptation there was a reliable increase in intensity of sadness compared to the baseline (-5.033 compared to -3.4667, respectively), while sadness adaptation reliably led to a decrease in intensity of sadness compared to the baseline (-1.4833 compared to -3.4667, respectively). Finally, for the Happiness Test, in spite of the clear trend consistent with the previous data, no pairwise comparisons were found to be significant. Taken together, these Tukey pairwise comparisons indicate that for Poser 1, intensity of emotion (similarly to identity of emotion) of the baseline is significantly adaptable for ambiguous, sadness and happiness test stimuli, i.e. happiness adaptation produced less perceived happiness (or more perceived sadness) and sadness adaptation produced less perceived sadness (or more perceived happiness). The cause of the two-way simple interaction for Poser 1 was the fact that mean adaptation differences were too small to be significant for the Happiness Test stimulus. This effect is shown in Figure 7.5.

Simple effects analysis (Adaptation at Test) for Poser 2's significant simple interaction revealed the same adaptation effect as Poser 1. Emotional adaptation produced a significant effect for all three test stimuli [Adaptation at Ambiguous $F(2, 132)=124.255$, $p<.05$; Adaptation at Sadness $F(2, 132)=41.622$, $p<.05$; Adaptation at Happiness $F(2, 132)=7.661$, $p<.05$]. There were more than two levels of adaptation, and therefore, Tukey (hsd) pairwise comparisons were obligatory for the final understanding of this simple interaction effect. For the Ambiguous Test, all pairwise comparisons were significant. For instance, the baseline intensity for the ambiguous test stimulus for this poser was perceived to be about neutral (-.0833). Following the happiness adaptation, however, there was a reliable increased intensity of sadness compared to the baseline (-1.7 compared to -.0833, respectively), while sadness adaptation reliably led to an increase in intensity of

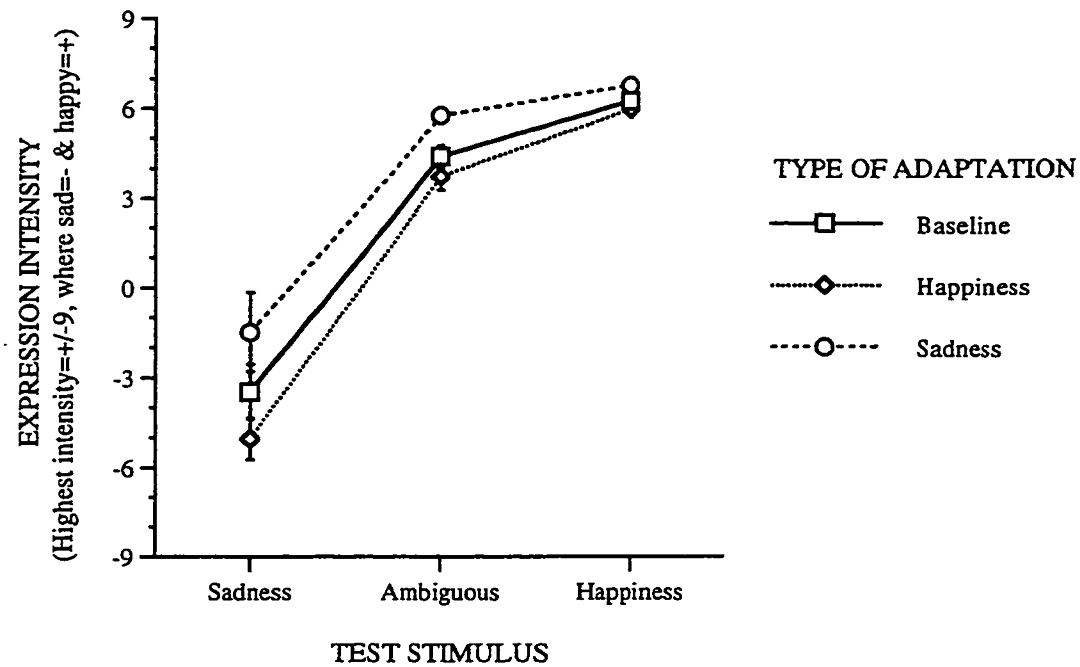

Figure 7.5. Intensity of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 1.

happiness compared to the baseline (3.0667 compared to -.0833, respectively). Next, for the Sadness Test, only happiness adaptation did not significantly differ from baseline, despite its appropriate effect. The baseline for the sadness test stimulus for this poser was perceived to be -3.8417. Following the happiness adaptation there was a reliable increase in intensity of sadness compared to the baseline (-4.775 compared to -3.8417, respectively), while sadness adaptation reliably led to a decrease in intensity of sadness compared to the baseline (-2.0167 compared to -3.8417, respectively). Finally, for the Happiness Test, only the happiness and sadness adaptation conditions were significantly different (i.e. happiness did not differ from baseline, and sadness did not differ from baseline). This was true despite the obvious trend. For instance, the baseline for the happiness test was 4.6583 prior to adaptation, 4.1417 following adaptation to happiness, and 5.3417 following adaptation to sadness. Taken together, these Tukey pairwise comparisons indicate that, similarly to Poser 1, for Poser 2, intensity of emotion of the baseline was significantly adaptable for ambiguous, sadness and happiness test stimuli (as shown in Figure 7.6), i.e. happiness adaptation produced less perceived happiness (or more perceived sadness) and sadness adaptation produced less perceived sadness (or more perceived happiness). The cause of the two-way simple interaction for Poser 2 was the fact that not all of the pairwise comparisons were significant (i.e. all three were significant for the Ambiguous Test, two were significant for the Sadness Test, and finally, one was significant for the Happiness Test).

Simple effects analysis (Adaptation at Test) for Poser 3's significant simple interaction revealed the same adaptation effect as the previous posers. Emotional adaptation produced a significant effect for all three test stimuli [Adaptation at Ambiguous $F(2, 132)=43.852$, $p<.05$; Adaptation at Sadness $F(2, 132)=7.661$, $p<.05$; Adaptation at Happiness $F(2, 132)=16.691$, $p<.05$]. There were more than two levels of adaptation, and therefore, Tukey (hsd) pairwise comparisons were obligatory for the final

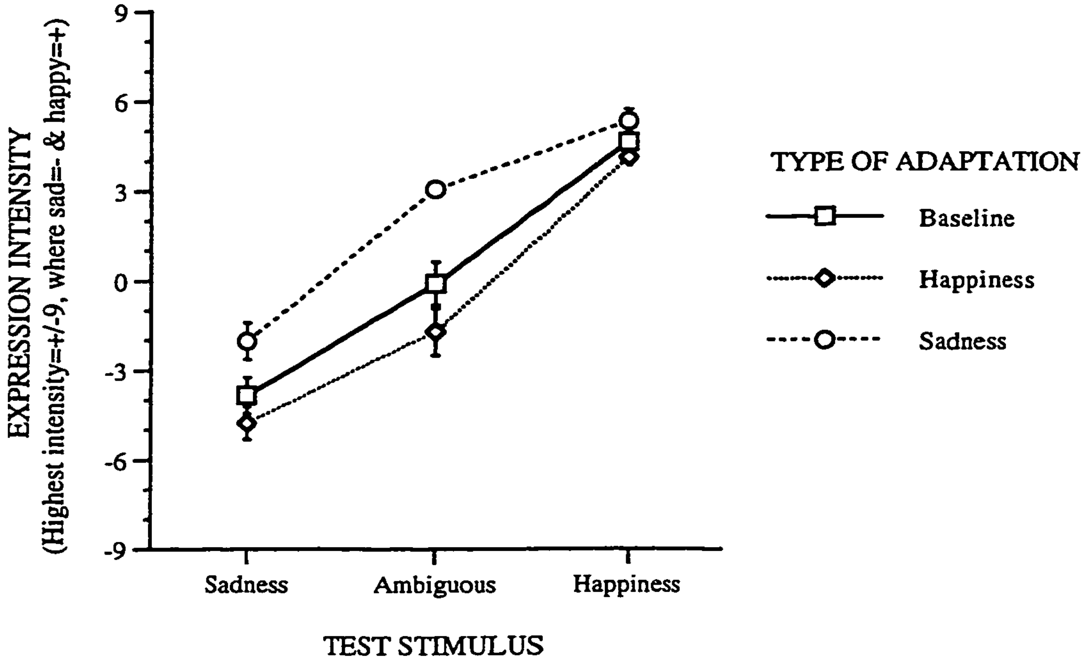

Figure 7.6. Intensity of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 2.

understanding of this simple interaction effect. For the Ambiguous Test, only sadness adaptation did not differ from baseline significantly, although it did differ in the expected direction (all other comparisons were significant). For instance, the baseline intensity for the ambiguous test stimulus for this poser was perceived to be about neutral (-.0833). Following the happiness adaptation, however, there was a reliable increased intensity of sadness compared to the baseline (-2.3167 compared to -.0833, respectively), while sadness adaptation led to a small increase in intensity of happiness compared to the baseline (.3750 compared to -.0833, respectively). Next, for the Sadness Test, only happiness versus sadness adaptation differed significantly (all other effects were, however, in the appropriate direction). The baseline for the sadness test stimulus for this poser was perceived to be -4.4333. Following the happiness adaptation there was a reliable increase in intensity of sadness compared to the baseline (-4.9500 compared to -4.4333, respectively), while sadness adaptation reliably led to a decrease in intensity of sadness compared to the baseline (-3.7500 compared to -4.4333, respectively). Finally, for the Happiness Test, only the happiness adaptation was not significantly different from baseline, despite its trend. For instance, the baseline for the happiness test was 3.5833 prior to adaptation, 2.975 following adaptation to happiness, and 4.725 following adaptation to sadness. Taken together, these Tukey pairwise comparisons indicate that, similarly to Posers 1 and 2, intensity of emotion of the baseline is significantly adaptable for ambiguous, sadness and happiness test stimuli (as shown in Figure 7.7) for this poser as well, i.e. happiness adaptation produced less perceived happiness (or more perceived sadness) and sadness adaptation produced less perceived sadness (or more perceived happiness). The cause of the two-way simple interaction for Poser 3 was again the fact that not all of the pairwise comparisons were significant (i.e. two were significant for the Ambiguous Test, one was significant for the Sadness Test, and finally, two were significant for the Happiness Test).

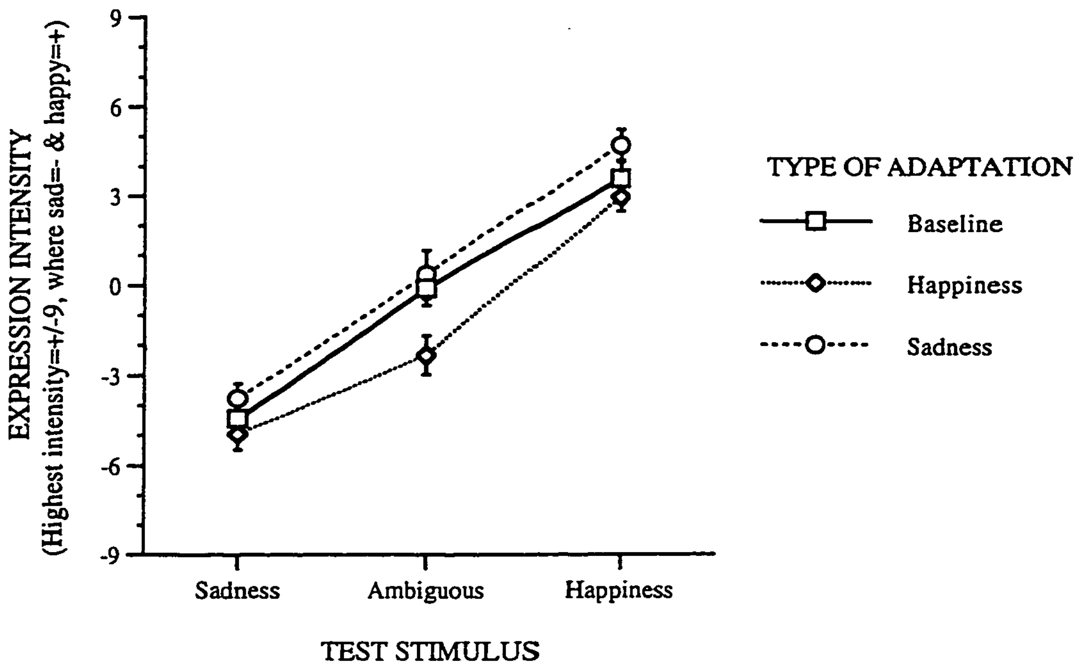

Figure 7.7. Intensity of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 3.

Finally, consistent with previous data, simple effects analysis (Adaptation at Test) for Poser 4's significant simple interaction revealed that emotional adaptation produced a significant effect for all three test stimuli [Adaptation at Ambiguous $F(2, 132)=54.771$, $p<.05$; Adaptation at Sadness $F(2, 132)=3.796$, $p<.05$; Adaptation at Happiness $F(2, 132)=9.721$, $p<.05$]. There were more than two levels of adaptation, and therefore, Tukey (hsd) pairwise comparisons were obligatory for the final understanding of this simple interaction effect. For the Ambiguous Test, only happiness adaptation did not differ from baseline significantly, although it did differ in the expected direction (all other comparisons were significant). For instance, the baseline intensity for the ambiguous test stimulus for this poser was perceived to be about neutral (-.0750). Following the happiness adaptation, however, there was an increased intensity of sadness compared to the baseline (-.1000 compared to -.0750, respectively), while sadness adaptation led to an increase in intensity of happiness compared to the baseline (2.7000 compared to -.0750, respectively). Next, for the Sadness Test, despite its trend, no pairwise comparisons were found to be significantly different, likely due to small mean differences. Finally, for the Happiness Test, only the happiness and sadness adaptation were significantly different from each other, although again the remaining comparisons were demonstrating the same adaptation effect. For instance, the baseline for the happiness test was 5.1833 prior to adaptation, 4.6833 following adaptation to happiness, and 6.0250 following adaptation to sadness. Taken together, these Tukey pairwise comparisons indicate that, similarly to Posers 1, 2 and 3, intensity of emotion of the baseline is significantly adaptable for ambiguous, sadness and happiness test stimuli (as shown in Figure 7.8) for this poser as well, i.e. happiness adaptation produced less perceived happiness (or more perceived sadness) and sadness adaptation produced less perceived sadness (or more perceived happiness). The cause of the two-way simple interaction for Poser 4 was again the fact that not all of the pairwise comparisons were significant (i.e. two were significant for the Ambiguous Test,

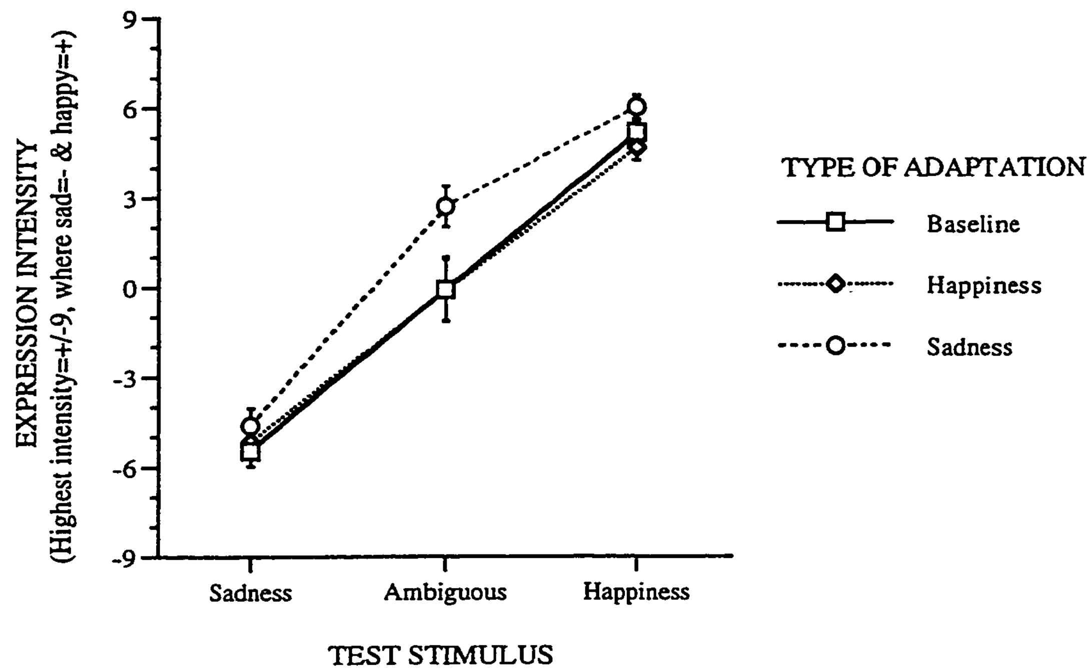

Figure 7.8. Intensity of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness static sequences for Poser 4.

none were significant for the Sadness Test, and finally, one was significant for the Happiness Test).

In summary, all four posers (two female and two male) demonstrated the same general adaptation effect. That is, adaptation to happiness decreases perceived happiness (or increases perceived sadness) and adaptation to sadness decreases perceived sadness (or increases perceived happiness). The only difference between the posers data is that the adaptation effect was not always significant for all Tukey pairwise comparisons. It is important, however, to stress that despite the lack of consistent significant adaptation effects at the pairwise comparison level, the effect size was large enough to maintain significant simple effects. Of even greater importance is the fact that the adaptation effect (significant or not) was consistent and present for all conditions for all posers. The fact that the identical adaptation effect was observed for both dependent measures, i.e. identity and intensity data, demonstrates the clear and meaningful effect of emotional adaptation on one's perceived identity and intensity of an emotional expression.

7.3.2 Dynamic Sequences

7.3.2.1 Identification of Expression

The subjects' identification response consisted of either an "s" for smile or an "f" for frown (the identical task as the static sequences). For the purpose of these analyses, this alphabetic response was also converted into a sign response. The frown response was converted into a "-1" whereas the smile response was changed into a "+1". This conversion was determined for each dynamic emotional sequence for each subject per condition and, like the static conditions a dependent t-test was conducted on the baseline identification data to determine if it was affected by the time of testing (i.e. the baseline condition was run both pre- and post-adaptation).

The two-tailed dependent t-test indicated that the baseline run prior to adaptation conditions did not differ from the baseline which was run following the adaptation conditions ($t(10)=.671$, $p>.05$). The lack of difference between the two baseline conditions suggests that there should be little if any carryover effects within the adaptation conditions, allowing for more reliable data and conclusions. It was therefore decided to collapse across these two baseline measures and use these combined data as the baseline or "no adaptation" data in the following ANOVA.

Next, a three-way analysis of variance was performed to examine the effect of Poser, Adaptation, and Test stimulus on the identification of the emotion. The highest order interactions that were significant were the Poser x Test [$F(6, 60)=7.801$, $p<.05$] and the Adaptation x Test [$F(4, 40)=2.802$, $p<.05$] interaction. All other effects were either non-significant or overridden by these higher order interactions [main effect of Poser $F(3, 30)=8.928$, $p<.05$; main effect of Adaptation $F(2, 20)=.515$, $p>.05$; main effect of Test $F(2, 20)=207.486$, $p<.05$; Poser x Adaptation interaction $F(6, 60)=.840$, $p>.05$; Poser x Adaptation x Test $F(12, 120)=.889$, $p>.05$].

As aforementioned, the Poser x Test interaction was one of the highest order interactions found to be significant [Note that this interaction did not involve the adaptation factor. The effect of adaptation will be discussed later on]. In other words, the effect of test stimulus (i.e. ambiguous, happiness and sadness) depended on the poser. Simple effect analysis (Test at Poser) was thereafter conducted on this two-way interaction to isolate the effect. It was determined that all four simple effects were significant [Test for

Poser 1 $F(2, 20)=59.060$, $p<.05$; Test for Poser 2 $F(2, 20)=131.938$, $p<.05$; Test for Poser 3 $F(2, 20)=189.570$, $p<.05$; Test for Poser 4 $F(2, 20)=76.932$, $p<.05$]. Tukey (hsd) pairwise comparisons were, thus, needed to isolate the Poser x Test interaction (since all the simple effects were significant it does not aid in the understanding of this effect), as well as, to isolate the simple effects. The pairwise comparisons for Test at Poser 1, Test at Poser 2, Test at Poser 3, as well as, Test at Poser 4 all indicated the same effect. All three tests were always significantly different from each other, which is not surprising since they should appear different to the subjects as they were constructed to do so. For instance, the ambiguous test was constructed to be just that, while the other two tests were made so as to be biased either toward happiness or sadness. The fact that these tests were perceived to be different from each other simply reinforces that the experimenter succeeded in creating these different tests. The fact that this was observed for all posers is also reassuring, but does leave some confusion as to why the Poser x Test interaction was significant. A graphical inspection suggests that the interaction is likely due to different degrees of differences in identity scores observed between the different tests (illustrated in Figure 7.9).

The Adaptation x Test interaction was the other highest order interaction found to be significant. In other words, the effect of emotional adaptation (i.e. none, happiness and sadness) depended on the type of test stimulus (i.e. ambiguous, sadness and happiness). Simple effect analysis (Adaptation at Test) was thus also conducted on this two-way interaction to isolate the effect. It was determined, however, that all three simple effects were non-significant [Adaptation at Ambiguous Test $F(2, 20)=.863$, $p>.05$; Adaptation at Sadness $F(2, 20)=1.764$, $p>.05$; Adaptation at Happiness Test $F(2, 20)=.500$, $p>.05$]. In other words, there was no evidence of an adaptation effect for emotional identification of dynamic sequences (as shown in Figure 7.10). This is contrary to what was observed in a clear way for the static counterparts.

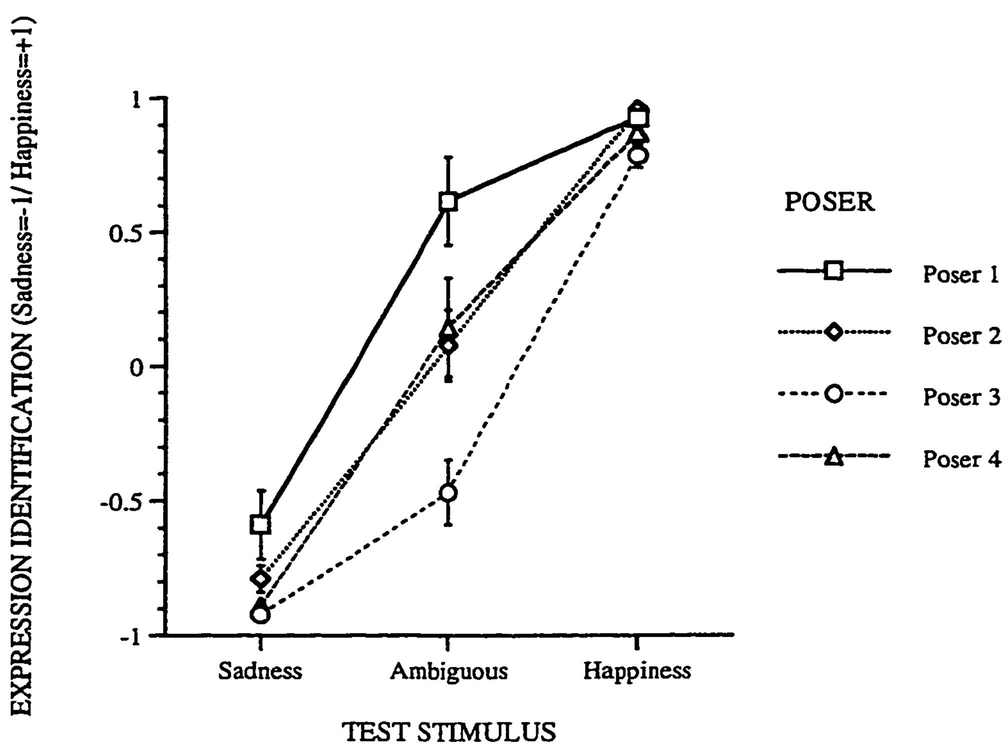

Figure 7.9. Identification of expression as a function of test stimulus for each poser with dynamic sequences.

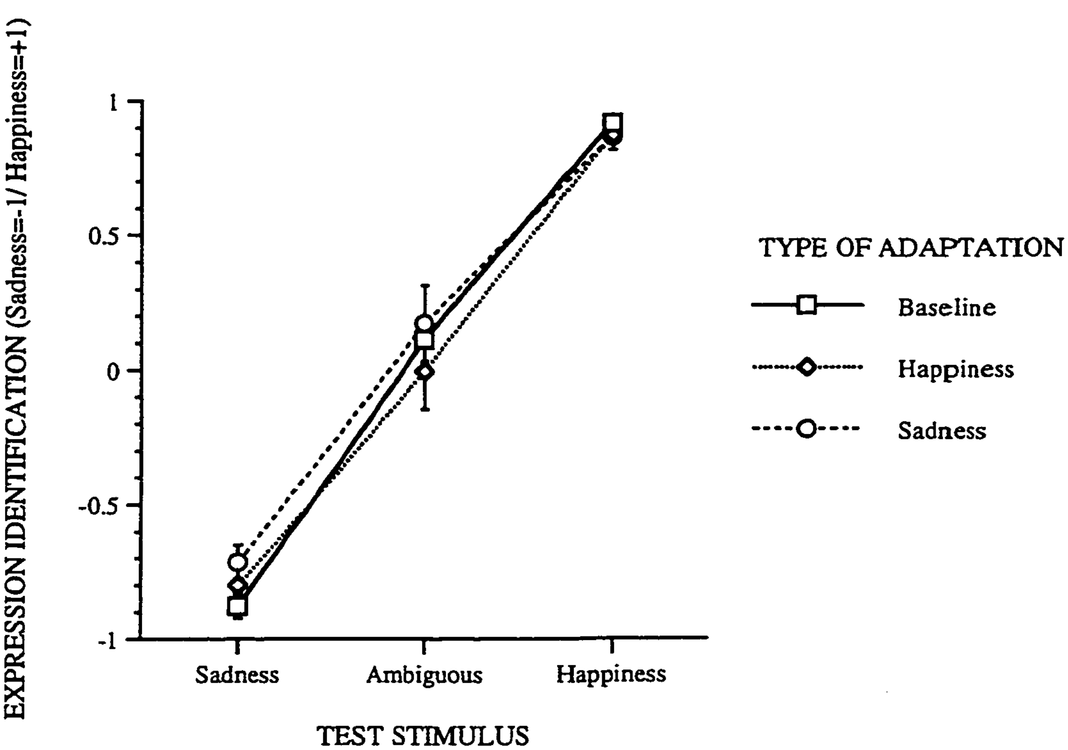

Figure 7.10. Identification of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness dynamic sequences.

7.3.2.2 Intensity of Expression

Like in the static conditions, the subjects' intensity response for dynamic sequences consisted of a numeric rating between 0 and 9, whereby 0 represented zero intensity and 9 indicated very high intensity. For an accurate comprehension of the possible adaptation effects, it was deemed necessary to know the identity response in addition to the intensity rating for the analyses. If a baseline intensity response was, for example, 2.4 (sadness) prior to adaptation and 2.3 (happiness) following adaptation to sadness, one can understand the need for the identity of emotion response in lieu of the intensity rating alone for a veridical conclusion. The researcher may have, for instance, mistakenly concluded that adaptation had no effect or only a marginal reduction of intensity (of .1). To accomplish this, each intensity rating was multiplied by its identity value. As previously mentioned, a "+1.0" represented a smile response while a "-1.0" represented a frown response. This conversion was determined for each dynamic emotional sequence for each subject per condition. Thus one would correctly conclude that there was indeed a substantial adaptation effect judged by the complete reduction in intensity of the frown (e.g. from -2.4 to 0) to the extent of becoming a moderate intensity smile (e.g. from 0 to +2.3). Thereafter, similarly to the identity data set, a dependent t-test was conducted on the baseline intensity data to determine if it was affected by the time of testing (i.e. the baseline condition was run both pre- and post-adaptation).

Like the identity data, the two-tailed dependent t-test indicated that the baseline run prior to adaptation conditions did not differ from the baseline which was run following the adaptation conditions ($t(10)=.953$, $p>.05$). The lack of difference between the two baseline conditions for the dynamic sequences suggests that there should be little if any carryover effects within the adaptation conditions, allowing for more reliable data and conclusions. It was therefore decided to collapse across these two baseline measures and use this combined data as the baseline or "no adaptation" data in the following ANOVA.

Next, a three-way analysis of variance was performed to examine the effect of Poser, Adaptation, and Test stimulus on the intensity of the emotion. Identical to the identity data, the highest order interactions that were significant were the Poser x Test [$F(6, 60)=6.395$, $p<.05$] and the Adaptation x Test [$F(4, 40)=3.219$, $p<.05$] interaction. All other effects were either non-significant or overridden by these higher order interactions [main effect of Poser $F(3, 30)=7.935$, $p<.05$; main effect of Adaptation $F(2, 20)=1.585$, $p>.05$; main effect of Test $F(2, 20)=131.302$, $p<.05$; Poser x Adaptation interaction $F(6, 60)=.874$, $p>.05$; Poser x Adaptation x Test $F(12, 120)=1.475$, $p>.05$].

As mentioned, the Poser x Test interaction was one of the highest order interactions found to be significant [Note that this interaction did not involve the adaptation factor. The effect of adaptation will be discussed later on]. In other words, the effect of test stimulus (i.e. ambiguous, happiness and sadness) depended on the poser. Simple effect analysis (Test at Poser) was thereafter conducted on this two-way interaction to isolate the effect. It was determined that all four simple effects were significant [Test for Poser 1 $F(2, 20)=65.923$, $p<.05$; Test for Poser 2 $F(2, 20)=77.481$, $p<.05$; Test for Poser 3 $F(2, 20)=112.015$, $p<.05$; Test for Poser 4 $F(2, 20)=59.859$, $p<.05$]. Tukey (hsd) pairwise comparisons were, thus, needed to isolate the Poser x Test interaction (since all the simple effects were significant it does not aid in the understanding of this effect), as well as, to isolate the simple effects. As was true for the identity data, the pairwise comparisons for the intensity data, i.e. for Test at Poser 1, Test at Poser 2, Test at Poser 3, as well as, Test at Poser 4 all indicated the same effect. All three tests were always significantly different from each other, which is in this case quite interesting since they need not appear different in their perceived intensity (unlike identity which was directly manipulated by the experimenter). For instance, the ambiguous test could be predicted to be somewhat low in intensity, while the other two tests, which were made so as to be biased either toward happiness or sadness, may have been predicted to be of about equal intensity. This in fact was observed. The happiness and sadness tests were about equal in intensity, as illustrated in Figure 7.11. The reason why these two emotional tests were found to be significantly different is simply due to the fact that one is a negative value (indicative of a perceived sadness) while the other is a positive value (indicative of a perceived happiness). Since this was consistent across posers it leaves some confusion as to why the Poser x Test interaction was significant. A graphical inspection suggests that the interaction is likely due to different degrees of differences in intensity scores observed between the different posers (again see Figure 7.11).

The Adaptation x Test interaction was the other highest order interaction found to be significant. In other words, the effect of emotional adaptation (i.e. none, happiness and sadness) depended on the type of test stimulus (i.e. ambiguous, sadness and happiness). Simple effect analysis (Adaptation at Test) was thus also conducted on this two-way interaction to isolate the effect. It was determined, however, that all three simple effects were non-significant [Adaptation at Ambiguous Test $F(2, 20)=2.122$, $p>.05$; Adaptation at Sadness $F(2, 20)=1.910$, $p>.05$; Adaptation at Happiness Test $F(2, 20)=.718$, $p>.05$]. In other words, there was no evidence of an adaptation effect for emotional identification of dynamic sequences (refer to Figure 7.12). This, like the identity data for dynamic sequences, is contrary to what was observed clearly for the static counterparts.

In summary, the dynamic sequences do not demonstrate an emotional adaptation effect like that observed for the static sequences. With the static clips, the perceived identity and intensity of an emotion could be strongly adapted by previously observing an emotional sequence (either sadness or happiness). The perceived identity and intensity of

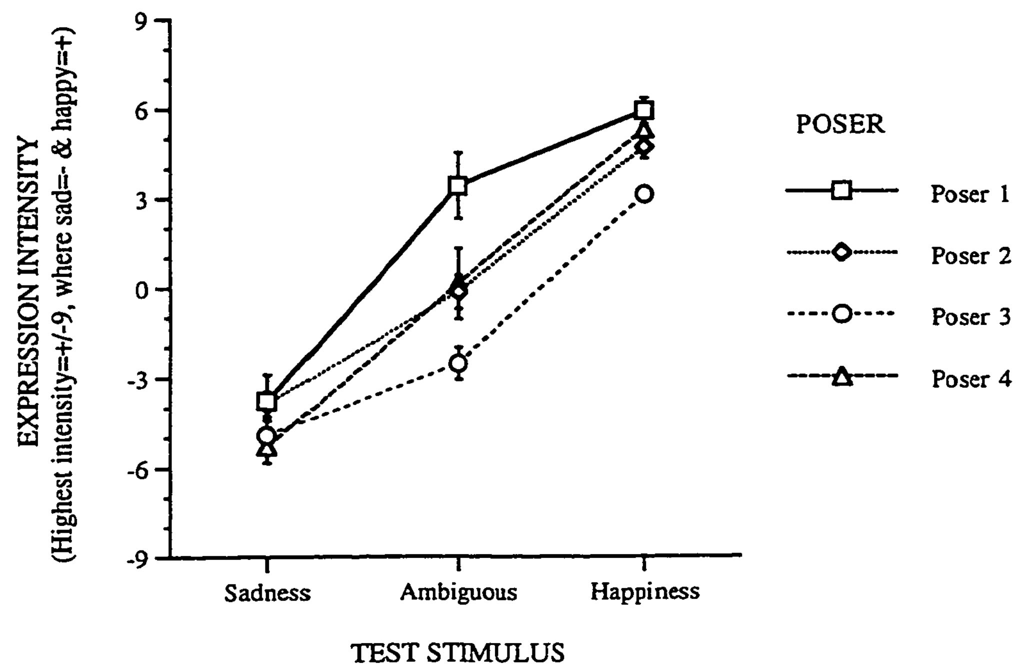

Figure 7.11. Intensity of expression as a function of test stimulus for each poser with dynamic sequences.

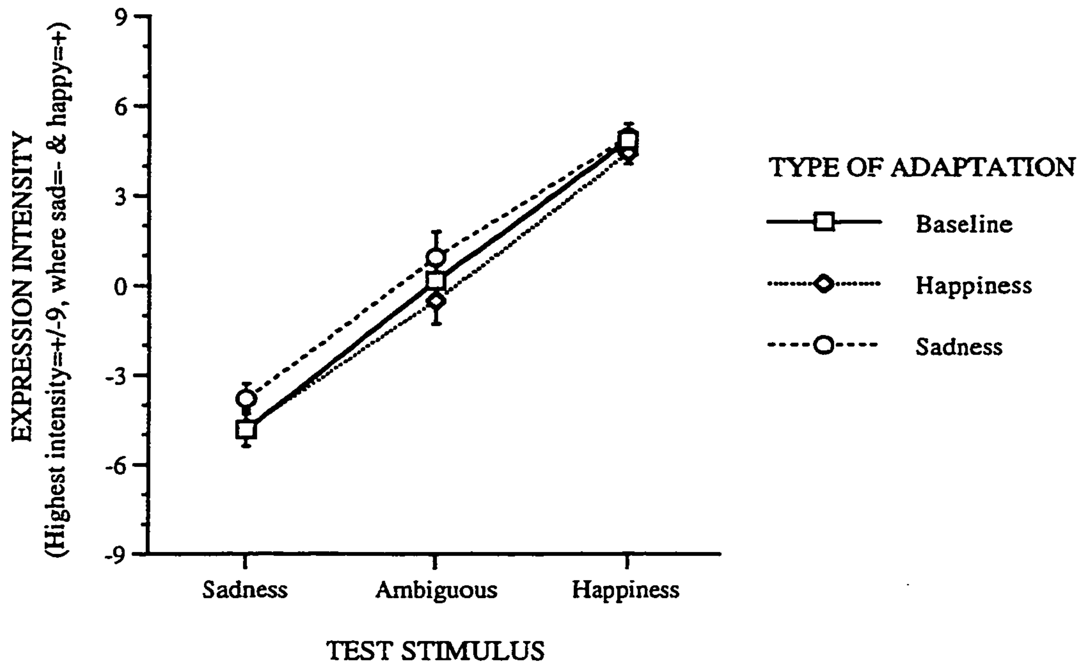

Figure 7.12. Intensity of expression as a function of test stimulus prior to and following adaptation to either sadness or happiness dynamic sequences.

dynamic sequences, on the other hand, do not appear to be influenced by the same emotional adaptation.

7.4 Discussion

The results obtained revealed an effect of adaptation, but contrary to the prediction, the effect was found only with the static adaptation stimuli. Therefore the hypothesis according to which dynamic information should lead to higher adaptation effects was not supported. A general adaptation effect was produced by the static stimuli on the identification as well as on the intensity ratings. For the identification measure, adaptation to happiness was followed by a decrease in perceived happiness (or an increase in perceived sadness). The same type of effect was true for the other emotion. Adaptation to sadness decreased the perceived sadness (or increases perceived happiness) in the test stimuli.

The differential effect of adaptation across the posers could be explained by the intensity of the bias present in the test stimulus. This bias was known to the experimenter and inherent in the construction of the stimuli. The morphing process was constant across all stimuli. In the final product, however, the ambiguous stimulus was totally dependent on the strength of the original end points. In considering the different strengths among the stimuli, it is still important to stress that the sadness and happiness test stimuli were not anchored. Adaptation was still capable of influencing the perceived identity of the test stimuli.

The intensity ratings produced the same pattern of results and can be considered as more sensitive to the effect. The adaptation effect (significant or not) was consistent and present for all conditions for all posers. This would support the idea that the sensitivity measure is more free to vary following the adaptation stimulus than the identity measure. The presence of similar adaptation effects for both dependent measures, i.e. identity and intensity data, suggest a clear and meaningful effect of emotional adaptation on one's perceived identity and intensity of an emotional expression.

Contrary to the expectations, the dynamic adaptation condition produced no evidence of an adaptation effect on either the identification or the intensity of the emotions. The contextual information preceding the required judgment was proposed as an explanation for the superiority of dynamic expressions in experiment 4. The rationale implied that the emotional signal would get integrated over time and lead to a stronger representation of the emotional intent. This view is similar to Thorton and Kourtzi's (1997) proposal that dynamic information may lead to a better perceptual representation than static information. The results, however, showed no such effect. Instead and in agreement with Prkachin and Prkachin (1994) an adaptation effect was obtained with static stimuli. With this paradigm, they found that the adapted emotional expression (static adaptation and test) led to a reduced level of correct identification whereas other emotional expressions were facilitated. The judged magnitude of the emotion was also reported to be less for the adapted emotions as opposed to the non-adapted ones. This would therefore suggest that the static condition utilized in this experiment replicated Prkachin and Prkachin's (1994) results.

The design of the present experiment, however, does not allow one to assess the effect of adaptation on other emotions as was done in their experiments. The conclusions are limited to the utilization of happiness and sadness and to the effect they have on each other. Contrary to Prkachin and Prkachin (1994) the present setting involved an orthogonal judgment which is tied to the two alternative forced choice procedure that was implemented. Even though the adaptation effect we obtained was reciprocal and crossed the boundaries of the emotions, it remains impossible to generalize the effect to other emotional expressions.

The difference observed between the static and the dynamic adaptation conditions support the idea that the two systems might be dissociated. Support for this proposal could be obtained using a similar paradigm but introducing a dynamic test. It is possible that if present the adaptation might not transfer to the static test. This could be examined empirically. Despite this possibility, one other factor may be important to consider about the static condition. Similar to the argument already raised in section 6.4, the temporal summation might play an important role in the production of an adaptation effect. Interestingly, figural aftereffects were often reported by the subjects in the static condition, whereas in the dynamic condition none were reported. This observation would support the existence of a low level adaptation distinct from the emotional adaptation proposed by Prkachin and Prkachin (1994). On that basis, they postulate the existence of a specific system responsible for the processing of facial expressions. If such a system exists, one might ask the question as to why the dynamic condition was not accessing the system. The response to this question is not clear, and might involve more than one system (see section 1.3).

Beside the possibility of an adaptation effect which would be the by product of a figural aftereffect in the static condition, there is another aspect that one could raise in order to explain the absence of adaptation in the dynamic condition. The emotional signal is a changing signal, with the exception of pictures, for which the capacity of processing over time is crucial. Following this logic one might propose that the system has a fast reset or refresh rate which would render it impermeable to adaptation effects, yet it might still experience priming effects. This interpretation would be consistent with Russell and Fehr

(1987), who have shown that the context surrounding an expression may affect the judgment of this expression. They called this effect the relativity thesis.

GENERAL DISCUSSION

The goal of the current project was to examine the processing of emotional facial expressions using a Psychophysical framework. This framework was adopted and judged suitable to answer questions related to the more microscopic feature components of the emotional facial signal (e.g., feature changes in space and time) rather than to the macroscopic issues (e.g., universality, etc.). As a first step, the project focused on establishing a set of stimuli that would be used in the subsequent experiments. These dynamic stimuli were then manipulated following global temporal parameters in order to assess the effects of different temporal onsets on the judgment of authenticity and intensity. The second part of the project focused mainly on the possible distinction existing between static and dynamic emotional facial expressions. A comparison was made between dynamic and static facial expressions using a Psychophysical approach in order to fragment the temporal components of facial expressions. The temporal components of the emotional facial expression have been stressed by different researchers (Ekman, 1982; Ekman & Friesen, 1984; DePaulo, Stone & Lassiter, 1985; Wallbott and Scherer, 1986; Hess & Kleck, 1990; Gosselin & Kirouac, 1994). This comparison was motivated and judged essential to substantiate or reject the notion that facial expressions of both types may be identical in the information that they convey. As already mentioned, this notion is implicitly recognized. However, little explicit or empirical information has been collected to support this claim. Therefore, the goal pursued by this set of experiments was first of all, to delineate some of the important dynamic parameters that are conveyed by the motion signal in dynamic emotional facial expressions and secondly, to determine how these parameters influence the judgment of facial expressions.

In this series of experiments, emphasis was put on two specific emotional expressions, happiness and sadness. This choice was motivated primarily by the fact that these two emotions are commonly referred to as opposites of each other. Another factor which also motivated this choice were the findings of Basilli (1979) who showed that these two emotional facial expressions yielded reliable recognition judgments when tested with point-light displays. This type of displays reduces the information available to the motion components exclusively. Consequently, these two emotions may be considered as containing reliable information in the temporal domain to produce accurate recognition.

To clarify some of the points that are going to be addressed in the discussion, it is important to remind the reader about some particularities of the stimuli used and their effect on the statistical analyses thereafter. Among the different variables that were analyzed, several were expected to lead to significant statistical differences due to the idiosyncratic characteristics of each poser as well as the type of sequence depicted (happiness to sadness and vice versa). In fact, the experimental conditions were not planned to be equated with each other (i.e. the posers were not coached as to how long each emotional expression should be displayed nor were the sequences selected according to their length). For this reason, the emergence of differences across posers reported in the results section were expected. Altogether, one can easily accept the notion that each poser produces dynamic emotional facial expressions of different strengths and different lengths. Similarly, the selection process to extract an exemplar of each emotional expression was not designed to screen for such differences either (i.e. equating the characteristics of the sequences across posers and across starting emotions). The selection criteria were simply based on the typicality of the sequence as a representation of the two emotions. Consequently, the apparent complexity of the experimental designs for each experiment can easily be reduced to the discussion of the variables that were actually manipulated.

8.1 The Neutral Phase

The discussion will address the main hypotheses in relation to dynamic and static emotional facial expressions as well as the temporal manipulations. However as a first step, it is important to focus attention on the first experiment for which an non-predicted outcome arose. In this experiment, forward and backward sequences were presented in order to determine the point of neutrality within the dynamic sequences. The sequences comprised a zone of neutrality which was flanked by happiness and sadness expressions on each end. Interestingly, the direction in which the movies were played affected the neutral zone. This outcome was unexpected and failed to support the hypothesis according to which the perceived neutral segment of the dynamic sequences should remain unaffected by the direction of presentation. The playback direction of the sequences did not introduce any feature changes within the sequences. The neutral duration measured with the true or original happiness-to-sadness sequences was found to be significantly longer in the forward than in the backward direction. A similar effect was obtained with the original sadness-to-happiness sequence presented backward. Taken together this observation suggests that there is specific information in the presentation direction of a emotional facial expression sequence utilized in the processing of facial affect. Specifically, these findings reflect an overall effect of emotional sequence. Sequences which start with the expression of sadness tend to produce shorter neutral durations. The analysis of the neutral edge revealed that for the original happiness-to-sadness sequence there seemed to exist a confusion at the edge between sadness and neutral and not at the edge between happiness and neutral.

One difficulty related to the interpretation of this pattern of results (mostly the ones concerning the neutral edges since other types of measure derive from them) deals with the fact that only the original happiness-to-sadness sequence produced the reduced neutral duration effect by shifting the neutral edge of the sequence when played backward. The trends observed with the other type of sequence (original sadness-to-happiness played forward), however, suggest that this effect might be real as opposed to just an artifact present in some sequences. The particularities associated with this reduction in neutral durations can not be explained easily on the basis of the present findings. This experiment was not constructed to assess such a question. It might be possible to answer this question by designing an experiment in which this variable can be directly examined.

Similarly because of this observed uniformity, it is possible to think that this effect may be dependent on the subject's perceptual processing of the emotional signal which is evidenced by the procedure used in this experiment. It is difficult to exclude the effect of direction as the major factor producing the neutral duration reduction. It might be, however, that the order in the emotional sequence is the crucial factor. A confusion that exists at the boundary between emotions might exist in a similar way as a confusion at the boundary between one emotion and neutrality (Etcoff & Magee, 1992; Calder, Young, Perrett, Etcoff & Rowland, 1996). Consequently, one could propose that the observer's extraction of the emotional visual signal is tuned in the temporal domain to specific features and feature changes in a similar way as the one encountered with the inverted face effect (Farah, Wilson, Drain and Tanaka, 1995; Moscovitch, 1996; Lyons, Kamachi, Tran, Gyoba & Akamatsu, 1997).

An observer bias might also explain the shift observed for the neutral edge toward the expression of sadness. This shift of the neutral edge corresponds to a reduced period during which sadness is perceived. The implementation of the bias would serve the purpose of reducing the unpleasantness with which the observer might have been confronted. This interpretation could perhaps be tested using morphed caricatures of emotional facial expressions in order to reduce the empathic disturbances that the sadness expressions might produce. On the other hand, a replication of the present results would also be necessary before any further interpretation is carried out. It is also impossible to argue that it might be a systemic effect which would not occur with a different pair of emotions. Along the same line, another question arises: Is this effect a repulsion from the happiness end or an attraction to the sadness end? To conclude, it is plausible to think that the subject's shift in the neutral edge was the result of a bias which prevented the observer from experiencing unpleasant feelings. If so, this effect might generalize to different pairs of emotions and therefore deserves to be addressed empirically.

8.2 Selection of the Sequences

One of the main hypotheses of the projects pertains to the fourth experiment. The position assessed was that dynamic sequences would better disambiguate and provide more information about the emotional intent of an individual as opposed to a static version. This proposition was based on the importance of the motion signal in the communication of emotions. In order to proceed in testing this hypothesis, both experiment 1 and 2 were necessary steps. In Experiment 2, the sequences from experiment 1 were split in two as determined by the location of the neutral point. The latter corresponded to the middle point within the neutral zone. Two excerpts were therefore obtained from each emotional sequence and a categorization of the stimuli was performed through experimentation. The excerpts that led to superior accuracy judgments were retained for the subsequent experiments (3, 4 and 5).

This experiment was therefore descriptive in nature. The categorization of each sequence was made at the point when the observers would stop the sequence. This point was defined in the instructions as the earliest moment in the dynamic sequence for which the subjects thought they could provide an accurate judgment of the depicted emotion.

This procedure revealed that sequences could be misjudged when insufficient information was given. Similarly, misjudgments also occurred when misleading visual signals were present in the sequences. This visual signal or noise ranges in variety and complexity from a simple blink to the presence of micro expressions (Ekman & Friesen (1984). This possibility was verified for poser 3 who obtained a significantly lower percentage of correct identifications in the forward condition while expressing sadness. The sequence was re-examined by the experimenter, and it was revealed that the point of judgment identified included a micro-expression in the opposite direction to the target emotion. A tint of happiness was present before the expression unfolded into sadness.

Another difficulty with this procedure was that the thresholds were approximations of the veridical ones. All thresholds were inflated since the recognition judgments always occurred after the subject had decided that sufficient information was presented prior to their decision. Despite this limitation, the judgment procedure was preferred over the more lengthy technique of constant stimuli. This procedure provided two types of information necessary for experiment 4. First, a threshold was obtained which could be adjusted as to reflect the possible veridical one. Secondly, this threshold provided an indication as to the length required for the sequences. The length was crucial in order not to unnecessarily inflate the duration of the other experiments.

8.3 Manipulation of the Temporal Factors

Several sections in the introduction discussed the importance of the temporal aspects of emotional facial expressions. Consequently, the third experiment was designed to examine the effect of varying the temporal characteristics of dynamic emotional facial expressions on the judgment of the authenticity and intensity of the expressions. It is worth mentioning that the two measures seem to be independent of each other with only a marginal effect of speed on the intensity ratings. On the other hand, authenticity ratings were more affected and therefore supported in part the hypothesis that any deviations from the normal speed of the dynamic sequences would produce lower ratings of authenticity. The posing speed was taken as the reference point and was also thought to reflect the veridical speed of the target emotions. The analysis of the authenticity rating showed a dissociation between the two emotions. First, the happiness sequences always received a rating more authentic than the sadness sequences, regardless of their original direction or poser. The superiority of backward over forward presentations is consistent with the results obtained in the previous experiments. Backward presentations were again found to be rated as more real than forward presentations with the exception of Poser 2 which would account for the three-way interaction reported in the previous section.

A dissociation between the two emotions was also identified with the speed variation. Half-speed sequences tended to increase authenticity ratings for happiness and decrease authenticity ratings for sadness while double-speed tended to decrease authenticity ratings for happiness and increase authenticity ratings for sadness. One reason which suggests that this effect, though weak, might be veridical is supported by the inverted relationship along the speed axis for both happiness and sadness. There is no clear explanation so far which could account for this observation. Some insight may reside in the microgenesis of the expressive sequence. One could also propose that the meaning of this effect would lie in the fact that a slow progression of the features over time accentuates the perception of realness in happiness displays while the opposite occurs for sadness. One explanation which could account for both types of effect at once would be the introduction of a concept where authenticity is linked with a particular speed, an ideal speed of progression. The ideal speed would correspond to a normalized temporal frequency in which the feature displacement at the time of recording would be combined with the speed of presentation. This idea cannot be tested a posteriori with the design and methodology employed here, but it would certainly deserve full attention in the future.

The hypothesis associated with the intensity variable was that faster speed would produce higher ratings of perceived emotional intensity. The analysis revealed a more complicated pattern of results. The happiness sequences were sometimes more intense and sometimes less intense than sadness. None of the effects were repetitive across posers. These results then suggest that the intensity judgment, as might be predicted, could be highly dependent on the feature configuration in the face. This is mainly supported by the difference observed across posers which would also underline a difference in their feature configurations. In considering the variation in intensity that may exist before the manipulations are introduced, it would be interesting to try to equate the intensity of the stimuli in the future before the experimental manipulations.

Contrary to the authenticity judgment, the effect of speed depended on the poser and direction. To simplify, the speed at which the movie was played sometimes interacted with the original direction of the movie, but always depended on the poser. Poser 5 accounted by himself for the interaction. For this reason, it might be more cautious to attribute this effect to random factors instead of postulating causes for a single stimulus out of six. The replication of this effect would therefore be necessary before attempting to search for a cause.

The two types of measure collected revealed an effect of the temporal factors on the perception of the emotion. One effect that is worth mentioning deals with the authenticity and intensity ratings which both were affected by the increase of the playback speed. Doubling the speed increased the perceived authenticity of the sadness expression at the same time as it reduced the perceived intensity of the same expression. This finding suggests that the increase in speed accentuates the authenticity while the intensity diminishes. It is difficult to reconcile this effect on intensity with the proposed impermeability introduced earlier. One possibility would be that the condensed sequence does not permit a full processing of the information presented before the mask occurred. The impoverished representation would inflate the authenticity by reducing the information that might revealed the lack of. Following the same rationale, the intensity would be reduced by the weaker perceptual representation.

Interestingly, Hess and Kleck's (1990) comparison of elicited and deliberate emotional facial expressions using happiness and disgust revealed an effect of temporal properties. Their results indicated that the two types of expression have different temporal properties. Interestingly, the authenticity judgment was more affected than the judgment of intensity. Intensity was only marginally affected by the temporal factors. This would suggest that the judgment of intensity would rely less on the temporal factors present in the emotional sequence. It could be that the information necessary to assess the intensity of an emotion is directly linked to the spatial displacement of the features in the face rather than to the speed at which the emotion develops.

As shown in the past, posed and spontaneous dynamic facial expressions possess subtle temporal information that can distinguish them from one another. Researchers argue that the typicality of posed expressions might affect the genuine aspect of an emotional expression (Ekman, Hager & Friesen, 1981; Kowner; 1995; Skinner & Mullen, 1991;

Ekman & Friesen, 1984; Rinn, 1984; Hager & Ekman, 1985; Weiss, Blum & Gleberman, 1987; Hess and Kleck, 1990; Gosselin & Kirouac, 1994). The judgment of authenticity in this experiment, however, seems not to have suffered from the utilization of posed expressions. This observation is supported by the high rating of authenticity obtained with the happiness sequences. One might argue that this judgment reflects a different set of standards as the one required when judging the authenticity among posed and spontaneous expressions (Gosselin & Kirouac, 1994).

There is one further interesting point that needs to be stressed concerning the consistent judgment of authenticity obtained in this experiment and the shift in the neutral edge reported in the first experiment. Together these findings converge to suggest that happiness and sadness might be particular in the judgment they elicit in the observer. The suggestion of an observer bias in favor of experiencing happiness seems to be supported by the present findings. Concerning the question raised while discussing the results of the first experiment, the results of the third experiment would support a repulsion of the neutral edge (on the sadness side) away from happiness. This would result in an increase of the duration of perceived happiness. The observer bias would prevent the observer from experiencing unpleasant feelings. As proposed earlier, this effect should be detectable with other unpleasant emotions for which reduced authenticity ratings should also be given. This could be tested using the same procedure but different pairs of emotions.

8.4 Static and Dynamic Emotional Facial Expressions

The comparison between static and dynamic emotional facial expressions was a central component of this project in order to substantiate the importance of the motion signal and to estimate the relative contribution of each mode. A basic Psychophysical method was utilized. The technique of constant stimuli with a two alternative forced choice procedure was adopted because of the inherent difficulties that the dynamic sequences contributed to other types of psychophysical methods such as direct adjustment. As reported in section 6.4 the dynamic information present in a sequence did not produce higher recognition rates in comparison with static sequences. Despite this lack of significance, all observers, regardless of the emotion portrayed, exhibited an increase in their identification rates and the saliency judgments for dynamic in comparison to static sequences. One of the probable causes for this failure to show an advantage of the dynamic sequences might be attributed to the ceiling effect obtained. Sadness sequences led to an easy and sometimes perfect identification judgment even when little was presented. Three out of the five posers produced recognition rates around 100%. A similar, but limited, performance was also found in the happiness sequences. One poser out of five showed this effect in performance.

The necessity to obtain a neutral state was crucial in this experiment. It is possible that the approach chosen did not meet the expectations. For example, the sadness sequences failed to portray a true neutral state. Consequently even with the least amount of information in the stimulus the observers were able to judge the expression segment as pertaining to the correct emotion. It was proposed in section 6.4 that the posers might involuntarily disclose information as to the underlying emotion. This explanation was also suggested for the happiness sequences. This possibility was nevertheless judged highly unlikely since the effect on sadness was too severe. Another explanation based on the similarity between neutral and sadness expressions could also be proposed. It is possible that sadness shares similar features with the neutral expression. The most probable explanation, however, is the summation process. Over time, static expressions become more heavily represented than dynamic ones since the static expression is the apex of its dynamic counterpart.

Landry (1993) found an advantage of dynamic sequences over static ones. It is possible that the failure to replicate these findings is associated with the choice of static stimuli. For example, Landry's static was the middle image extracted from the dynamic excerpts. This would suggest that this image is different from the dynamic apex. Therefore, one might propose that the informational content is different. The difference suggested would result in a reduced signal in reference to the apex of the dynamic sequence.

To conclude, despite the emergence of a nonsignificant effect, dynamic facial expressions were often identified with more accuracy than static depictions of the same expression. The difference between the two Psychophysical functions suggests that the visual information present in emotional facial expressions varies in strength when dynamic and static comparisons are made. These results support the idea that information present in frames preceding the final, or static depiction, provide important information for the disambiguation of the emotional expression. Furthermore, the difficulty experienced with the sadness sequences suggests that the expression of neutrality may contain a great deal of sadness. In the same vein, as proposed by Etcoff & Magee (1992) and Calder, Young, Perrett, Etcoff & Rowland (1996), confusions arise at the boundary between emotions. Similar confusions might also arise at the boundary between one emotion and neutrality. This would suggest that the categorical boundary between sadness and neutrality is somewhat blurred.

8.5 Adaptation to Static and Dynamic Emotional Facial Expressions

The discussion in the previous section concerning the strength of the static signal can be applied to the results obtained in the fifth experiment as well. As mentioned in section 7.4, contrary to the prediction, the adaptation effect was found only with the static stimuli. Therefore the hypothesis, according to which dynamic information should lead to higher adaptation effects, was not supported. A general adaptation effect was produced by the static stimuli on the identification as well as on the intensity ratings. For the identification measure, adaptation to happiness was followed by a decrease in perceived happiness (or an increase in perceived sadness). The same type of effect was true for the other emotion. Adaptation to sadness decreased the perceived sadness (or increased perceived happiness) in the test stimuli.

The intensity ratings produced the same pattern of results and can be considered as more sensitive to the effect. The adaptation effect (significant or not) was consistent and present for all conditions for all posers. This would support the idea that the sensitivity measure is more free to vary following the adaptation stimulus than the identity measure. The presence of similar adaptation effects for both dependent measures, i.e. identity and intensity data, suggests a clear and meaningful effect of adaptation on one's perceived identity and intensity of an emotional expression.

In conclusion and contrary to the expectations, the dynamic adaptation condition produced no evidence of an adaptation effect on either the identification or the intensity of the emotions. The contextual information preceding the required judgment was proposed as an explanation for the superiority of dynamic expressions, though not significant, in experiment 4. In agreement with Prkachin and Prkachin (1994) an adaptation effect was obtained with static stimuli. These researchers also found that the adapted emotional expression (static adaptation and test) led to a reduced level of correct identification whereas other emotional expressions were facilitated. The judged magnitude of the emotion was also reported to be less for the adapted emotion as opposed to the non-adapted ones.

There is one interesting proposition that might be put forward on the basis of these findings. The difference observed between the static and the dynamic adaptation condition seems to imply a dissociation between the two systems. This proposition could be assessed using a similar paradigm but by introducing a dynamic test. It is possible that if present the adaptation might not transfer to the static test. This could be examined empirically. Despite this possibility, one other factor may be important to consider with respect to the static condition. Similarly to the argument already raised in section 6.4, the temporal summation might play an important role in the production of an adaptation effect. Interestingly, figural aftereffects were often reported by the subjects in the static condition whereas in the dynamic condition none were reported. This observation would support the existence of a low level adaptation distinct from the emotional adaptation proposed by Prkachin and Prkachin (1994). On that basis, they postulated the existence of a specific system responsible for the processing of facial expressions. If such a system exists, one might ask the question as to why the dynamic condition is not accessing the system. The response to this question is not clear, and might involve more than one system (see section 1.3).

Beside the possibility of an adaptation effect which would be the by product of a figural aftereffect in the static condition, there is another aspect that one could raise in order to explain the absence of adaptation in the dynamic condition. The emotional signal is a changing signal, with the exception of pictures, for which the capacity of processing over time is crucial. Following this logic one might propose that the system has a fast reset or refresh rate which would render it impermeable to adaptation effects, yet it might still experience priming effects as the one obtained by Thornton and Kourtzi (1997). This interpretation would be consistent with Russell and Fehr (1987), who have shown that the context surrounding an expression may affect the judgment of this expression. They called this effect the relativity thesis.

8.6 Concluding Thoughts and Further Directions

It has often been argued in the past that the effect of dynamic presentations could not be seen because the effect produced with static presentations already was too strong to allow a dynamic presentation to contribute to improve the percept in a noticeable way (Bruce & Valentine, 1988). This project did not permit to verify that claim directly. However, the results obtained from experiment 4 and 5 support indirectly but not unequivocally this proposition. The failure to demonstrate a facilitation effect of dynamic emotional facial expression on the processing of the emotional content is counterintuitive. Several researchers have stressed the importance of dynamic information in the disambiguation of the emotional signal (Ekman, Hager & Friesen, 1981; Kowner; 1995; Skinner & Mullen, 1991; Ekman & Friesen, 1984; Rinn, 1984; Hager & Ekman, 1985; Weiss, Blum & Gleberman, 1987; Hess and Kleck, 1990; Gosselin & Kirouac, 1994). Rare are the studies that demonstrated this effect when comparing static and dynamic displays of emotions (Landry, 1993). The rationale for this project implied that the emotional signal in dynamic displays of emotions would get integrated over time and lead to a stronger representation of the emotional intent. Thorton and Kourtzi (1997) proposed a similar rationale to explain the results they obtained.

One must conclude that the approach undertaken in this project did not allow to control for several factors. One of these is certainly the temporal summation that occurs with the static stimuli. Other factors such as the quality of the stimuli and their intensity were not equated in this project. The rationale for utilizing untrained posers was driven by ecological validity. The question now remains as to whether trained posers might have provided us with more suitable emotional depictions. In considering the limitations associated with the utilization of trained posers, the same procedure could again be implemented. On the other hand, it is needless to say that everyday life encounters do not necessarily involve highly trained emotional "displayers".

Finally, the idea put forward by Prkachin & Prkachin (1995) concerning the existence of feature detectors is questionable on the basis of the results collected in the fifth experiment. Adaptation effects limited to static displays alone do not reflect a suitable apparatus for the perception of emotional facial expressions. The evolution should have favored the emergence of feature detectors sensitive to dynamic information rather than to non existing or rarely encountered static ones. The argument proposed to explain these results as well as the one that was obtained in experiment 5 stressed the presence of retinal aftereffects which would produce the adaptation effects reported without the participation of higher levels of processing. Several questions remain unanswered in terms of the absence of an effect of the dynamic adaptation stimuli. Interestingly, no adaptation effect was found in a pilot project using dynamic stimuli that were repeated over time in order to strengthen the adaptation phase. The difficulty in eliciting an adaptation effect with dynamic inducing stimuli suggests that the dynamic emotional encoding system might be protected.

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APPENDIX A: HUMAN ETHICS PROTOCOL FORM

CONCORDIA UNIVERSITY

SUMMARY PROTOCOL FORM

RESEARCH WITH HUMAN SUBJECTS

Please comment briefly on each item using additional space if necessary. Please Type or print. Grant applications are not forwarded to the committee; be concise but specific regarding procedures, etc.

1. Title of Research Project:

Visual basis for the perception of dynamic facial expressions.

2. Granting Agency:

NSERC and FCAR

3 .Sample of persons to be used:

Subjects will all have normal, or corrected-to-normal vision. They will be approximately in the age range of 18 to 50 and be recruited from the general population.

4 . Method of Recruitment of Participants:

Subjects will be recruited among the adult general population, on a voluntary basis. A greater participation from the University community is expected. Sollicitation will be performed through poster or one to one basis. Advertisement through the University or any other major newspapers may be necessary. It is intended that subjects will be made aware that this is voluntary and that no prejudice may arise against them if they decline participation.

5. Treatment of Participants in the course of the Research:

Subjects will be asked to participate in a series of separate experiments, each one lasting approximately 1 hour or less. In all experiments, they will be presented with stimuli on a computer screen and asked to perform accuracy as well as speed discrimination judgments.

A distinction among the participants is made between those recruited as subjects and those recruited as posers. The poser's group refers to the participants which will be selected to provide stimuli for the experiment (video sequences). Participants belonging to this bank of emotional facial expressions in particular will be informed of the purposes and manipulations which are intended to be done on their extracted video segments. Both groups of particpants will be presented with an informed consent form which differs according to which of the two groups the participant belong to.

6. <u>Indicate briefly how the research plan deals with the following potential ethical concerns:</u>

(a) Informed Consent (Written Consent Form or Draft of Verbal Instructions given to participants must be attached)

The subjects will be required to sign a written consent form in which the general purpose of the research will be mentioned. One consent form will be used for the subjects and one for the posers (see examples).

(b) Deception (Includes: deliberate presentation of false information; Suppression of material information; Selection of information designed to mislead; Selected disclosure)

Except for not revealing the rationale and the specific hypotheses prior to the experiments, no deception will be used in this research project.

(c) Freedom to discontinue

Subjects will have complete freedom to discontinue their participation at any time. Neither their University standing or their future participation in research conducted in the Psychology Department of Concordia University will be prejudiced in any way.

(d) Risk to Subjects' Physical and Psychological Welfare (Including low-level risk or any form of discomfort raised by the experimental procedure and how it will be dealt with)

To the extend of our knowledge, no particular risk to the subjects' physical or psychological welfare is expected to arise from this study.

(e) Post-Experimental Explanation:

Once the study is completed, subjects wishing to receive an explanation about the rationale underlying the study, will be provided with all the pertinent information. Also, the results of the study will be available to any subject who wishes to consult them.

(f) Confidentiality of Results:

The results of each subject individually will remain confidential, even though the results of the study may be published. The posers will be informed that their picture or video segments become the property of the researcher exclusively and that this right may be shared with other researchers in the future.

(g)Protecting and/or Adressing Participant "At risk" Situations: (If measurement tools or other data reveal something about the physical or mental status of the subject, placing the subject at risk, what will be done to insure that subjects are referred to appropriate counselling/medical personnel)

Not applicable

7. <u>Please comment on any other potential ethical concerns which may arise in the course of the research</u> (e.g. Responsability to subjects beyond the purposes of the study)

There should not be any other ethical concerns arising in the course of this study. However each subject will be told not to hesitate to get in touch with the experimenter if any problem should arise. A telephone number where the experimenter can be reached will be provided to each subject.

8. <u>Please comment on expected benefits to be derived from this research.</u>

This research will help the understanding of the mechanisms underlying motion perception. More specifically how the basic characteristic of an image get extracted and analyzed to lead to the recognition of emotional facial expression. Little is known about the perception of facial emotional signals with dynamic stimuli.

PLEASE ATTACH COPIES OF THE RESEARCH INSTRUMENT/LETTER OF CONSENT (If applicable)

Michael von Grünau ______________.
Name of Project Director

____
Signature of Project Director

Psychology ____________________________
Department

848-2190 ____________________________
Telephone

____
Date

Names of any Research Associate or Assistant involved in this project

Stéphane Dubé ________

APPENDIX B: CONSENT FORM FOR POSERS

CONSENT FORM TO PARTICIPATE IN RESEARCH

Research Title: Visual basis for the perception of dynamic facial expressions.

The series of experiments in which you are about to participate is concerned with the extraction of the principle factors and attributes that the visual system utilizes in the perception of facial expressions. The subjects will be presented with short sequences displaying particular emotions. Your task as a poser will be to produce different expressions on request or following a video clip designed to induce a particular emotion. Your different expressions will be recorded and stored on a video tape to serve as comparisons stimuli among different individual and expression displays. Video segments could be edited to cut or add information to the signal which in some case could render the new composite sequences caricatural or absurde looking. It should be understood that subjects will be judging either a non-modified or a composite of your original emotional facial expression. The purpose of this experiment is to further our knowledge on motion perception in general and motion extraction signal in emotional facial expressions. No deception will be used in this experiment.

I understand that:

-this research is conducted by Stéphane Dubé, under the supervision of Dr. Michael von Grünau, as part of the Ph.D. programme in psychology at Concordia University.

-I may ask any questions about the experiment prior to signing this consent form and that I can expect a satisfactory explanation.

-my participation as poser in this experiment is voluntary, and that my refusal to participate would not prejudice my University standing in any way, nor my participation in other experiments in the Concordia University Psychology Department.

-each one of the recording sessions will last approximately 1hour, and that I am free to discontinue my participation at any time.

-my participation in this experiment will not lead to any risk or discomfort.

-my particpation in the recording session may lead to the publication and communication of these emotional facial expressions in total or in parts, in which case I agree to this diffusion and utilization by other researchers.

-the picture or video segments become the property of the researcher exclusively and that this right may be shared with other researchers in the future.

-as poser manipulations and modifications will be applied to the video sequences so that in some case they could appear distorted or caricatural.

I have carefully studied and understood this agreement, and therefore I freely consent to participate in the experiment mentioned above.

Print your name :________________________________

Poser's signature: ________________________________

Experimenter's signature:____________________________

Date:____

APPENDIX C: CONSENT FORM FOR PARTICIPANTS

CONSENT FORM TO PARTICIPATE IN RESEARCH

Research Title: Visual basis for the perception of dynamic facial expressions.

The series of experiments in which you are about to participate is concerned with the extraction of the principle factors and attributes that the visual system utilizes in the perception of human facial expressions. You will be presented with short sequences displaying particular emotions. Your task will be to indicate whether the expressions portrayed are similar to a set of comparison stimuli. The purpose of this experiment is to further our knowledge on motion perception in general and extraction of motion signals in emotional facial expressions. No deception will be used in this experiment.

I understand that:

-this research is conducted by Stéphane Dubé, under the supervision of Dr. Michael von Grünau, as part of the Ph.D. programme in psychology at Concordia University.

-I may ask any questions about the experiment prior to signing this consent form and that I can expect a satisfactory explanation.

-my participation in this experiment is voluntary, and that my refusal to participate would not prejudice my University standing in any way, nor my participation in other experiments in the Concordia University Psychology Department.

-my participation is anonymous, and that my data will remain strictly confidential. Only the experimenter, the research supervisor and/or research assistants will have access to it, even though the results may be published.

-each one of the experimental segments will last approximately 1hour, and that I am free to discontinue my participation at any time.

-my participation in this experiment will not lead to any risk or discomfort.

I have carefully studied and understood this agreement, and therefore I freely consent to participate in the experiment mentioned above.

Subject's signature: ______________________________

Print your name :________________________________

Experimenter's signature:__________________________

Date:____