University of Alberta

Variable Motivational Value of Facial Expressions of Emotion

by

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ABSTRACT

The purpose of this thesis is to examine if facial expressions of emotion influence motivated behaviour in healthy human subjects. This study builds on previous work which shows facial attractiveness influences motivated behaviour, as assessed in a keypress paradigm in which subjects have to work to increase or decrease viewing time for pictures of faces. In the present study, the effect of facial expressions of emotion on motivation to view pictures was assessed. It was hypothesized that both the valence and intensity of the emotional expression would influence motivation. The main finding was that subjects worked to view happy facial expressions for longer periods, whereas they decreased the viewing time for the negative expressions of sad, fear and angry. Furthermore, the apparent intensity of facial expression was manipulated by computer morphing, and was related to the degree of motivation, as shown by the measure of viewing duration. The main conclusion is that facial expressions of emotion have motivational value that can be related both to the valence and intensity of the expression.

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I would be remiss if I didn't personally thank Dr. Glen Baker. Dr. Baker is often acknowledged but perhaps never fully appreciated. I want you to know, Dr. Baker, that I appreciate everything that you have done for me. Thank you.

To my friend Pips Wolfaardt, who next to my family, was the greatest support in my graduate program. I viewed myself fortunate to be privy to your warmth and encouragement.

Ultimately it is my parents to whom I am most grateful. I hope you recognize, as I do, the impact of your extreme love and dedication in my life. Your sacrifices have not gone unnoticed and I try to model my life after yours. If I become half the person that you two are, I will be truly blessed.

DEDICATION

There can be but two people to whom this thesis is dedicated, my parents John and Debbie Armstrong. Without your unconditional love and support nothing in my life would have been possible. I can never fully express my love and gratitude, but I am honoured and privileged to be your son.

TABLE OF CONTENTS

CHAPTER 2   *EMOTIONS*

CHAPTER 3   *REWARD*

CHAPTER 4   *FACIAL EMOTION RECOGNITION*

CHAPTER 5   *HYPOTHESES*

CHAPTER 6   *MATERIALS & METHODS*

CHAPTER 7   *RESULTS*

CHAPTER 8   *DISCUSSION*

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

α	alpha
±	plus or minus
%	percent
p-value	statistical significance
df	degrees of freedom
n	sample size
ms/msec	millisecond
ANOVA	analysis of variance
ANS	Autonomic Nervous System
DSM-IV	Diagnostic and Statistical Manual for Mental Disorders-4th edition
FACS	facial action coding system
fMRI	functional magnetic resonance imaging
GABA	γ-aminobutyric acid
JACFEE	Japanese and Caucasian Facial Expressions of Emotion
LHD	left hemisphere damage
MFB	medial forebrain bundle
OFC	orbital frontal cortex
PET	positron emission tomography
PTSD	posttraumatic stress disorder
RBF	regional cerebral blood flow
RHD	right hemisphere damage
RMANOVA	repeated measures analysis of variance
SD	standard deviation
STS	superior temporal sulcus
VAS	Visual Analogue Scale
VTA	ventral tegmental area

THESIS OBJECTIVE AND RATIONALE

The aim of the study was to further develop a quantitative method to determine how positively and negatively valenced social stimuli influence motivation. The study builds on prior research with a key-press response task, developed by Aharon et al. (2001), which uses key-presses as a response measure to quantify the work or effort that subjects are willing to expend to view pictorial stimuli. In the Aharon et al study, it was shown that healthy heterosexual males will perform more key-presses to look at pictures of attractive females than they will to look at similarly attractive male images, or less attractive male or female images. The advantage of this method is that it operationalizes motivation in terms of measurable, objective responses, i.e., the amount of physical work expended in response to stimuli. This is in contrast to subjective measures, such as self-ratings of wanting, or tasks in which motivation is inferred from preferences in decision-making tasks. To define some terms:

- A preference is a selection from a range of choices. The selection may be positive, i.e., liking, or negative, i.e., disliking.

- A positive reinforcement or reward is a stimulus that when administered after the response by an organism increases the probability of the response.

- A punishment is a stimulus that when administered after the response by an organism decreases the probability of the response.

Motivation is an internal state that activates or energizes goal-oriented behavior. When considered relative to preferences, it describes not just liking, but wanting. Motivation may be positive valenced, where the organism is energized to attain a goal. This can be

1

termed incentive motivation. Motivation may also be negatively valenced, where the organism is energized in the goal of avoiding something. This can be termed aversive motivation.

The present study aimed at extending the methods described by Aharon et al. (2001), in this case to determine the effects of social stimuli, consisting of facial expressions of emotion, on motivation to view images. Facial expressions of emotion can be seen as social displays that cue recipients to the likely occurrence of reward or punishment (Blair 2003). A specific goal of the study was to distinguish the effects of facial expressions of emotion on the valence and degree of motivation. The main hypotheses were that:

- The emotional expressions displayed in facial image stimuli would influence the valence and degree of subjects' motivation to view those stimuli.

- Positively valenced facial expressions (happy expressions) would lead to incentive motivation, such that subjects would work or expend effort to view these stimuli for longer durations.

- Negatively valenced facial expressions (fear, sad, anger) would lead to aversive motivation, such that subjects would work or expend effort to shorten the duration of viewing these stimuli.

- The degree of incentive or aversive motivation would be related to the intensities of the emotional expressions that are displayed.

If the task can be used successfully to quantify the valence and degree of motivation, then it may be developed into a useful psychological tool to study and measure variations of

2

motivation in health and disease. For example, using the measure developed by Aharon et al. (2001), Elman et al. (2005) have recently shown that male patients with posttraumatic stress disorder (PTSD) are less motivated than matched healthy controls to view pictures of attractive females, but not similarly attractive male images, or less attractive male or female images. Interestingly, PTSD patients and controls did not differ in their ratings of attractiveness of the images. These data suggest a possible deficit in incentive motivation in PTSD that may be dissociable from positive preferences. This type of task may therefore be useful in testing dysregulation of motivational systems in a range of psychiatric disorders.

At a technical level, the present study aimed to improve on the task used by Aharon et al. (2001) and Elman et al. (2005) by including stimuli with opposing valences, by using stimuli with graded intensities to induce variable levels of motivation, and by modifying some of the key-press task parameters to control for individual differences in maximal key-press rates.

3

1.1 THEORIES OF MOTIVATION

Research on motivation is directed towards determining what causes behavior and why

individuals engage in said behavior. All self-directed behavior has aspects of instigation,

persistence, change, goal directedness and termination. Motivation is a key element of,

and influences the stream of behavior. Behaviors are also known to vary in intensity and

often express a uniqueness such as unusually high or low effort, persistence or

spontaneity (Carlson & Buskist, 2000). Furthermore, there are considerable motivational

differences among individuals. Although people may share many basic motivations,

many motives are relatively strong for one person yet weak for others. In sum, motivation

studies deal with the processes that give behavior its energy and direction. The term

motive is general in that it identifies the common ground shared by needs, cognitions and

emotions (Rolls, 1999). Needs are physiological or psychological states that energize and

direct action in either a deficiency-remedying or a growth-promoting manner. Hunger

and thirst exemplify two physiological deficiency-remedying needs, whereas competence

and self-actualization represent two psychological growth-promoting needs (Rolls, 1999).

The difference between a motive on one hand and a need, cognition or emotion on the

other hand, is simply whether the analysis is general or specific (Figure 1).

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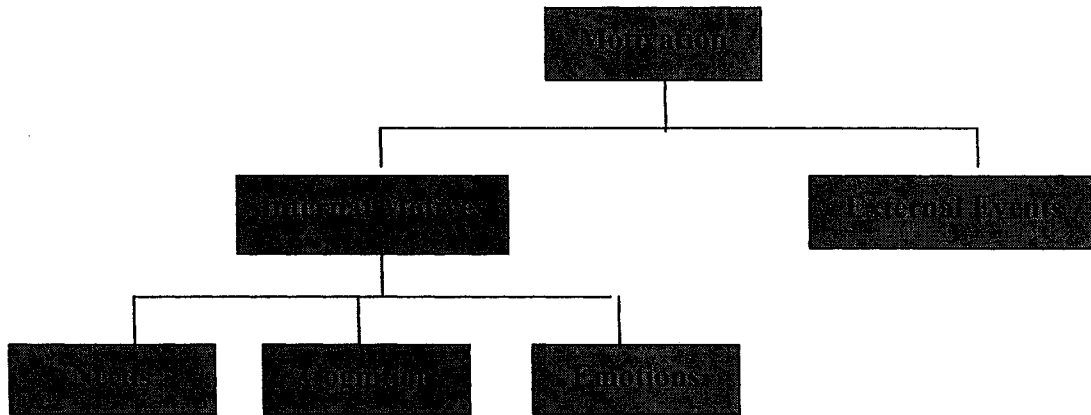
Figure 1. Hierarchical Categorization of the Four Sources of Motivation

Adapted from: Carlson, N., & Buskist, W. (2000). Motivation and Emotion, in:

Psychology: The Science of Behavior, Canadian edition, Scarborough, Ontario: Prentice

Hall.

1.2 HISTORICAL PERSPECTIVES ON MOTIVATION

1.2.1 Biological Theories

Many theories of motivation are biologically based and look for inborn processes that

control and direct behavior. Among these biologically oriented theories are the *will*,

instinct, and *drive* theories.

5

1.2.2 Will Theory

Descartes posited the first grand theory on motivation. He believed that will was the ultimate motivational force (Reeve, 1999). Will was thought to initiate and direct action, influencing the choices regarding whether to act and what to do when acting. Descartes suggested that, while passions, pains and pleasure certainly arose from the body, they did not motivate behavior directly; rather they merely served to excite the will. Philosophers painted themselves into a corner by adopting the will as the agent of motivation (Reeve, 1999). Now two unexplained phenomena needed elucidation, not only motivation but also that of the will. For this reason, those involved with the new science of psychology (which emerged in the 1870s) (Schultz, 1987) searched for a less ambiguous motivational principle.

1.2.3 Instinct Theory

Darwin's idea of biological determinism shifted the mood of scientific thinking away from mentalistic motivational concepts such as will towards more mechanistic ones like biological systems (LeDoux, 1996). Animal behavior seemed largely unlearned, automated, and mechanistic (Darwin, 1859, 1872). To explain the unlearned automated behavior displayed by animals (such as hunting or nesting), Darwin proposed that instinct could explain what the philosopher's will could not, namely, where the motivational force came from in the first place (Rolls, 1999). Instincts were thought to arise from the

6

genetic endowment of the individual. Instincts were in the genes and expressed

themselves through bodily reflexes given the appropriate stimulus (Huffman & Vernoy,

2000). The early days of psychology saw researchers like James (1890) and McDougall

(1908) propose that humans had numerous physical and mental instincts by which they

acted. Instinct theory declined because of its circular reasoning. The naming and

explanation of a behavior had become one. "A person acts that way because they

naturally act that way." For example, a person is aggressive because they want to be

aggressive. Circular reasoning contributes nothing to the science of understanding

motivation and emotion

1.2.4 Drive Theory

In the 1930s, the concepts of drive and drive reduction began to replace the theory of

instincts. According to drive-reduction theory (Hull, 1952; Spence, 1951), all living

organisms have certain biological needs such as food, water and oxygen that must be met

if they are to survive. A drive state arises when these needs are not met and the organism

is motivated to reduce this drive state.

Drive-reduction theory is based largely on the biological concept of homeostasis, a state

of balance or stability in the body's internal environment (Hull, 1952). Body temperature,

blood sugar, oxygen level, water balance and so forth are all normally maintained in a

state of equilibrium. When this balance is disrupted, a need arises, a drive is created, and

we are motivated to restore homeostasis (Spence, 1951).

7

1.3 PSYCHOSOCIAL THEORIES

Instinct and drive-reduction theories explain some, but not all, motivation. Many people maintain a behavior even after the point of satiety (e.g. continuing to eat after feeling full). Psychosocial theories emphasize the importance of incentives, cognition and hierarchies of needs in the initiation or maintenance of goal-directed behavior.

1.3.1 Incentive theory

Drive theory may be thought of as pushing people in certain directions; conversely, incentive theory says that external stimuli pull people in certain directions (Bolles, 1975). An incentive is an external event, object, condition, or stimulus in the environment that induces a state of arousal that energizes behavior (Cofer, 1972). Incentive theory fundamentally seeks to explain why people approach positive incentives and avoid negative ones. How one comes to characterize any particular incentive as either positive or negative is thought to be partly innate and partly a function of learning (Rolls, 1999).

8

1.3.2 Cognitive Theory

In the 1970s the psychological *Zeitgeist* turned decidedly cognitive (Gardner, 1985).

This focus on cognition argued for the importance of internal processes such as

expectancies, beliefs, and meaning representations to explain directed behavior (Bandura,

1977; Markus, 1977). Attribution research has shown that how one interprets behaviors

in themselves and others affects individual motivation (Weiner, 1982). Expectancies have

also proven to be important in motivated behavior (Higgins, 1997).

1.4 CONTEMPORARY THEORIES OF MOTIVATION

1.4.1 Needs

Need describes a condition of the individual that produces energy and behavioral

direction. That condition can be rooted in biological forces, human nature, or ways of

thinking (beliefs and values) that are acquired through experience (Deci, 1992). Hence,

humans possess physiological, organismic, and acquired needs. Examples of

physiological needs include thirst, hunger, and sex, whereas self-determination,

competence and relatedness represent organismic needs (Deci, 1992). Needs such as

achievement, affiliation, and power can best be thought of as acquired needs.

Figure 2 diagrams the relationship among the basic categories of needs:

9
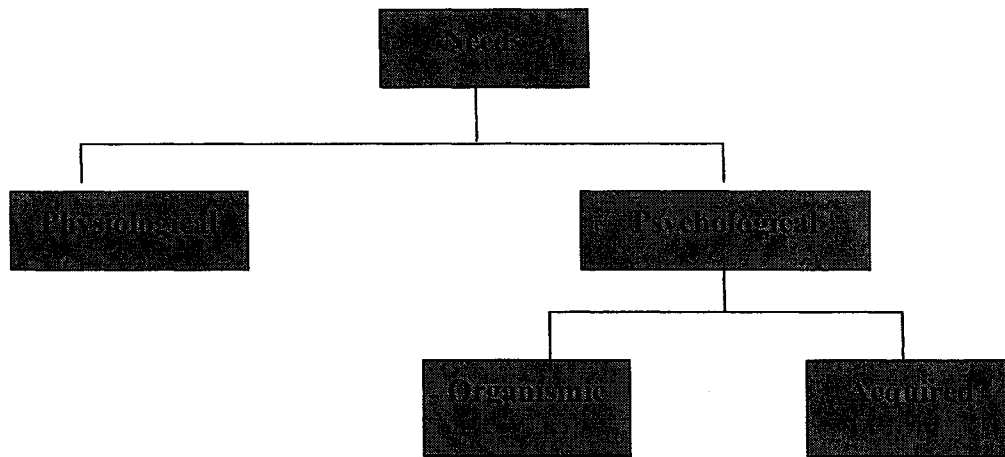
Figure 2: Relationships amongst Categories of Needs

Physiological needs revolve around regulating biological systems such as neural brain

circuits, hormones, and bodily organs. Physiological needs, when unmet for an extended

period, signal life-threatening emergencies and therefore dominate consciousness (Deci,

1992). When gratified, these needs lose their salience and tend to abate. Psychological

needs do not conform to a cyclical time course as do physiological needs, but rather they

are omnipresent, and specific environmental conditions make some psychological needs

more salient than others (Deci, 1992). The distinction between organismic and acquired

psychological needs is that organismic needs are innate and exist as an inherent part of

development and human nature; acquired psychological needs are gained through

experience, such as through socialization or learned ways of adjusting or coping (Deci,

1992). All people inherit the same constellation of organismic psychological needs, but

10

individuals tend to accrue a unique collection of acquired psychological needs, at least to the extent to which their life histories and experiences vary (Deci, 1992).

1.4.2 Relationship of Needs to Cognition, Emotion, and Behavior

Needs play a important role in the study of motivation. Cognition, emotion and external events are important constructs as well, but needs are of particular importance because of their direct effects on motivational processes (Deci, 1992). Needs affect our cognitions such that a person with a strong need for affiliation thinks disproportionately about friends or relationships and interpersonal interactions (McAdams & Losoff, 1984). Needs affect our emotions such that opportunities to satisfy needs, bring emotions of pride or enjoyment (Weiner, 1986). Behaviors are also affected by needs, such that when needs arise we narrow our ways of behaving to specific need-directed courses of action (McAdams & Losoff, 1984). Conversely, cognitions, emotions and behaviors in turn can affect our needs. Needs not only energize and direct behavior but also affect the full range of motivational processes. Needs may be best distinguished from emotions and cognitions by appreciating that they are generally considered a deficiency-satisfying or growth-promoting condition of the individual that produces energy and behavioral direction (Deci, 1992).

11

1.4.3 Relationship of Needs to Extrinsic and Intrinsic Motivation

Needs, as stated, energize and direct our behavior. They motivate us to seek out those situations which we believe to be capable of satisfying our needs. Experience teaches us that there are two ways to enjoy an activity, either intrinsically or extrinsically. Individuals may engage in particular behaviors because they are psychologically satisfying (intrinsic) or because they provide an opportunity to fulfill physiological needs, which may be more extrinsically driven. Pittman & Heller (1988) suggest that any activity can be approached with either an intrinsic or extrinsic motivational orientation.

Intrinsic motivation is the innate propensity to engage one's interests and exercise one's capacities (Pittman & Heller, 1988). It emerges spontaneously from organismic psychological needs, personal curiosities, and innate strivings for growth. As such, intrinsic motivation provides a natural motivational force that fosters learning and development, and it can motivate behavior without the assistance of extrinsic rewards and pressures (Deci, 1975). The functional significance of intrinsic motivation is that it provides us with an innate motivational force to engage our environments and to exert the effort necessary to exercise and develop our skills and capabilities (Deci, 1975).

Extrinsic motivation arises from external contingencies. Whenever one acts to obtain a high grade, win a trophy or comply with a deadline, their behavior is said to be extrinsically motivated (Deci, 1992). Extrinsic motivation is a means to an end in which

12

the means is the behavior and the end is some attractive reward, or the prevention of a undesirable consequence.

Intrinsically and extrinsically motivated behaviors can often look the same. The essential difference between the two lies in the source that energizes and directs the behavior. With intrinsically motivated behavior, the source of the activity emanates from organismic needs; with extrinsically motivated behavior, the source of the activity emanates from incentives, rewards, and punishments that are contingent on the behavior and are external to the organism (Deci, 1992).

1.5 REWARDS, PUNISHMENTS, & INCENTIVES

Research on extrinsic motivation tends to revolve around three central concepts of reward, punishment, and incentive. A reward can be thought of as an attractive environmental stimulus that tends to increase the probability that a behavior will occur (Rolls, 1999). These are things that people are likely to work for, such as a paycheck or approval; furthermore, the recipient of this approval is more likely to repeat this rewarded behavior than one who is not rewarded.

A punishment is an unattractive environmental stimulus that tends to decrease the probability of a behavior occurring (Rolls, 1999). These are generally things that people tend to avoid such as jail terms or criticism, and those who receive these undesirable consequences are less likely to repeat the antecedent behavior than those who were not

13

affected by the consequences (Rolls, 1999). Both rewards and punishments follow behavior and affect the probability of its recurrence.

Incentives are also an important concept to consider. They are environmental influences that attract or repel individuals towards or away from certain behaviors. Incentives precede behavior and facilitate the expectations that individuals have when attractive or unattractive consequences are forthcoming (Rolls, 1999). Positive incentives can include smiles or the presence of friends whereas negative incentives may include grimaces or the presence or enemies or competitors. The primary differences between rewards, and punishers and incentives are (1) when each occurs and (2) what the external event is supposed to do. Deci (1992) states that unlike rewards and punishments that follow behavior and increase or decrease its probability of recurrence, incentives precede behavior and excite or inhibit its initiation. Contemporary perspectives on the neurobiology of reward processes will be addressed in Chapter 3.

14

CHAPTER 2   EMOTIONS

2.1 FUNCTIONS OF EMOTIONS

An appreciation of the functions of emotion is essential for understanding the nature of

emotions. Emotions have many functions, which are not always mutually exclusive

(Rolls, 1999; Ekman, 1994).

2.1.1 Adaptive Functions

Work on the functional significance of emotion stems from Darwin's *The Expression of*

Emotions in Man and Animals (1872). Darwin argued that expressive characteristics had

a functional significance for the adapting organism much in the same way that physical

characteristics such as height and the position of eyes do. From a functional point of

view, emotions evolved for their adaptive value in dealing with fundamental life tasks

(Ekman, 1994). Fundamental life tasks are universal human predicaments such as loss,

frustration and achievement (Johnson-Laird & Oately, 1992). Emotions are believed to

direct our behavior, in response to life tasks, in evolution-benefiting ways (Tooby &

Cosmides, 1990).

Emotions have survival value in that they elicit autonomic and endocrine responses.

These actions are extremely adaptive in that they prepare the body to react more

efficiently in response to a reinforcing stimulus (Rolls, 1999). The neural projections

15

from the amygdala and orbitofrontal cortex via the hypothalamus as well as directly towards the brainstem autonomic motor nuclei may be strongly involved in this function (Kandel & Schwartz, 2000).

A second function of emotions may be that they provide flexibility in behavioral responses to reinforcing stimuli (Rolls, 1999). The belief here is that when a stimulus in the environment elicits an emotional state, we can modify our response based on our motivation to approach or avoid the stimulus. Rolls (1999) argues that this is much more functional than simply learning a fixed behavioral response to a stimulus. A behavioral decision-making process can then develop, comparing the different emotional responses based on the cost or value of approaching or avoiding the stimulus (Rolls, 1999).

A third function of emotion is that it is motivating, such that the emotion of fear, for example, motivates one to avoid noxious stimuli (Rolls, 1999). Positive reinforcers also elicit motivation, such that people will generally work to obtain desirable rewards. This concept will be explored in depth in Chapter 3 on motivation and reward processes.

2.1.2 Social Functions

Emotions serve important social functions. Izard (1989) and Manstead (1991) state that they: (1) communicate our feelings to others; (2) regulate how others interact with us; (3) invite and facilitate social interaction; and (4) are pivotal in creating, maintaining and dissolving relationships.

Emotions affect social interactions in a variety of ways. Facial expressions of emotions in humans, for example, convey ones' emotional state and may influence the behavior of others (Blair 2003). Neural systems in the amygdala and overlying temporal cortical visual areas are specialized for processing and decoding facial expressions of emotion (Kandel & Schwartz, 2000). This concept will be thoroughly elucidated in Chapter 4.

It can be beneficial to be mindful of these functions of emotions when considering the neural basis of emotion, for each function is likely to have particular output pathways associated with specific emotional systems (Rolls, 1999).

2.2 THEORIES OF EMOTION

Studies on emotion began 100 years ago by asking what role the autonomic nervous system (ANS) played in the subjective experience of emotion (Schultz & Schultz, 2000). Current literature tends to agree on the cognitive, physiological and behavioral aspects that constitute an emotion. There tends to be less agreement, however, on how we become emotional (i.e. how emotions arise). The major theories of emotion are the James-Lange theory, Cannon-Bard theory, facial feedback hypothesis and Schachter's two-Factor theory (LeDoux, 2000). Figure 3 shows the four major theories of emotion and their respective hypotheses.

17
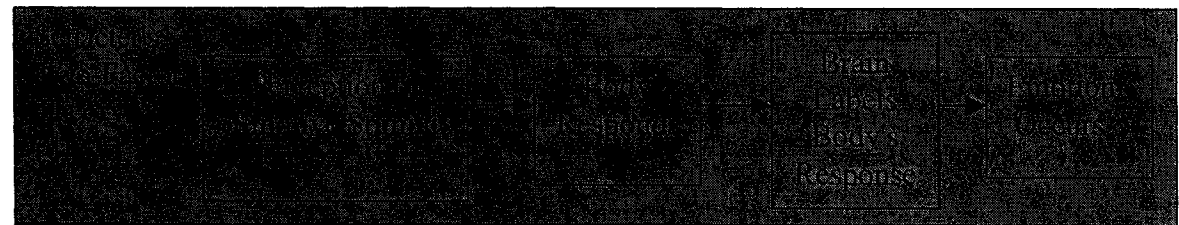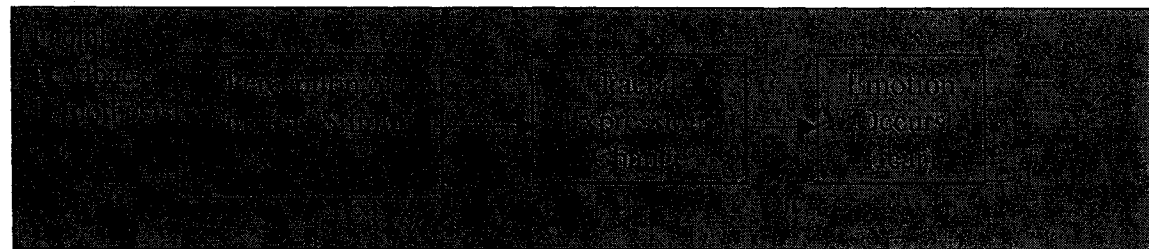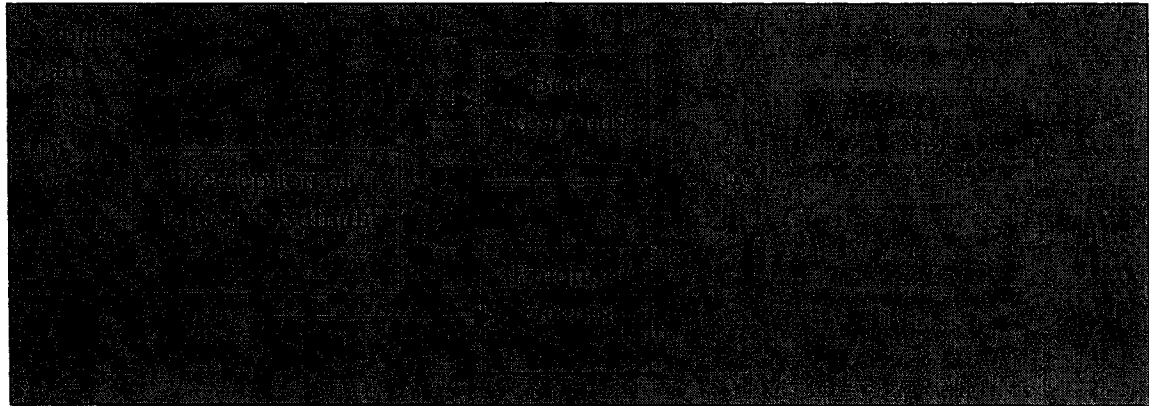
Figure 3: Four Major Theories of Emotion

Adapted From: Carlson, N., & Buskist, W. (2000). Motivation and Emotion, in:

Psychology: The Science of Behavior, Canadian edition, Scarborough, Ontario: Prentice

Hall

18

2.2.1 James-Lang Theory

James (1890) argued that our bodily changes do not follow emotional experiences; rather, emotional experience follows and depends on bodily and behavioral responses to the salient stimuli. Hence, bodily changes cause emotional experience: stimulus leads to bodily reaction, which leads to emotion (LeDoux, 2000). To James, emotion is the perception of one's own bodily reactions. James' theory implies that each emotion is physiologically distinct. Physiological changes (such as a decrease in heart rate or blood pressure) were thought to precede feelings, (Kandel & Schwartz, 2000). Thus when you see something traumatic you feel afraid because your cortex has received signals about your anxiety, be it heart palpitations or an increase in perspiration (Kandel & Schwartz, 2000). According to James (1890), emotions are cognitive responses to information from the periphery. Lange (1885) proposed a similar theory of emotion, and for this reason the idea that emotion emanates from our interpretation of patterns of physiological arousal is traditionally called the James-Lange theory (LeDoux, 2000).

The James-Lange theory however, fails to explain why people tend to remain emotionally aroused long after the physiological changes have subsided (Kandel & Schwartz, 2000). If, as James and Lange (1922) suggest, physiological feedback is the only controlling factor, emotions should not outlast the physiological change. Yet a person can sustain a feeling of fear long after a threat has abated (Kandel & Schwartz,

19

2000). Walter B Cannon's study of peripheral response to emotion seriously challenged the James-Lange theory.

2.2.2 Cannon-Bard Theory

Whereas the James-Lange theory argues that each emotion has its own distinct physiological reaction, the Cannon-Bard theory holds that all emotions are physiologically similar. Walter Cannon (1927) and Philip Bard (1934) proposed that during perception of the emotion-provoking stimuli, two subcortical structures, the thalamus and hypothalamus, send simultaneous messages to both the general body and the cerebral cortex. Messages to the cortex produce the experience of emotion while messages to the ANS produce bodily changes such as heart palpitations, widening of eyes or an open mouth (Bard, 1934). Cannon and Bard believed that the body's response is not a necessary or even major factor in emotion. This idea was based on studies by Cannon and Bard in which cats were surgically altered such that they were devoid of a cerebral cortex (Kandel & Schwartz, 2000). Despite being incapable of experiencing physiological arousal, these animals still displayed behaviors like growling and defensive postures that could be labeled emotional reactions (Cannon, Lewis, and Britton, 1927).

20

2.3 CONTEMPORARY PERSPECTIVES OF EMOTION

The modern perspective on whether emotions have distinctive patterns of physiological activity is that a few emotions do while most do not. Persuasive evidence exists for distinctive ANS activity associated with anger, fear, disgust and sadness (Ekman, 2003; Ekman & Davidson, 1993; Ekman, Levenson, & Friesen, 1983; Levenson, 1992; Levenson et al., 1991). These patterns of ANS activity emerge because these emotions recruit patterns of behavior that proved to be adaptive (Ekman & Davidson, 1994). For instance, in a fight that arouses anger, increased heart rate and skin temperature facilitate adaptive aggressive behavior. Not all emotions, however, have distinctive associated patterns of ANS activity. If no specific pattern of behavior has survival value for an emotion, there is little reason for the development of a specific pattern of ANS activity (Ekman, 1992). What for example, is the most adaptive behavior pattern for jealousy, envy, joy or hope? These emotions have no single adaptive activity which seems universally most appropriate, thus there is little reason to expect a single pattern of ANS activity to evolve (Ekman, 1992).

Contemporary researchers generally agree that physiological arousal accompanies, regulates and sets the stage for emotion, but it does not cause it directly (Ekman, 2003). The modern perspective is that emotions recruit physiological support for adaptive behaviors such as fighting, fleeing and nurturing. The physiological function of emotion

21

is to create the optimal physiological milieu to support the particular behavior called for

by a life situation (Ekman, 2003).

2.3.1 Neural Circuits and Specific Physiological States

Many researchers have searched for emotion-specific patterns in the central nervous

system (Gray, 1994; LeDoux, 1987; Panksepp, 1986). Gray's (1994) neuroanatomical

findings with nonhuman mammals documented the existence of three distinct brain

systems, each of which regulates a distinctive pattern of emotional behavior. These

systems are: (1) a behavioral approach system that readies the animal to seek out and

interact with attractive environmental opportunities and events; (2) a fight/flight system

that readies the animal to flee or escape some aversive environmental events and to

defend aggressively against others; and (3) a behavioral inhibition system that readies the

animal to freeze in the face of aversive environmental events (Gray, 1994). These three

systems are associated with the four distinct emotions of joy, fear, rage and anxiety and

therefore correspond to unique and specific physiological states (Gray, 1994).

Overall the conclusion is that four emotions (anger, fear, disgust, and sadness) involve

distinct patterns of peripheral (autonomic nervous and endocrine systems) physiological

activity whereas four emotion systems (joy, rage, fear, and anxiety) involve distinct

patterns of (subcortical) central nervous system physiological activity (Gray, 1994).

22

2.3.2 Neural Activation

Another physiologically based source of investigation regarding what causes an emotion involves neural activation, namely, that different emotions are activated by different rates of cortical neural firing (Tomkins, 1970). Neural firing refers to the pattern of electrocortical activity at any given time in the brain. According to Tomkins (1970), there are three basic patterns: the rate of neuronal firing (or activity) either increases, decreases or remains constant. The activity rate is mostly dependent on external and internal environmental events. Sleeping, for example, tends to decrease rate of firing whereas stimulating events such as concerts tend to increase the rate of neuronal firing (Tomkins, 1970). Other times, neural activity is constant, as in persistent cognitive effort while reading a book (Tomkins, 1970).

With these three basic patterns of neural firing, the person is equipped for virtually every contingency in terms of cortical activity (Tomkins, 1970). If neural firing suddenly increases, the person experiences one class of emotions: interest, surprise or fear. The emotion elicited depends on the suddenness of the increased rate of neural firing. A very gradual increase activates interest or perhaps fear whereas a sudden increase may activate surprise (Tomkins, 1970). Figure 4 illustrates each specific emotion as activated from these changes in the rate of neural firing.

23
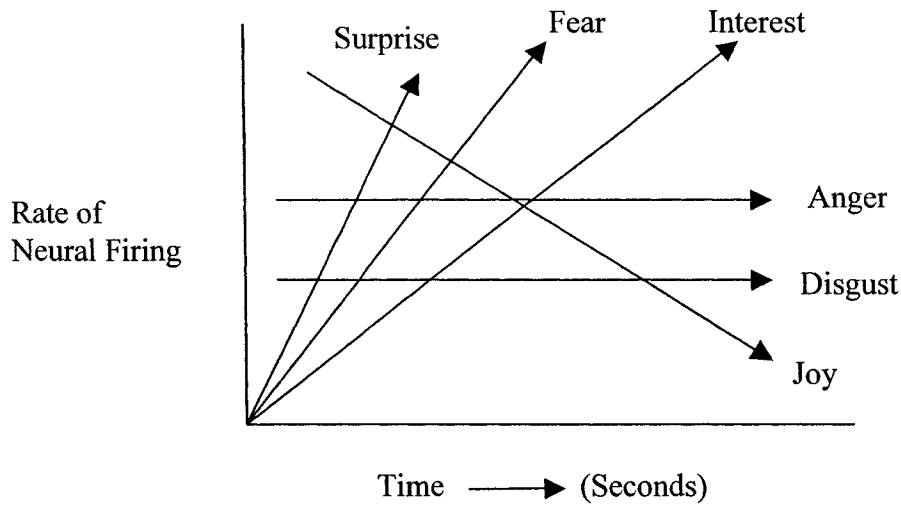
Figure 4:

Emotion Activation as a Function of Changes in Rate of Neural Firing in the Cortex

Adapted from: Tomkins, S.S. (1970). Affect as the primary motivational system. In M.B. Arnold (Ed.)., *Feelings and Emotions* (pp. 101-110). New York: Academic Press

2.4 FACIAL FEEDBACK HYPOTHESIS

A third major explanation of emotion called the facial feedback hypothesis arose in reaction to the James-Lang and Cannon-Bard theories of emotion. According to the facial feedback hypothesis, facial changes not only correlate with and intensify emotions, but also cause or initiate the emotion itself (Adelman and Zajonc, 1989; Laird and Bressler, 1992). Proponents of this theory assert that human beings possess innate, genetically wired, emotion-specific programs in the subcortical brain. When activated, these programs generate discrete facial expressions and a particular pattern of changes in the

24

ANS as well as endocrine systems, which are involved in rate of respiration, cardiovascular activity or vocalizations (Tomkins, 1962). The facial feedback hypothesis suggests that our evolutionary past equipped our subcortical brains with emotion-specific programs for anger, for fear and any other emotion we may feel. When a specific program is activated, one's facial muscles and body change in predictable ways (Tomkins, 1962). According to the facial feedback hypothesis, the subjective aspect of emotion stems from feelings arising from (1) movements of the facial musculature, (2) changes in facial temperature, and (3) changes in glandular activity in the facial skin (Tomkins, 1962). To proponents of this theory, emotions are sets of muscle and glandular responses located in the face (Tomkins, 1962).

The facial feedback hypothesis suggests that a stimulus causes a quick increase in neural firing, which activates a subcortical emotion program (e.g., fear), and the facial musculature quickly displays a fear expression. Immediately afterwards, the brain interprets the facial feedback from drawn back corners of the mouth, decreased facial temperature, and activated glandular secretions, and this particular pattern of facial feedback gives rise to the feeling of fear (Izard, 1991). Once fear is activated, the whole body typically becomes involved. The glandular-hormonal, cardiovascular, and respiratory systems are aroused and their activity amplifies and sustains the fear experience (Izard, 1991).

Facial feedback is crucial for emotion activation (Izard, 1994) as it activates the specific emotion program. The emotion program, not the facial feedback, then arouses cognitive and bodily participation to continue the emotional experience beyond activation (Izard,

25

1994). Thus, following emotion activation from facial feedback, people monitor not their

facial feedback but their changes in heart rate, respiratory rate, muscle tonus, and how

much they perspire (Izard, 1989). People also monitor their posture and gestures and

these bodily changes maintain their emotional experience over time. Nonetheless, it is the

facial feedback that activates the chain of events that underlie emotion experience.

Figure 5 illustrates the sequential process of emotional activation, according to Izard

(1991). Internal (memory) or external events change the gradient in neural firing (see

Figure 4). Impulses from the neocortex are directed to the limbic system. The limbic

system plays a key role in emotion differentiation by determining which particular facial

expressions will be affected (Izard, 1991). Impulses are thought to travel from the limbic

system to the basal ganglia, which organize the neural message for facial expressions and

send excitatory impulses to the motor cortex (Izard, 1991). Impulses from the motor

cortex travel through the facial nerve (cranial nerve VII) and produce a specific facial

expression. In the facial musculature, specific muscles are contracted and relaxed and

changes in blood flow and glandular secretions occur. The trigeminal nerve (cranial nerve

V) relays changing proprioceptive stimulation to the sensory cortex where cortical

integration of the proprioceptive stimulation generates the subjective experience of

emotion (Izard, 1991). Izard (1991) believes that it is in the frontal lobe of the neocortex

where the individual eventually becomes aware of the emotional experience at a

conscious level.

26
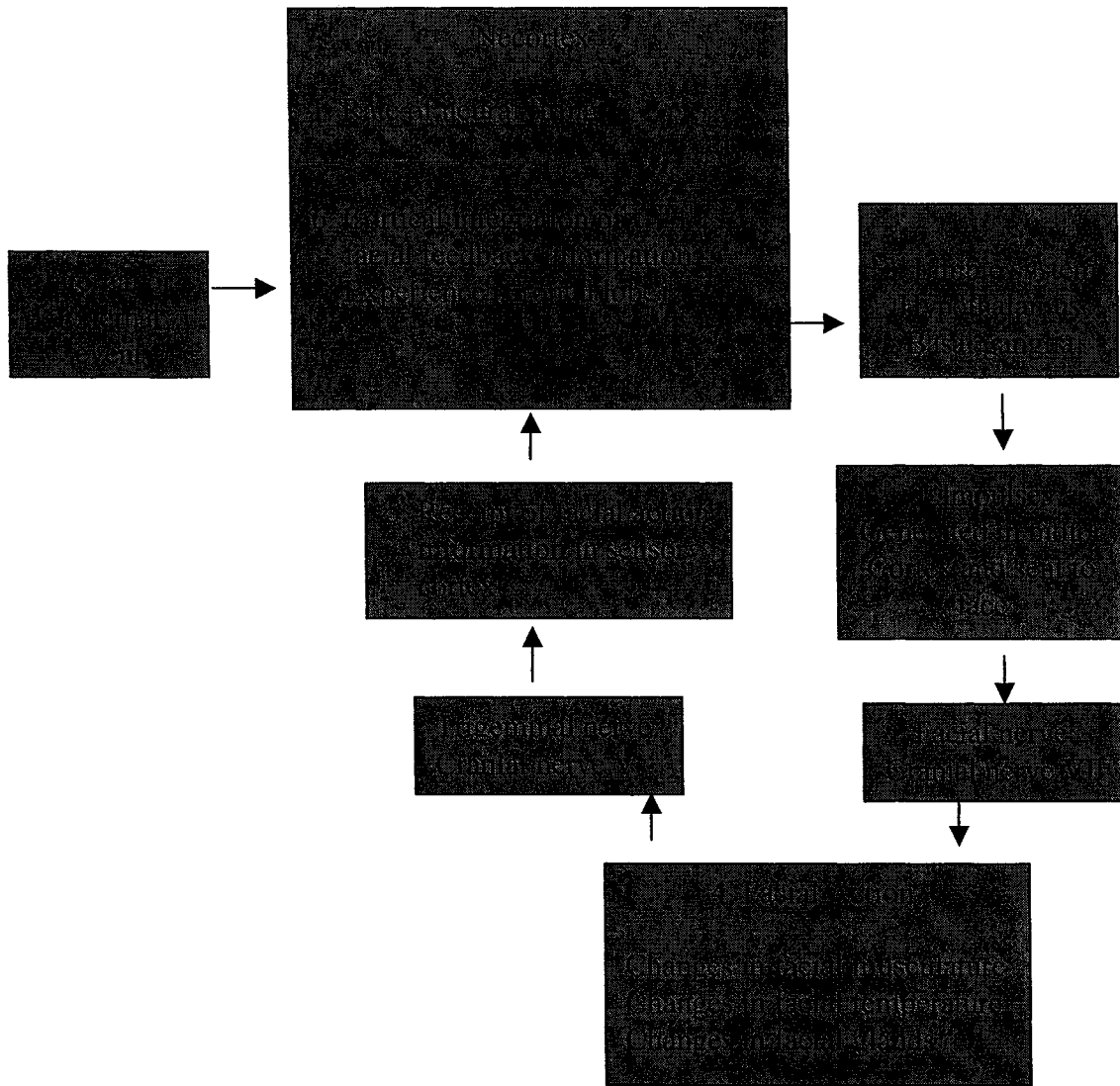
Figure 5. Sequence of Neurological Events in Facial Feedback Hypothesis

Adapted from: Carlson, N., & Buskist, W. (2000). Motivation and Emotion, in:

Psychology: The Science of Behavior, Canadian edition, Scarborough, Ontario: Prentice

Hall

27

2.4.1 Musculature of the Face

Descriptions of facial expressions rely on the particular muscles that produce them (Ekman & Friesen, 1978). There are 80 facial muscles, three dozen of which are involved in facial expressions (Ekman & Friesen, 1978). For purpose of exposition, however, 8 facial muscles are sufficient to differentiate among the basic emotions. Figure 6 shows the 8 major muscles underlying human facial expressions (Ekman & Friesen, 1978).
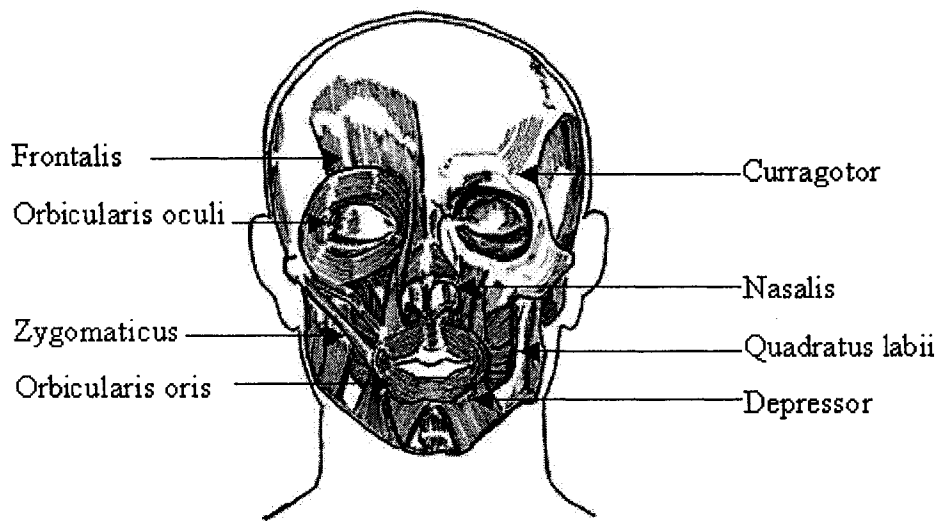
Figure 6: Eight Major Facial Muscles (Ekman & Friesen, 1978).

The upper section of the face has three major muscles: the frontalis, corrugator, and orbicularis occuli. The frontalis covers the forehead, the corrugators lie beneath each

28

eyebrow, and the orbicularis oculi is the circular muscle surrounding each eye (Ekman & Friesen, 1978). The middle section of the face has two major muscles, the zygomaticus and nasalis. The zygomaticus extends from the corner of the mouth to the cheekbone, and the nasalis wrinkles the nose (Ekman & Friesen, 1978). The lower section of the face is comprised of three major muscles: the depressor, orbicularis oris and the quadratus labii. The depressor is essential for drawing the corners of the mouth downward, the orbicularis oris is the circular muscle surrounding the lips and the quadratus labii draws the corners of the mouth backward (Ekman & Friesen, 1978).

Particular patterns of facial behavior produce discrete emotional signals. Anger, fear, disgust, distress and joy for instance, are each associated with a particular pattern of facial behavior (Ekman & Friesen, 1978), as shown in Figure 7.

Anger   Sadness

Happy   Disgust   Fear
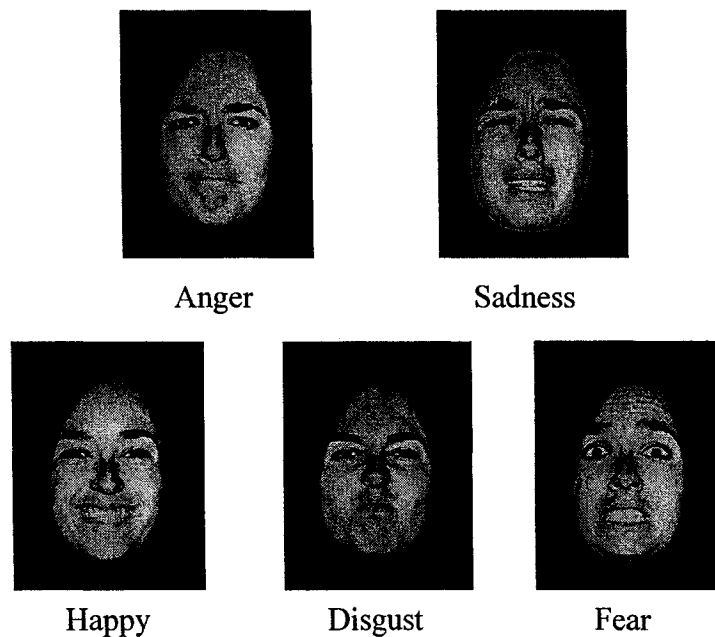
Figure 7: Facial Expressions for Five Emotions

Source: Ekman, P., & Friesen, W. V. (1976). Pictures of Facial Affect. San Francisco, CA: University of California Medical Center.

29

For anger, the corrugators draw the eyebrows inward and downward, the orbicularis oculi

tenses the lower eyelid upward so the eyes have a hard stare appearance and the

orbicularis oris presses the lips firmly together (Ekman & Friesen, 1978). For fear, the

corrugators raise the inner corners of the eyebrows, the contracted frontalis produces

horizontal wrinkles, the orbicularis oculi raises the upper eyelid and tenses the lower

eyelid, and quadratus labii pulls the lips tightly backwards (Ekman & Friesen, 1978). For

disgust, the orbicularis oris raises the upper lip, the nasalis wrinkles the nose, and the

zygomaticus raises the cheeks. For sadness, the corrugators raise and draw together the

inner corners of the eyelids, the orbicularis oculi raises the upper eyelid inner corner, and

the depressors pull the corners of the lips down. For joy, the corners of the lips are pulled

back and slightly up by the zygomaticus quadratus labii, and the cheeks raise and push

the lower eyelid up (Ekman & Friesen, 1978).

2.5 SCHACTER TWO-FACTOR THEORY

Previous theories have proven helpful for providing some insight into the experience of

emotions, yet they give little attention to the role of cognition and interpretation.

According to Schacter's two-factor theory, emotions depend on two factors: (1) physical

arousal and (2) cognitive labeling of that arousal. It was Schacter (1962) who emphasized

the role of the cortex in constructing emotions, much like it does audition or vision, i.e.,

from signals it receives from the periphery (Kandel & Schwartz, 2000). Schacter thus

agrees with James-Lange that our experiences of an emotion come from our awareness of

30

our bodily arousal, but he also agrees with Cannon-Bard that emotions are physiologically similar. Schacter effectively reconciles the two theories by proposing that we look to external rather than internal cues to differentiate and label our emotions. Crying at a wedding could be a sign of joy, whereas that same physiological action of crying at a funeral could be construed as sadness.

In Schacter and Singer's classic study (1962) participants were given injections of adrenaline and told it was a type of "vitamin". Their subsequent arousal and labeling were then investigated. One group of subjects was correctly informed about the expected effects of the "vitamin" (hand tremors, palpitations, excitement), and a second group was misinformed and told to expect itching, numbness and headache. A third uninformed group was told nothing about the possible effects. The subjects were then exposed to either a pleasant, unpleasant or emotionally neutral situation. As predicted, mood varied in accordance with the context for the subjects given adrenaline but not for the control group, which received placebo injections. Adrenaline-treated subjects exposed to a joyful situation came out feeling happy, those exposed to an unpleasant situation came out feeling sad and the neutral ones reported no specific emotion. Specific emotions were produced by the combination of artificial arousal and social cues. Participants in the correctly informed group, on the other hand, knew their physiological arousal was the result of the "vitamin" so their emotions were generally unaffected. Schacter (1962) argued that when emotionally ambiguous physiological arousal occurs naturally in the presence of real emotional stimuli, the aroused feeling is labeled on the basis of social

31

cues; thus emotions, in short, result from the cognitive interpretation of physiological responses to situations.

2.6 BIOLOGICAL ASPECTS OF EMOTION

Emotions are, in part, biological reactions to important life events. There are at least 5 biological systems involved in the generation and experience of emotion: ANS, endocrine system, neural brain circuits, rate of neural firing and facial feedback (Kandel, Schwartz & Jessell, 2000). Emotions mobilize the body for specific actions, such as running or fighting, by activating biological systems that arouse and regulate the heart, lungs and muscles (ANS) (Kandel, Schwartz & Jessell, 2000). Glands, hormones, and organs that comprise the endocrine system in concert with limbic brain structures such as the hypothalamus are also components of emotional behavior (Kandel, Schwartz & Jessell, 2000). Finally, neuronal firing or increases and decreases in the pace of information processing and discrete patterns of facial musculature (facial feedback) round out the five biological systems associated with emotion (Kandel, Schwartz & Jessell, 2000).

CHAPTER 3   *REWARD*

3.1   REWARD DEFINED

There tend to be three fundamental consequences that follow behavior: positive

reinforcers, negative reinforcers, and punishers. Positive and negative reinforcers increase

behavior; punishers decrease behavior. Positive reinforcers are generally thought of as

rewarding and tend to be environmental stimuli that we return to after previous exposure

to them. Reward function in this capacity may be best thought of within the framework of

instrumental conditioning. A second component of reward is its relation to subjective

feelings of liking and pleasure (Cannon & Bseikri, 2004). The hedonic experience of

reward accounts for why some behaviors repeat themselves, i.e., because they produce a

pleasant outcome. Rewards can be the effects of drugs of abuse, natural, or social in

nature. Natural rewards, such as food or mating opportunities, are necessary for survival

and social rewards can include money, power, beauty and facial expressions of emotion.

Wise (2002) provides a strong definition of rewards stating that they are the

environmental incentives we tend to return to after having previous exposure to them.

This explanation of reward, however, does not explain the reinforcement generated by the

avoidance of or escape from aversive stimuli, as is the case with negative reinforcement.

Negative reinforcement (e.g. the relief of withdrawal symptoms) has been postulated to

have an important role in opioid-seeking behavior (Jaffe, 1985). Future definitions will

have to satisfactorily explain reward with respect to all reinforcement principles.

33

3.2   IMPORTANCE OF REWARD

The brain's system of reward approach motivation is usually activated when we perceive a potential reward in the environment. Humans generally guide their behavior by the expectation of reward gain or loss, and if researchers strive to predict and understand behavior, then it is necessary to measure how modifications of available information about potential rewards (and thus of reward expectations) can alter a subject's expectation and behavioral response (Peterson, 2005). An understanding of human behavior may come from an appreciation of how environmental cues stimulate the reward system. It is only natural that individuals are more likely to pursue rewards when they believe their behavior will lead to a positive outcome and avoid losses when they have strong negative expectations (Peterson, 2005). Reward approach and loss avoidance behaviors lie at the foundation of understanding motivated behavior.

The study of reward has been a fascination of neuroscientists for many decades, paralleling the classical dualism between body and mind (Schultz, 2006). Research on the neurochemical and neurophysiological events in reward processes has yet to fully converge with both mental events and motivated behavior (Schultz, 2006). Mapping neuronal substrates such as specific neurotransmitters or pathways to the construct of reward is difficult, due in part to the various stimuli, (food, water, sexual attraction, drugs, money, and novelty) that generate and maintain motivated behavior. The study of reward presupposes that all of these events derive from the activation of a common

34

underlying neuronal system, whether this be a single or interrelated set of neuronal projections, or the global release of a given neurotransmitter or neuropeptide (Schultz, 2006).

The investigation of rewards has direct applications to psychiatry. Many individuals seek hedonic stimuli in a compulsive manner, to the point where functioning in society becomes difficult. Drug addictions and alcoholism are strong examples, but other related disorders may include bulimia or sexual promiscuity (Rolls, 1999). Numerous psychiatric conditions seem characterized by abnormal responsiveness to positive reinforcers or by related hedonic disturbances (Strumwasser, 2003). Autistic children for example, appear poorly responsive to stimuli that may serve as a potent reinforcer for guiding behavior in normal children (Strumwasser, 2003). Patients suffering from severe depression or from chronic schizophrenia also appear poorly responsive to conventional reinforcers (Nestler & Carelzon, 2006; Juckel et al., 2006; Elman et al, 2005). Although these deficits are commonly characterized as involving disorders of affect, they appear to have prominent hedonic aspects (Koob, 1996). These disorders may be characterized in part by a common deficit in the mechanism by which reinforcers act to direct subsequent behaviors. The apparent deficit in reinforcement may be secondary to a disease process, but clearly deserves study in its own right (Strumwasser, 2003). Psychiatric researchers have long recognized individual psychopathology as a correlate to drug and alcohol abuse (Edenberg & Kranzler, 2005), and this vulnerability may have biological correlates related to disorders in the regulation or reinforcement mechanisms as well. Although biological factors interact in a complex manner with behavioral and environmental

35

variables, they may predispose individuals to the abuse of reinforcers (Edenberg & Kranzler, 2005). Elucidating the neurotransmitters and neuromodulatory systems that mediate reward can help researchers to point out directions for clinical investigation of other possible biological correlates (Schultz, 2006).

3.3 NEURAL SUBSTRATES OF REWARD

Converging evidence suggests that the reward system runs from the midbrain through the limbic system and ends in the neocortex (Peterson, 2005). The most strongly implicated systems in the brain related to reward function are the mesolimbic, mesocortical, and nigrostriatal dopamine systems (Jaworski & Jones, 2006; Wise, 2005; Kandel et al., 2000). Animal studies have shown that pharmacological blockade of these systems prevents or facilitates the reinforcing effects of hypothalamic brain stimulation, several drugs of abuse, and food or water for hungry or thirsty animals (Wise, 2005). Of these three systems the mesolimbic system is of primary importance. It extends from the ventral tegmental area at the base of the brain, through the nucleus accumbens in the limbic system, to the gray matter of the frontal lobes (e.g. medial prefrontal cortex) (Peterson, 2005). Numerous neuroscientific approaches, including neuroimaging, psychopharmacological, and electrophysiological studies, have been useful in elucidating the pathophysiology of reward.

36

3.3.1 Neuroimaging

Using neuroimaging techniques, many experimental stimuli have been found to activate the brain's reward systems. Attractive faces have been found to activate the nucleus accumbens in healthy controls, and subjects are more motivated to view them (Aharon et al., 2001). Through functional neuroimaging Aharon et al. (2001) were able to dissociate motivational and aesthetic behavioral responses to beautiful faces. Although subjects rated the male and female images relatively comparable in attractiveness, they were only motivated to view the attractive female faces, and this motivation was associated with activation of the nucleus accumbens. Humour (Mobbs et al., 2003), money (Brieter et al., 2001), and, of course, psychostimulants (Jaworski & Jones., 2006) have also been found to activate the reward system through their modulation of midbrain dopaminergic nuclei, which project to the amygdala, hippocampus, striatum (caudate and putamen) as well as the frontal cortex.

3.3.2 Pharmacological and Electrophysiological Studies

The majority of pharmacological evidence for the role of neurotransmitters in reward function comes from animal studies in which the animals are trained to perform a task then tested under the influence of specific antagonists. In these studies the animal is exposed to rewarding stimuli and generally fails to maintain established response habits

37

once the antagonist is introduced. These studies suggest that dopamine is the most strongly implicated neurotransmitter in reward function (Wise, 2005). Most addictive drugs including psychomotor stimulants such as amphetamine, cocaine and nicotine, are known to elevate brain dopamine (Jaworski & Jones, 2006; Mameli-Engvall et al., 2006). Although the role of dopamine is not limited to reward, food, brain stimulation, and psychomotor stimulant rewards are not normally effective in animals with impaired dopamine function (Wise, 2005).

Electrical stimulation of the brain can be reinforcing as can chemical stimulation by intracranial microinjections of neurotransmitters or drugs (Wise, 2005). Extensive research has focused on the complex fiber systems that comprise the hypothalamic portion of the medial forebrain bundle (MFB). The ventral tegmental area (VTA) in the MFB has been identified as a site of interest with respect to reward processes (Zangen et al., 2002). Research demonstrates that the rewarding effects of MFB stimulation are attenuated by performance-sparing doses of dopamine antagonists (Nakamura & Hikosaka, 2006) and are enhanced by indirect dopamine agonists such as cocaine and amphetamine and by drugs, such as nicotine or morphine, that stimulate or disinhibit the forebrain dopamine system (Wise, 2005). In conjunction, dopamine has been argued to be necessary to elicit neural activity in the nucleus accumbens that drives the behavioral response to cues (Nicola et al., 2005).

38

CHAPTER 4   *FACIAL EMOTION RECOGNITION*

Substantial research has investigated the processing of facial expressions of emotion. This has particularly focused on how disorders and drugs affect explicit emotion recognition and on elucidating the neural systems that are involved in implicit and explicit processing of facial emotional expressions in health and disease. There has been relatively little research into how emotional expressions may be used to test decision-making and motivational processes. This section will briefly outline some general aspects of emotion recognition, its neural substrates, computer morphing techniques to assist the quantification of emotion recognition and prior work on the motivational effects of facial expressions of emotion.

4.1   IMPORTANCE OF FACIAL EXPRESSIONS

Emotions may be best thought of as organized behavioral, autonomic and hormonal responses to existing situations in the environment (LeDoux, 1998). For humans, we are able to communicate our emotions by means of language, postural changes and facial expressions. Facial expressions of emotion serve useful social functions in that they can tell other individuals how we feel, and perhaps what we are likely to do. Singh and Ellis (1998) suggest that the ability to perceive, interpret and respond appropriately to facial expressions is required for the nonverbal exchange of thoughts and emotions in interpersonal interactions and for social information processing. Evidence indicates that

39

newborns are able to recognize and distinguish individual faces and expressions (Turati et al., 2006), leading theorists to postulate that there may be innate components to the ability to recognize facial expressions of emotion which develop further with experience.

Many studies of facial emotion recognition use a series of standardized pictures of affect such as the Pictures of Facial Affect (Ekman & Friesen, 1976) series, or Matsumoto and Ekman's (1988) Japanese and Caucasian Facial Expressions of Emotion series. Through these images, many cross-cultural studies have identified 6 basic facial expressions of emotion: happy, sad, fear, anger, disgust and surprise (Ekman et al., 1987; Matsumoto, 1992; Elfenbein, 2002). Facial emotion recognition research generally has actors posing one of the 6 basic emotions or a neutral face. These actors have been trained to move their facial muscles into the appropriate position, as guided by the Facial Action Coding System developed by Ekman and Friesen (1976) for recording muscle positions associated with specific facial expressions of emotion. The assumptions of studies of facial emotion recognition is that facial expressions can represent an accurate reflection of ones' emotional state, or a social display that is aimed at communicating emotional information to others. Research has shown that people are generally quite skilled at accurately interpreting facial expressions of emotions from photographs (Susskind et al., 2006; De Sonneville et al., 2002). Numerous factors influence accurate detection and identification of facial expressions, including characteristics of the individual (mental health status), his or her race, or culture, the specific face (as some are more difficult to interpret than others), and the context and type of task used to study the accuracy of emotion recognition. Subjects' responses are most consistent when language is

40

standardized and they have to make a forced choice from a limited list of labels, rather than when they are given the opportunity to assign any adjective that they may choose (Goren et al., 2006; Ekman & Friesen, 1976).

4.2   NEURAL SUBSTRATES OF EMOTION RECOGNITION

Research into the processes underlying face perception has accumulated at a very rapid pace. The process of face perception is a complex skill and is an important component of non-verbal social behavior and human interaction. Contemporary research suggests that face perception is mediated by a widely distributed neural system of multiple brain regions (Adolphs et al., 2003; Kandel et al., 2000). The most accepted model of organization of this system involves a distinction between recognition of the various aspects of the face such as expression, gaze or facial muscle movement that are necessary for social communication, and the invariant aspect of whole object or template face recognition.

4.2.1   Neural Substrates

Much research suggests that facial emotion recognition is predominantly dependent on right hemispheric processes and involves structures such as the amygdala, superior temporal sulcus (STS) and the prefrontal cortex (Adolphs et al., 2003; Adolphs, 2002; Kandel et al, 2000; Sprengelmeyer et al., 1998). The basic requirements of facial emotion recognition are the ability to perceive geometric components of facial features (visual

41

object and motion pathways and their associated areas) and an understanding of the emotional meaning of these configurations (limbic and association areas) (Adolphs et al., 2003; Adolphs, 2002).

There are a variety of techniques that can be utilized to investigate the neural underpinnings of facial emotion recognition. Neuropsychological, electrophysiological, pharmacological and imaging studies in humans have yielded much data in this domain. Current trends in facial emotion processing research have also shown alterations in patients with psychiatric conditions and/or organic brain injury (Leppanen, 2006; Dawson, 2005; McDonald, 2005).

4.2.2 Neuropsychology and Neuroimaging

Studies using a restricted range of split field chimeric faces have suggested that the processing of facial expressions of emotion is a highly lateralized phenomenon (Urgesi et al., 2005; Indersmitten et al., 2003; Wager et al., 2003; Workman et al., 2000). Two theories have since emerged with respect to the role that the cerebral hemispheres play in the processing of facial expressions of emotion. Positive emotion processing is thought to lateralize towards the left hemisphere, whereas negative emotion processing is believed to be restricted to the right hemisphere. Recently, Compton et al. (2005) were able to demonstrate enhanced interhemispheric processing advantages, including increased computational complexity and subcortical transfer of emotionally salient stimuli. There

42

can be little doubt that emotion-laden stimuli are afforded special priority in information processing and that lateralization of emotion-related activation is more complex and region-specific than predicted by early theories of emotion and the brain.

There is an abundance of literature based on neuroimaging techniques that identify specific brain areas involved in the recognition and processing of facial expressions of emotion. Techniques such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and regional cerebral blood flow (RBF), have proven invaluable in their elucidation of the neurobiology of facial emotion recognition. Olivares et al. (2000) conclude that in both cerebral hemispheres there are neural mechanisms specialized in the perception and recognition of faces, and in particular the ventral and posterior regions of the occipito-temporal cortex play a pivotal part in these processes. Face perception is indeed mediated by a distributed cortical network, and as suggested by Ishai et al. (2005), this network of face-responsive regions includes the inferior occipital gyrus (Watanabe et al., 2005), fusiform gyrus (Morris et al., 2006), superior temporal sulcus (Watanabe et al., 2005; Winston et al., 2003), hippocampus (Britton et al., 2006; Holt et al., 2005), amygdala (Wright et al., 2006; Fitzgerald et al., 2006; Gur et al., 2002), inferior frontal gyrus (Morris et el., 2006), and orbitofrontal cortex (Rolls et al., 2006). Bilateral activation is found in all regions, though the response in the right hemisphere tends to be stronger (Wright et al., 2006; Canli et al., 1998).

While neuroimaging provides us with some valuable insight into specific brain regions of interest with respect to the processing of facial expressions of emotion, it can at times

43

lack specificity in its ability to detect regions which respond exclusively to certain emotions. Furthermore, neuronal activation involves complex processes that depend on the response set as well as the stimuli. In relation to the present study, no neuroimaging investigations, to our knowledge, have investigated neural activity that is related to motivation in the way that is assessed in the present study. Although rapidly advancing, technical limitations of neuroimaging include signal-to-noise ratio, spatial resolution, and temporal resolution. It may also behoove the reader to appreciate the unique nature of laboratory emotion recognition research, particularly in contrast to the dynamic, interactive social aspects of facial emotion recognition in real world settings.

4.3   FACIAL STIMULI & TASKS

Numerous stimuli have been utilized in determining the processes involved in detecting and discerning facial expressions of emotions. Of the options available such as drawings, actors, animation and videos, still photographs tend to provide the most validity and reliability as they allow the researcher to investigate the processing of simple stimuli.

4.3.1. Computer Morphing

Calder et al. (2000) have described the technique of computer morphing in detail. It is used to study facial emotion recognition by synthesizing continuous tone images where two expressions have been gradually transformed from one to the next over a serious of

44

stages (Benson & Perrett, 1991). These continuous tone images are produced by taking the full expression image of each emotion and the neutral facial expression of the same actor, marking the corresponding feature points based on each image. The computer software then interpolates the feature points and local texture and colour information between the two images in a specified number of stages (Hess et al 1997; Calder et al., 2000). Morphing is an effective technique for studying facial emotion recognition and detection thresholds, as it creates highly realistic images, at varying degrees of intensity. Studies that have varied morphed intensities of expression from neutral to the full expression have shown that the degree of morphed intensity corresponds with the judged intensity of the emotion and the accuracy of emotion recognition (Hess et al 1997; Matsumoto et al 2002). Morphing between different expressions is also a useful tool to explore the contrasting predictions that facial expressions of emotion are either perceived and recognized as a whole with underlying terms, or whether there are unique factors within each emotional expression that the observer attends to.

Computer morphing was used to create the faces used for the key press task in the study reported in this thesis. Neutral faces were morphed into the full emotional expression over a series of stages. Subjects were exposed to the emotions of happy, sad, fear and anger at varying degrees of intensities (0%, 30%, 60%, 100%) dependent on their trial and condition

4.3.2. Influence of facial expressions of emotion on motivation

Although published after the completion of our study, the most comparable work to the present research is that of Strauss et al. (2005), in a study which in part investigated motivation to view images of angry, happy, fearful and neutral faces using a keypress paradigm similar to the one employed in the present study. The happy expressions led subjects to work to increase their viewing duration on the keypress task, whereas the negative expressions (anger, fear) led to reductions in viewing duration. This study therefore suggested that positive and negative expressions have differential effects on the valence of motivation, but used only full intensity emotional expressions and therefore did not assess relationships between the intensity of expression and degree of motivation. A possible limitation of the key-press method employed was that it used relationships between the absolute key-press rate and viewing durations, which does not control for individual differences in maximal key-press rates.

46

CHAPTER 5   *HYPOTHESES*

5.1.   MAIN HYPOTHESES

- The emotional expressions displayed in facial image stimuli will influence the valence and degree of subjects' motivation to view those stimuli.

- Positively valenced facial expressions will lead to incentive motivation: subjects will work or expend effort to view these stimuli.

- Negatively valenced facial expressions will lead to aversive motivation: subjects will work or expend effort not to view these stimuli.

- The degree of incentive or aversive motivation will be related to the intensity of the emotional expressions that are displayed.

5.2.   EXPLORATORY HYPOTHESES

- Motivation to view facial stimuli may be influenced by stimulus sex (of the actor posing the expression) or subject gender (of the participants in the experiment).

- Motivation to view facial stimuli may be influenced by differences in attractiveness of the facial expression stimuli.

47

CHAPTER 6   *MATERIALS & METHODS*

6.1 SUBJECTS

The study was approved by the Faculty of Medicine and Dentistry's Health Research Board (Panel B). Written informed consent was obtained from all subjects prior to their participation in the study. Healthy volunteers between the ages of 18 and 45 years of age were recruited via notice boards and newspaper advertisements. The inclusion and exclusion criteria were as follows:

Inclusion criteria:

 (1) Male or female

 (2) Age 18-45 years

 (3) Subjects raised in North America

 (4) Heterosexual

Exclusion criteria:

 (1) Lifetime psychiatric disorders or substance dependence or abuse, as assessed via structured interview – the Anxiety Disorders Interview Schedule-IV (Brown et al., 2001).

 (2) Subjects with first-degree relatives with a history of mood disorders or psychosis.

 (3) Regular alcohol intake of more than 14 standard alcoholic drinks a week for males and 7 for females. Alcohol use within 72 hours of testing.

(4) Subjects with a history of significant past neurological disorders or current

medical disease.

(5) Subjects using prescribed or non-prescribed drugs with psychotropic properties.

These criteria excluded subjects with a personal or family history of psychiatric disorders,

physical disorders, or psychotropic drug use that might influence the results.

A total of 20 subjects, 12 females and 8 males, participated in the keypress component of

this study. The average age of the males and females respectively was 24.3 ± 6.8 years,

and 21.2 ± 2.9 years. The average age of all participants in this study was 22.5 ± 5.0

years.

An independent sample of 14 healthy Caucasian subjects, age range 20-30 years, was

also used for the attractiveness rating component of this study. Seven were male and 7

female.

6.2 STIMULI

The image set for emotions used in this study consisted of color photos derived from

Matsumoto and Ekman's Japanese and Caucasian Facial Expressions of Emotion

(JACFEE; Matsumoto & Ekman, 1988). The JACFEE consists of 56 different models

expressing 7 different facial emotions overall: anger, contempt, disgust, fear, happiness,

sadness, and surprise. Each expression was demonstrated by 8 different models: 4

49

Caucasian and 4 Japanese, 2 men and 2 women of each ethnic background. Each expression was coded by the Facial Action Coding System (Ekman & Friesen, 1978) to ensure that it included only the facial muscles associated with each of the prototypical expressions. For each model there was also an image showing a neutral expression. All images in the data set have previously been validated in rating studies, which showed that they were consistently rated as depicting the posed emotion (Matsumoto & Ekman, 1988).

From this set we extracted the images of the expressions of happy, sad, angry, and fearful expressions posed by male and female Caucasian subjects. Computer morphing techniques (see 4.3.1; Calder et al., 2000; Coupland et al., 2003) were used to produce continua between each model's neutral expression and their full expression of the posed emotion. Images were produced using Adobe Photoshop 6.0 and Winimages Morph 7.0 software. Briefly, the images for each pair of neutral and emotional expressions were resized and aligned to match image color, face size, inter-pupillary distance and eye position, using Adobe Photoshop 6.0. Using Winimages Morph 7.0, multiple control points were then highlighted on corresponding feature positions on each image. The highest density of control points was placed on features that contribute the most facial expression information, i.e. the eyes and mouth. The morphing software then interpolates position, color and texture information between the images in a specified number of steps. In this case, 9 steps were interpolated between 0% and 100% expressions, to produce 10% increments in feature position.

There are numerous advantages to using morphed stimuli. Images have been shown to be judged as realistic in prior studies (Armstrong & Coupland, unpublished data). A greater degree of control can be exerted over the apparent intensity of the stimulus than when asking subjects to pose different intensities of expressions. The degree to which the expression is morphed from neutral towards the full intensity has been shown to be proportional to the accuracy of identification, the intensity of perceived emotion and the activation of specific brain regions in neuroimaging studies (Blair et al., 1999; Hess et al, 1997).

For the experimental tasks in the present thesis, images were selected at 0%, 60%, and, 100% intensities of expression in the first study and 0%, 30%, 60% and 100% intensities in the second study, as seen in Figure 8.
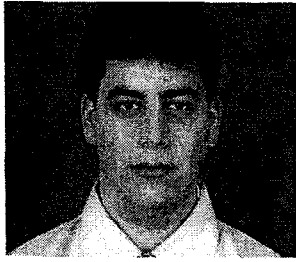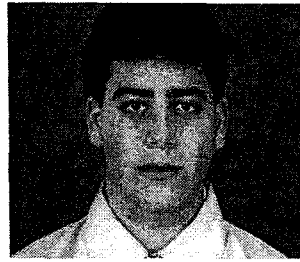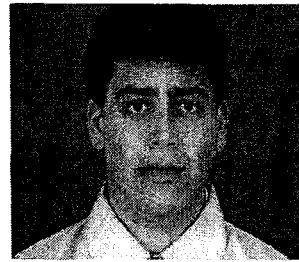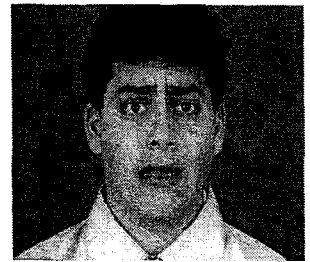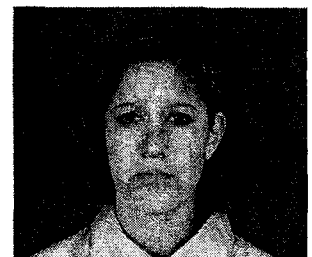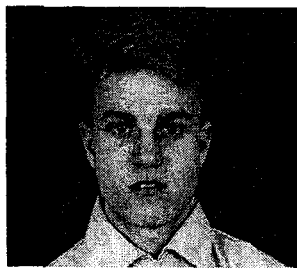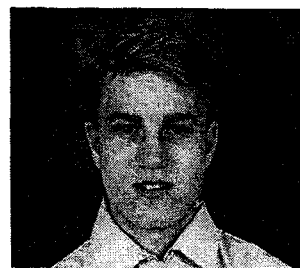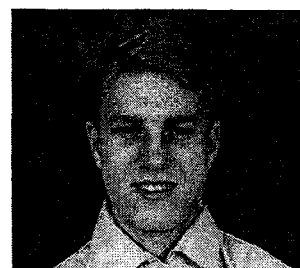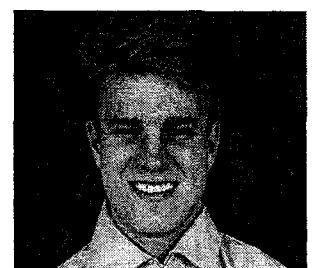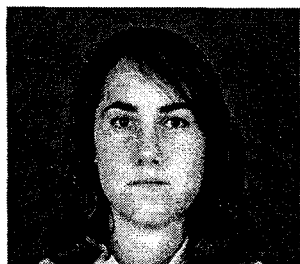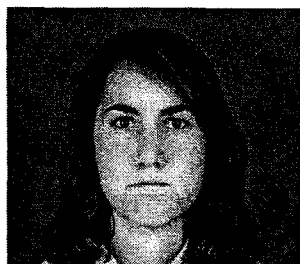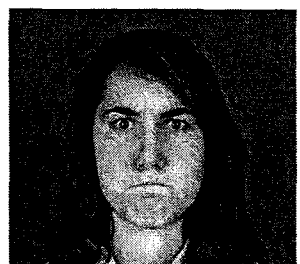
Figure 8. Examples of faces used in both experiments (Matsumoto & Ekman, 1988).

6.3   KEYPRESS EXPERIMENT

6.3.1   Keypress Task

The keypress procedure was used to examine the reward value of facial expression

images by assessing the duration for which subjects viewed the different expressions.

The duration of viewing was used as an operational measure of the amount of work that

subjects were willing to do to view, or to avoid viewing, each image.

All testing was done using customized software that was written in executable

Microsoft Windows 2000 code and presented on a Pentium PC. The facial stimuli were

all standardized with respect to size and resolution (638 x 510 pixels) and were viewed on

a 17" Samsung LCD color monitor with a screen resolution of 800 x 600 pixels.

The images were presented on the PC monitor and subjects were told that without

interference they would remain on the screen for a fixed period of time. However, if

subjects wished to increase or decrease their viewing time for a particular image, they

could do so by repeatedly pressing on alternating pairs of specific keys on the PC

keyboard. If they wanted the picture to remain longer on the screen, they could do so by

alternately pressing the "n" and "m" keys which were also labelled "+ +". Conversely, if

they wanted the picture to disappear faster, they could do so by alternately pressing the

"z" and "x" keys (labelled "- -"). The task therefore assessed the amount of work,

53

measured as changes in viewing time, that subjects were willing to perform to modify

their viewing time.

As modified from Aharon et al. (2001), each pair of keypresses increases or decreases

the total viewing time according to the following formula:

$$\text{NewTotalTime} = \text{OldTotalTime} + [(\text{ExtremeTime} - \text{OldTotalTime}) * R_{image}] /$$

$$(R_{max} * K)$$

where (for the current study) ExtremeTime is 3,000 msec for keypresses reducing the

viewing time, 13,000 msec for keypresses increasing the viewing time, and K is a scaling

constant set to 40. R_{max} is the subject's maximum keypress rate and R_{image} is the subject's

actual keypress rate whilst viewing the image, which is updated for each keypress. The

effect is that for a subject with a high maximal tapping rate, the incremental change with

each pair of taps is smaller than for a subject with a low maximal tapping rate, in order to

reduce the effect of individual differences in motor function on performance. The overall

effect of the function described by the equation is exponential: as effort increases further,

the resulting incremental changes in viewing time become smaller. As soon as the

elapsed time for each picture surpasses the total time determined by keypress

(NewTotalTime), the picture is removed and the next image is displayed. A progress bar

is displayed beneath each image on every trial, indicating the proportion of total viewing

time that has elapsed at any moment, which changes with every keypress.

54

The effects are illustrated in figures 9 and 10.
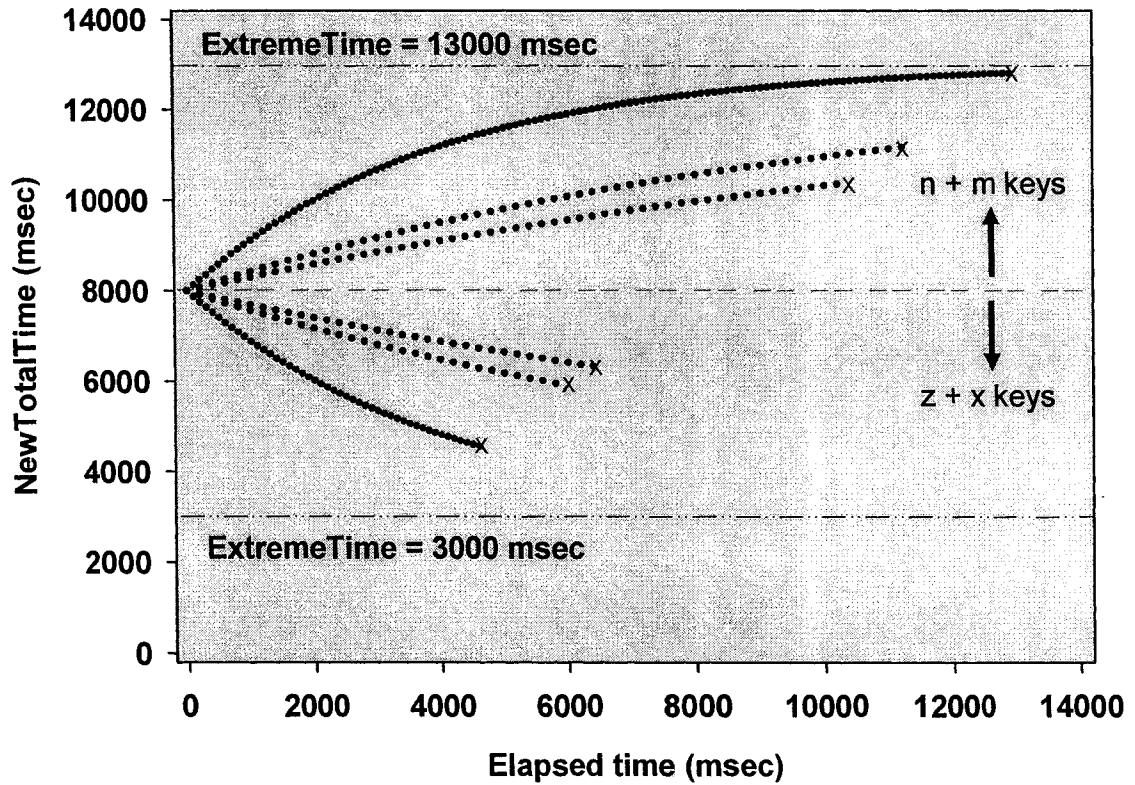
Figure 9. Demonstration of keypress responses with subjects tapping at constant rates during the whole of each viewing period. Each display terminates when the elapsed time reaches X.

Red circles and Xs: subject with maximum keypress rate (R_{max}) = 10 keypress/sec and keypress rate during image (R_{image}) = 10 keypress/sec.

Green circles and Xs: subject with maximum keypress rate (R_{max}) = 10 keypress/sec and keypress rate during image (R_{image}) = 5 keypress/sec.

55

Purple circles and Xs: subject with maximum keypress rate (R_{max}) = 7 keypress/sec and keypress rate during image (R_{image}) = 5 keypress/sec.

Figure 10. Demonstration of keypress responses with subjects tapping at constant rates, in two second bursts with two second gaps, during each viewing period.

Red circles and Xs: subject with maximum keypress rate (R_{max}) = 10 keypress/sec and keypress rate during image (R_{image}) = 10 keypress/sec.

Green circles and Xs: subject with maximum keypress rate (R_{max}) = 10 keypress/sec and keypress rate during image (R_{image}) = 5 keypress/sec.

Purple circles and Xs: subject with maximum keypress rate (R_{max}) = 7 keypress/sec and keypress rate during image (R_{image}) = 5 keypress/sec.

56

6.3.2 Keypress Procedure

As outlined above, the keypress task provides a measure of how much work subjects are willing to perform to modify their exposure to visual stimuli. In the experiments, the keypress task was divided into three parts. In the first part, subjects were asked to perform the alternating keypresses twice, as fast as possible, in the absence of any stimuli, in order to determine their maximum keypress rate, R_{max}. In the second part, they were given the instructions for viewing images and then presented with a series of 6 non-facial images of pleasant or unpleasant scenes, in order to familiarize themselves with the procedure. In the third part, they were presented with the facial emotion stimuli.

In this study, subjects were presented with facial stimuli that featured 4 basic emotions: happy, fear, anger and sad. These facial expressions of emotion displayed varying degrees of emotional intensity and were produced via a computer morphing technique (see 4.3.2.). The first group of subjects (n=9) was exposed to the 4 stimulus classes: happy, fear, sad and anger, each displayed by 2 male and 2 female Caucasian actors and at 3 different morphed intensities: 0% (neutral), 60% and 100%, giving a total of 48 images. The second group (n=11) only varied from the first by their exposure to a 4th level of intensity of 30%, giving a total of 64 images. All images were displayed in random order.

57

Subjects were told that they would be shown a series of pictures and that without interference the images would remain on the screen for 8 seconds. The participants could, however, influence the duration that the image was shown by pressing specific keys on the keyboard.

Subjects were able to track their total viewing time of each image by a progress bar that changed with every keypress. The decrease or increase in duration (maximum of 5,000 msec) was proportional to the key-press rate, which was set in relation to the maximum rate that the subject could achieve. The degree to which subjects were motivated to view each image could then be assessed by the total duration for which the image was shown.

The instructions on the computer screen were as follows:

(1) You will be shown different pictures. You may like some pictures, you may dislike others.

(2) The picture will stay on the screen for several seconds. You can see how much longer the picture will be on the screen by looking at the long progress bar at the bottom of the screen. When the progress bar looks full, the next picture will be shown.

(3) If you like a picture, you can keep it on the screen longer. To keep a picture on the screen longer, press the two + + keys one after another really fast. The faster you

58

press the keys, the longer the picture will stay on the screen. To continue, quickly

press the two + + keys until the progress bar below is full.

(4) If you do not like a picture, you can make it go away faster. To get a picture off

the screen more quickly, press the two - - keys one after another really fast. The

faster you press the keys, the less time the picture will stay on the screen. To

continue quickly press the two - - keys until the progress bar below looks full.

(5) The task will begin now. The keys you need to press will be printed at the bottom

of the screen in case you forget. Please take a moment to prepare yourself, and

press the ENTER key whenever you are ready.

In addition to the progress bar under each image, the following message was displayed:

"Press the + + keys to keep the picture on the screen longer. Press the - - keys to

make the picture go away faster. The faster you press the keys, the more of an

effect you will have on the picture."

The dependent measure of interest in this task was the amount of work, in key press units,

that the subjects exert in response to their exposure to facial stimuli and the resulting

viewing duration.

59

This presented the following variables for analysis

(1) Total viewing duration :

(2) Time added to viewing duration by positive (++) keypresses.

(3) Time subtracted from viewing duration by negative (--) keypresses.

6.4   ATTRACTIVENESS EXPERIMENT

6.4.1   Attractiveness Task

The attractiveness task was used to assess how attractive subjects found the faces when
they were presented at a neutral (0%) intensity. Using pencil and paper stimuli, subjects
were asked to rate how they thought "… people would generally judge the appearance…"
of each face, on a 0-100 mm visual analogue scale (VAS), where 0 mm was anchored as
"unattractive, ugly" and 100 mm was anchored as "good-looking, attractive" (Figure 11).
A separate group of subjects was used so that performance of the attractiveness ratings
would not influence keypress performance, or vice versa. Subjects were asked to make
ratings from a third person perspective to make the judgements more generalizable and
less likely to be highly personal. VAS ratings were averaged for the four neutral faces
that were presented for each emotional stimulus set in the keypress task.

60
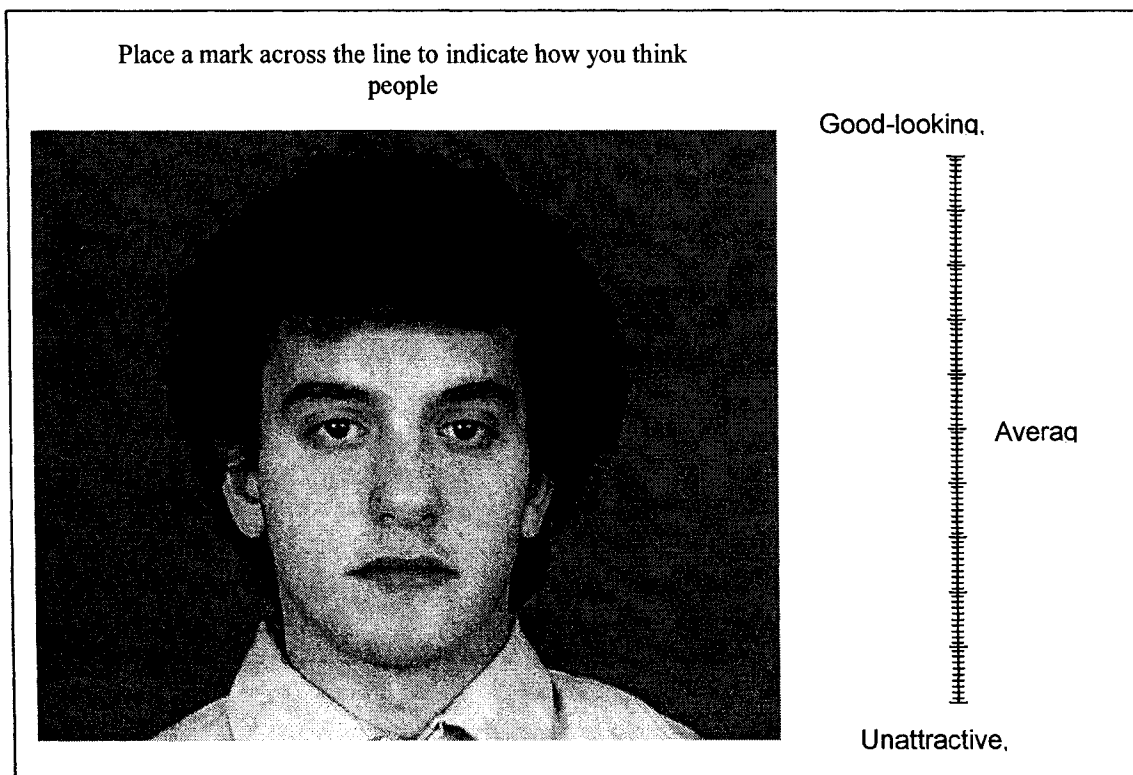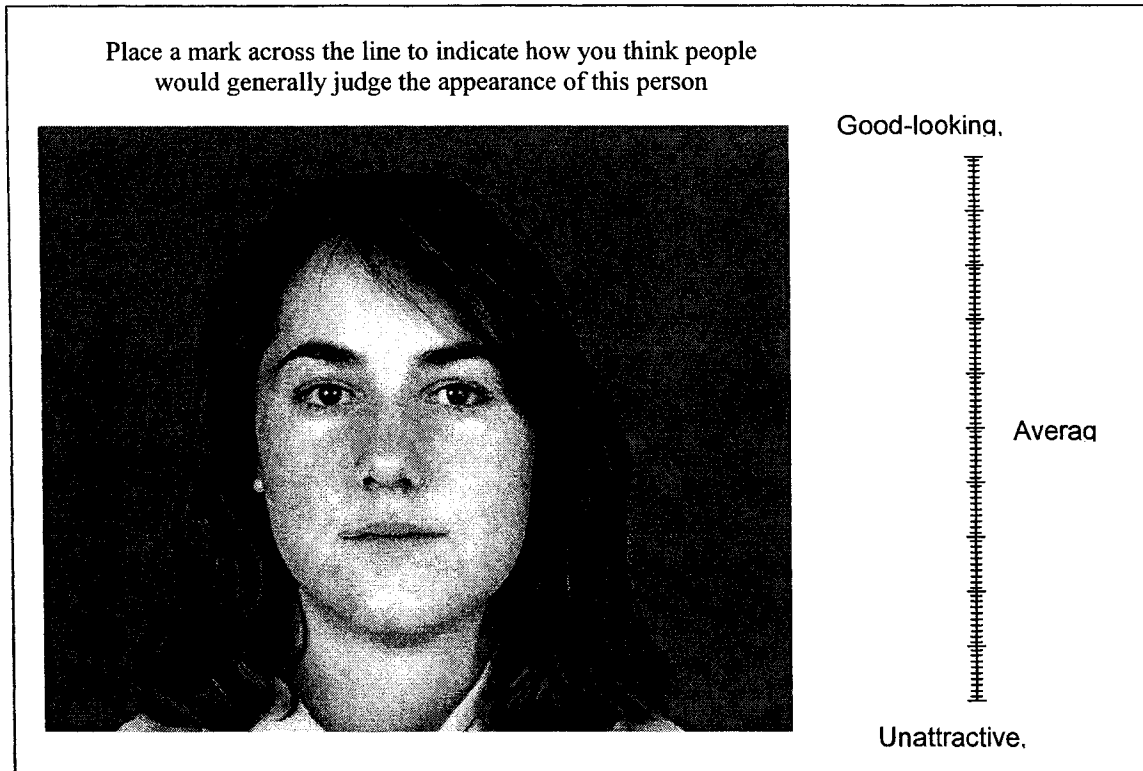
Figure 11. Examples of visual analogue scale (VAS) facial attractiveness test materials.

6.5   STATISTICAL ANALYSES

The test data presented the following factors for analysis: Emotion (happy vs. fear vs. sad vs. anger), Intensity (0%, 60% and 100% for the first subject group, and 0%, 30%, 60% and 100% for the second subject group) , and the Stimulus Sex (male or female image). Emotion, Intensity and Stimulus Sex were within-subject factors.

Subject Group was analyzed as a between-subject factor in analyses that compared the responses of the first and second subject groups.

Subject Gender was analyzed as a between-subject factor in analyses that compared the responses of male and female subjects.

Responses were first analyzed overall, using Repeated Measures Analysis of Variance (RMANOVA) for the within factors of Emotion, Intensity and the Emotion x Intensity interaction. Subsequently, the effects of Intensity on viewing of each emotional expression type was examined using RMANOVA with the single within factor of Intensity. Changes from viewing at baseline (neutral, 0% intensity) were then examined using paired t tests. Given the directional nature of the hypotheses, one-tailed paired t tests were used.

62

For analyses that compared viewing across different emotional stimulus sets at baseline (0% intensity), a RMANOVA with the single within factor of Emotion was used, followed by paired, two-tailed t tests.

For the VAS ratings of attractiveness RMANOVA for the within factors of Emotion Set and Stimulus Sex was used, followed by paired two-tailed t tests.

For all of the repeated measures analyses, Mauchley's test for sphericity was used and, where indicated, Greenhouse-Geisser adjustments were made to the degrees of freedom (df) and significance (p) values. In the results tables, asterisks are used to indicate each analysis where Greenhouse-Geisser adjustments were made.

CHAPTER 7   *RESULTS*

Summary results for total viewing duration for the two groups of subjects are first

presented separately. Subjects' responses to changes in the intensity of the emotional

expressions were similar in the two subject groups. Therefore, data were combined for

the two subject groups for the 0%, 60% and 100% intensity stimuli to increase the sample

size for additional analyses.

7.1.   TOTAL VIEWING DURATION FIRST SUBJECT GROUP
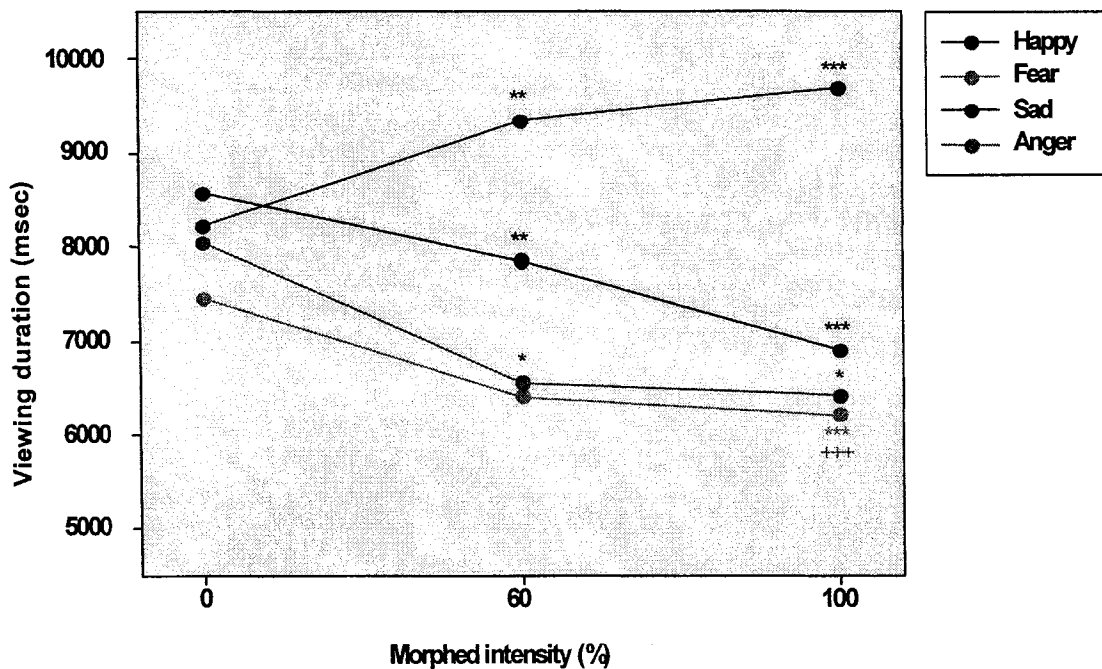
Figure 12. Total viewing duration, first subject group (n=9).
Significant change from viewing duration at 0% intensity: *p<0.05; **p<0.01; ***p<0.005.
Significant change from viewing duration at 60% intensity: +++p<0.005.

64

Subjects increased their viewing duration as happy expressions increased in intensity and decreased their viewing duration as negative (sad, fearful or angry) expressions increased in intensity.

The overall repeated measures analysis of variance (RMANOVA) showed a significant emotion x intensity interaction (Table 1.).

Factor	F	df	p-value
Emotion	11.4	3,24*	.005
Intensity	9.3	2,16	.002
Emotion x Intensity	8.6	6,48*	.003

*Greenhouse-Geisser corrected significance

Table 1. Overall RMANOVA (within factors = Emotion, Intensity) of total viewing duration. First subject group (n=9).

The changes in viewing duration as the intensity of expressions increased were significant for each emotional expression, as shown by the RMANOVAs for the individual types of expression in Table 2. The changes in viewing duration from those at 0% intensity were significant for all emotions at 100% morphed intensity and for all emotions other than fear at 60% intensity, as indicated in figure 12.

Emotion	F	Df	p-value
Happy	5.4	2,38*	.020
Fear	15.5	2,38	.000
Sad	11.5	2,38	.000
Anger	14.8	2,38*	.001

*Greenhouse-Geisser corrected significance

Table 2. RMANOVAs (within factor = Intensity) of effects of expression intensity on total viewing duration for each individual emotion. First subject group (n=9).

65

	Mean	Std. Deviation
hap0	8,225	1,610
hap60	9,333	2,351
hap100	9,692	2,469
fear0	7,451	1,044
fear60	6,414	881
fear100	6,216	1,415
sad0	8,574	1,603
sad60	7,861	1,872
sad100	6,906	1,386
anger0	8,053	1,509
anger60	6,565	1,405
anger100	6,420	1,701

Table 3. Descriptive statistics for total viewing duration (msec). First subject group (n=9).

66

7.2. TOTAL VIEWING DURATION SECOND SUBJECT GROUP
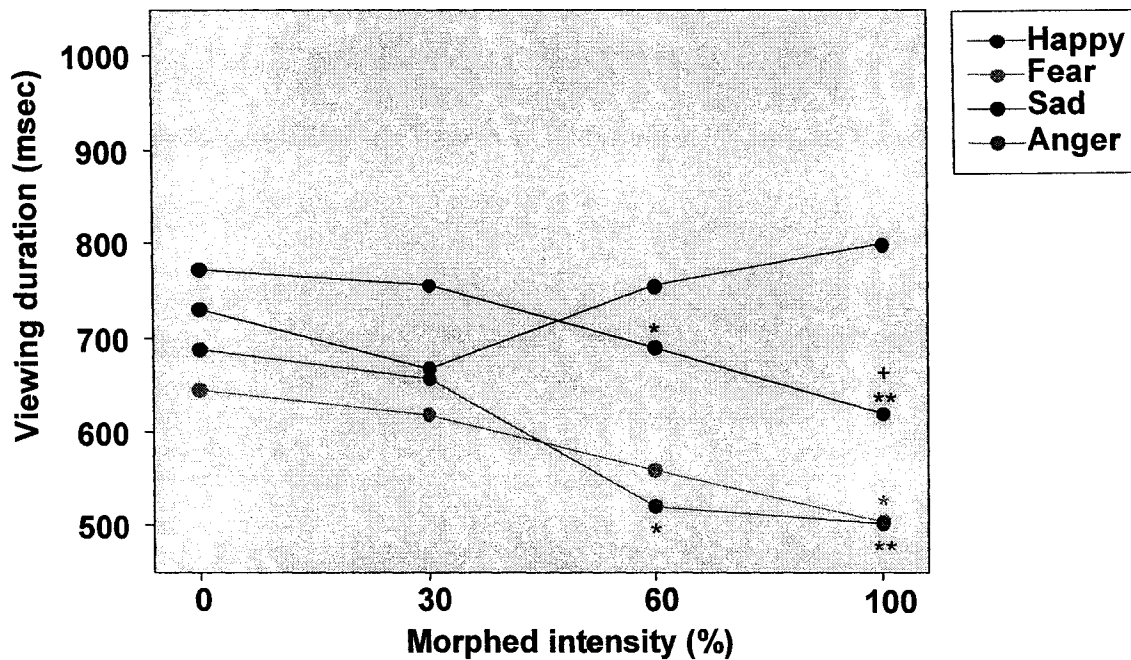
Figure 13. Total viewing duration for the second subject group (n=11).
Significant change from viewing duration at 0% intensity: *p <0.05; **p< 0.01.
Significant change from viewing duration at 60% intensity: +p <0.05.

Subjects tended to increase their viewing duration as happy expressions increased to higher intensities (60% and 100%), but these changes were not statistically significant. They decreased the viewing durations as negative (sad, fearful or angry) expressions increased in intensity. The overall repeated measures analysis of variance (RMANOVA) showed a significant emotion x intensity interaction (Table 4.).

67

Factor	F	df	p-value
Emotion	6.2	3,30*	.013
Intensity	7.2	3,30*	.014
Emotion x Intensity	3.5	9,90*	.030

*Greenhouse-Geisser corrected significance

Table 4. Overall RMANOVA (within factors = Emotion, Intensity) of total viewing duration. Second subject group (n=11).

However, the results were more complicated than for the first stimulus set and subject group because there were no significant effects for the low intensity (30%) stimuli. Changes in viewing duration across the different intensities of expression were significant for the negative expressions, but not for the happy expressions, as shown in table 5. Happy expressions did not show significant changes in viewing duration from 0% expressions at any level of intensity. Indeed, mean viewing durations for happy expressions even decreased at 30% intensity, although they did tend to increase at higher intensities (60% and 100%), as shown in figure 13.

Emotion	F	df	p-value
Happy	1.9	3,30*	.180
Fear	3.8	3,30*	.048
Sad	7.2	3,30	.001
Anger	6.8	3,30*	.004

*Greenhouse-Geisser corrected significance

Table 5. RMANOVAs (within factor = Intensity) of effects of expression intensity on total viewing duration for each individual emotion. Second subject group (n=11).

The individual subject data for happy expressions were inspected to determine why the second group of subjects might have shown this pattern of response to happy expressions.

Changes in viewing duration from the 0% expressions were plotted for the individual

subjects in each group for the 30% (second group only), 60% and 100% intensity happy

expressions. These plots showed an outlier in the second group, whose viewing duration

markedly decreased for happy expressions. This outlier was one of the two non-caucasian

subjects.
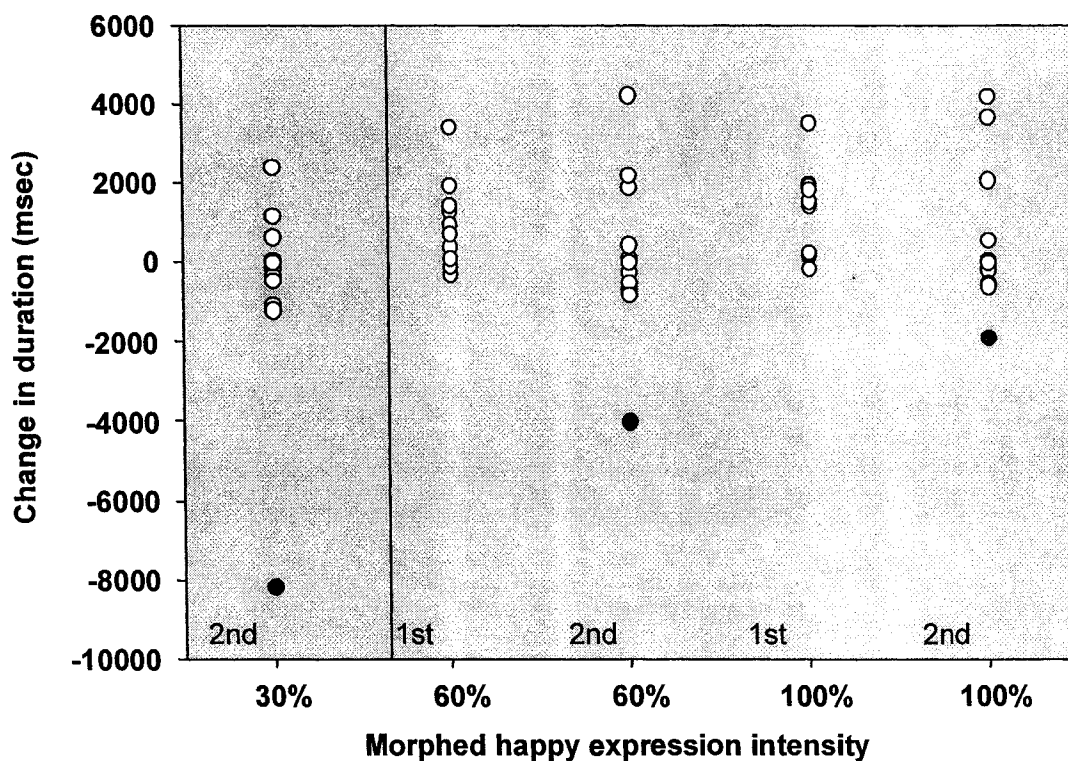
Figure 14. Individual subject data showing change in viewing time from
neutral (0%) expressions in the two subject groups. Outlier shown in red.

The analyses for the second group were therefore repeated after exclusion of the outlier.

In this case, mean viewing durations for happy expressions increased more linearly with

intensity, as shown in figure 15. The overall RMANOVA was again significant for the

emotion x intensity interaction (Table 6.).

69

Factor	F	df	p-value
Emotion	4.9	3,27*	.042
Intensity	8.5	3,27*	.006
Emotion x Intensity	3.6	9,81*	.039

*Greenhouse-Geisser
corrected significance

Table 6. Overall RMANOVA (within factors = Emotion, Intensity) of total viewing

duration. Second subject group after exclusion of outlier (n=10).
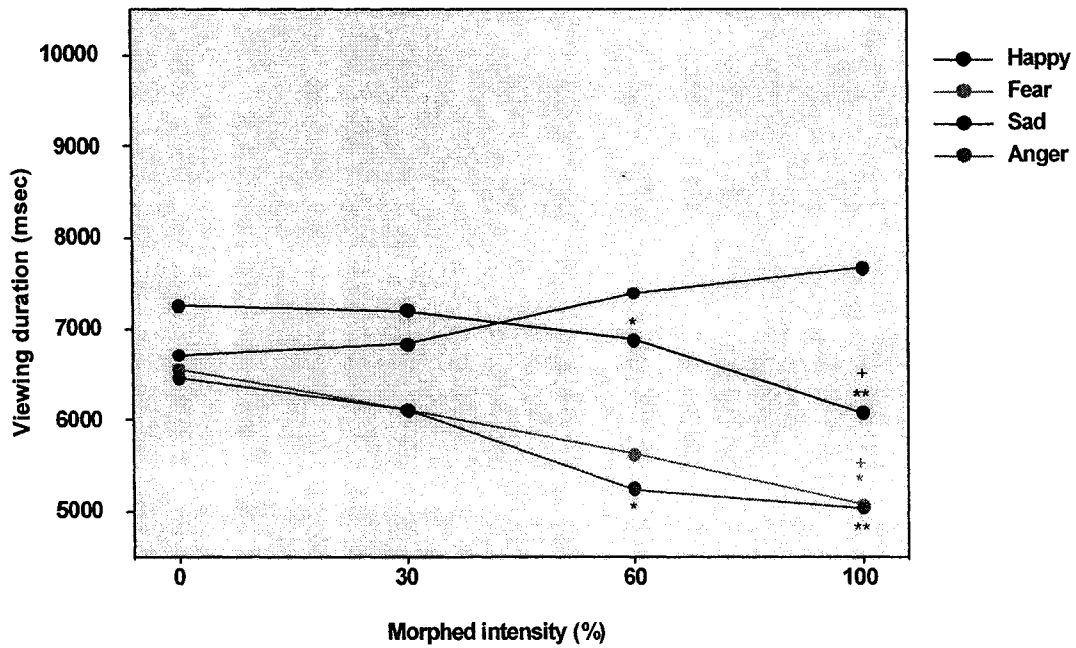
Figure 15. Total viewing duration for the second subject group, excluding outlier (n=10).
Significant change from duration at 60% intensity: *p <0.05; **p<0.01.
Significant change from duration at 60% intensity: p<0.05

70

	Mean	Std. Deviation
hap0	6,719	1,475
hap30	6,843	2,275
hap60	7,400	2,807
hap100	7,675	3,016
fear0	6,560	1,458
fear30	6,123	1,196
fear60	5,631	1,003
fear100	5,081	707
sad0	7,257	1,558
sad30	7,205	1,409
sad60	6,881	1,643
sad100	6,082	925
anger0	6,470	1,616
anger30	6,111	1,324
anger60	5,245	868
anger100	5,047	631

Table 7. Descriptive statistics for total viewing duration (msec). Second subject group

after removal of outlier (n=10).

71

7.3. TOTAL VIEWING DURATION. COMPARISION BETWEEN FIRST & SECOND SUBJECT GROUPS
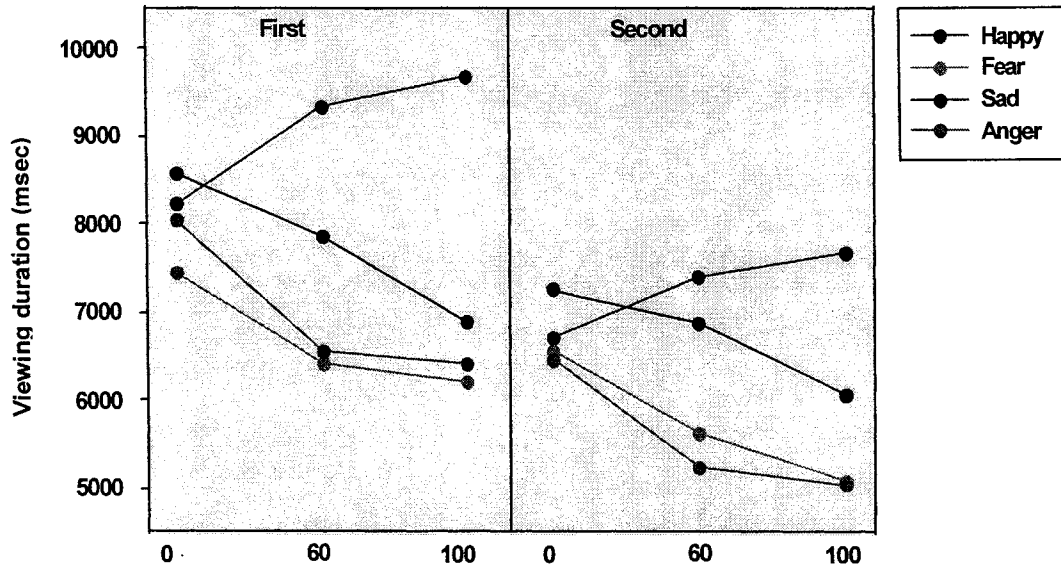
Figure 16. Total viewing durations for first and second subject groups compared.

Comparing the responses of the first and second subject groups, the most obvious differences are in the baseline viewing durations for the 0% intensity expressions, which were shorter for the second subject group. However, the pattern of responses to increasing stimulus intensities was similar. In the overall mixed ANOVA that compared responses between subject groups, this was evident as a significant between group effect of group membership, with no interactions between group membership and emotion, intensity, or group x intensity effects, as shown in Table 8.

Factor	F	df	p-value
Emotion	15.7	3,51*	.000
Intensity	17.9	2,34	.000
Emotion x Intensity	10.6	6,102*	.000
Group	5.7	1,17	.029
Group x Emotion	0.7	3,51*	.433
Group x Intensity	0.1	2,34	.944
Group x Emotion x Intensity	0.3	6,102*	.763

*Greenhouse-Geisser corrected significance

Table 8. Mixed ANOVA (between factor = Group; within factors = Emotion, Intensity) comparing total viewing durations in the first and second subject groups.

These data suggested that the first and second subject groups were similar in terms of how they responded to changes in emotional expression intensity, but different in baseline viewing durations for neutral (0% intensity) expressions. Given the small sample sizes, this might simply be explained by sampling error. When the two samples were combined, the viewing durations for the neutral expressions were normally distributed (Table 9.) and the distributions for the two subject groups overlapped, as shown in figure 17. The two subject groups were therefore combined for all subsequent analyses, excluding the outlier in the second subject group that was identified previously.

	Shapiro-Wilk test		
	Statistic	df	Sig.
hap0	.966	19	.696
fear0	.942	19	.284
sad0	.966	19	.702
anger0	.959	19	.552

Table 9. Shapiro-Wilk test of distribution normality for viewing duration of neutral (0% intensity) stimuli in the combined sample.

73
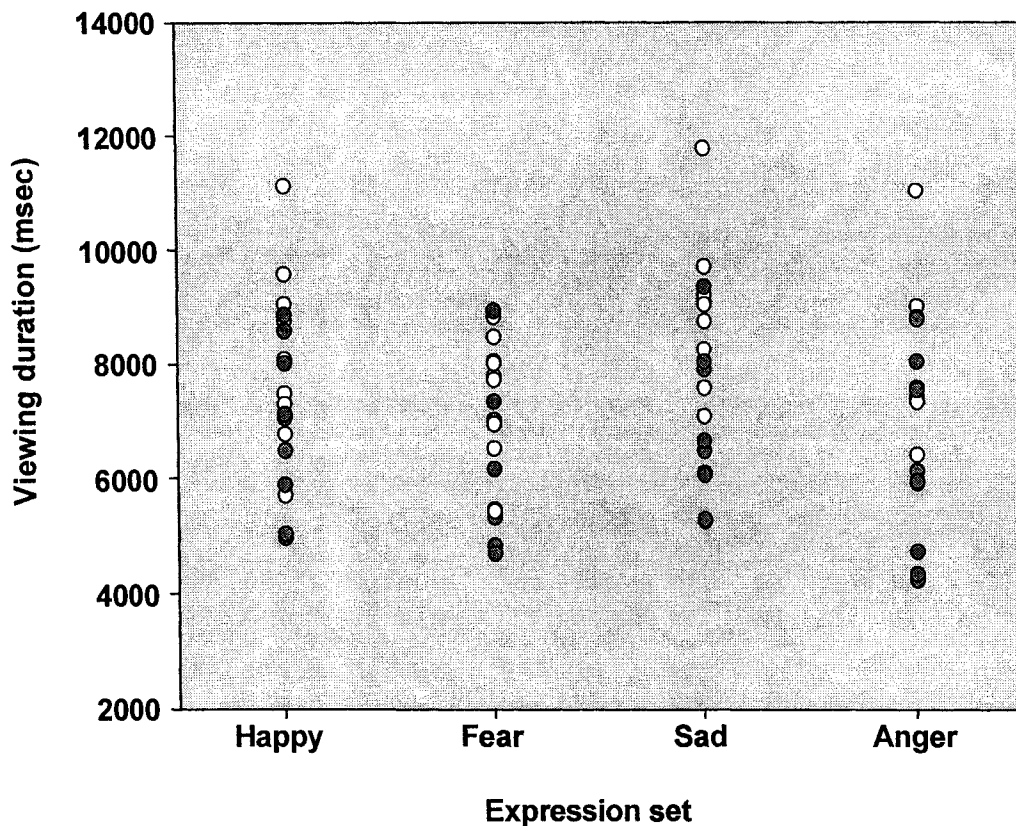
Figure 17. Individual data of viewing durations for the neutral stimuli from each Expression set. Open circles = first group, yellow circles = second group.

7.4. TOTAL VIEWING DURATION, COMBINED SAMPLE

Viewing durations in the combined sample increased with expression intensity for the happy expressions and decreased with intensity for the negative expressions, as shown in Figure 18. The overall RMANOVA showed significant main and interaction effects for emotion and intensity (Table 10.). Each emotional expression type showed significant effects of intensity on viewing duration (Table 11.). Intensity had significant effects on viewing durations for all emotions except fear at 60% intensity. Increasing expression intensity from 60% to 100% increased the effect on viewing duration for all emotions

74

except anger. Effects on viewing durations were significant for all emotions at 100%

intensity.
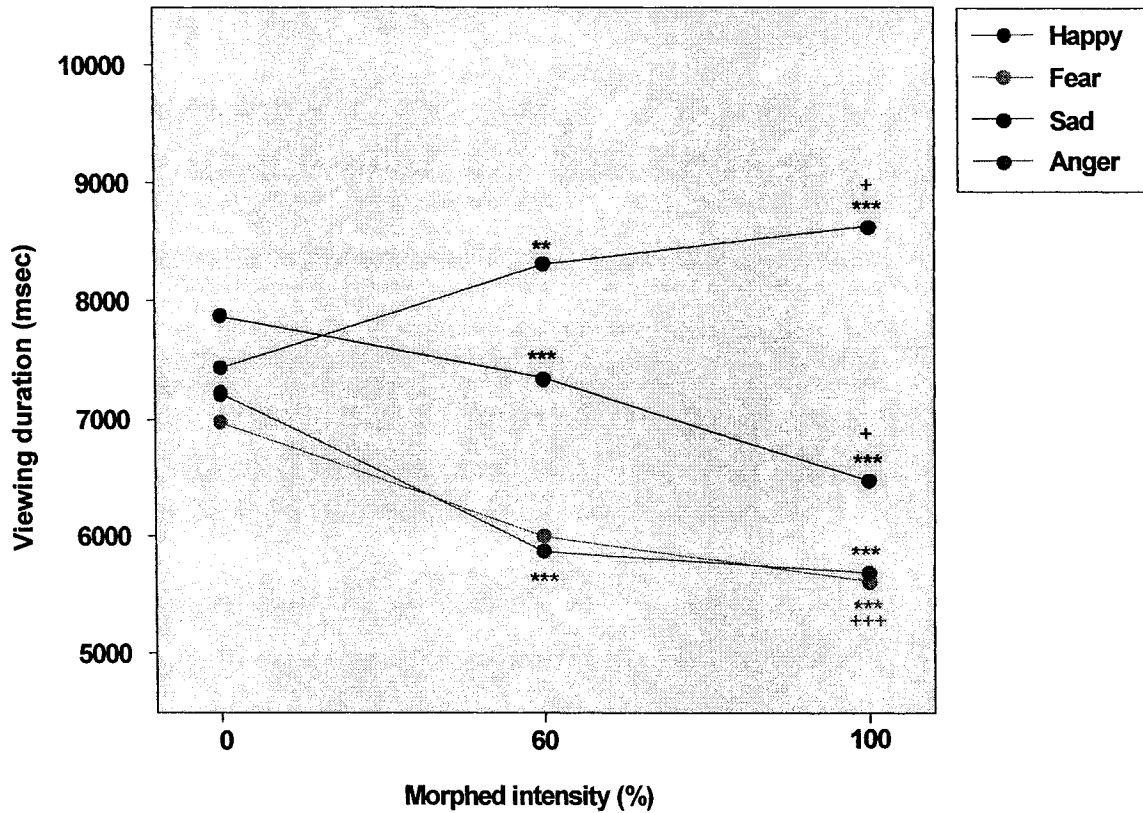
Figure 18. Total viewing duration, combined sample (n=19).
Significant change from viewing duration at 0% intensity: **p<0.01; ***p<0.005.
Significant change from viewing duration at 60% intensity: $^+$p<0.01; $^{+++}$p<0.005.

Factor	F	df	p-value
Emotion	15.7	3,54*	.000
Intensity	18.9	2,36	.000
Emotion x Intensity	10.9	6,108*	.000

*Greenhouse-Geisser
corrected significance

Table 10. Overall RMANOVA (with factor = Emotion, Intensity) of total viewing
duration. Combined sample (n=19).

75

Emotion	F	df	p-value
Happy	9.6	2,36*	.002
Fear	11.5	2,36*	.000
Sad	15.4	2,36	.000
Anger	13.7	3,36*	.001

*Greenhouse-Geisser corrected significance

Table 11. RMANOVAs (within factor = Intensity) of effects of expression intensity on total viewing duration for each individual emotion. Combined sample (n=19).

	Mean	Std. Deviation
hap0	7,432	1,685
hap60	8,315	2,717
hap100	8,631	2,886
fear0	6,982	1,325
fear60	6,002	1,004
fear100	5,619	1,216
sad0	7,881	1,677
sad60	7,345	1,777
sad100	6,472	1,208
anger0	7,220	1,726
anger60	5,870	1,309
anger100	5,697	1,407

Table 12. Descriptive statistics of total viewing duration (msec). Combined sample (n=19).

76

7.5. TOTAL VIEWING DURATION BY SUBJECT GENDER
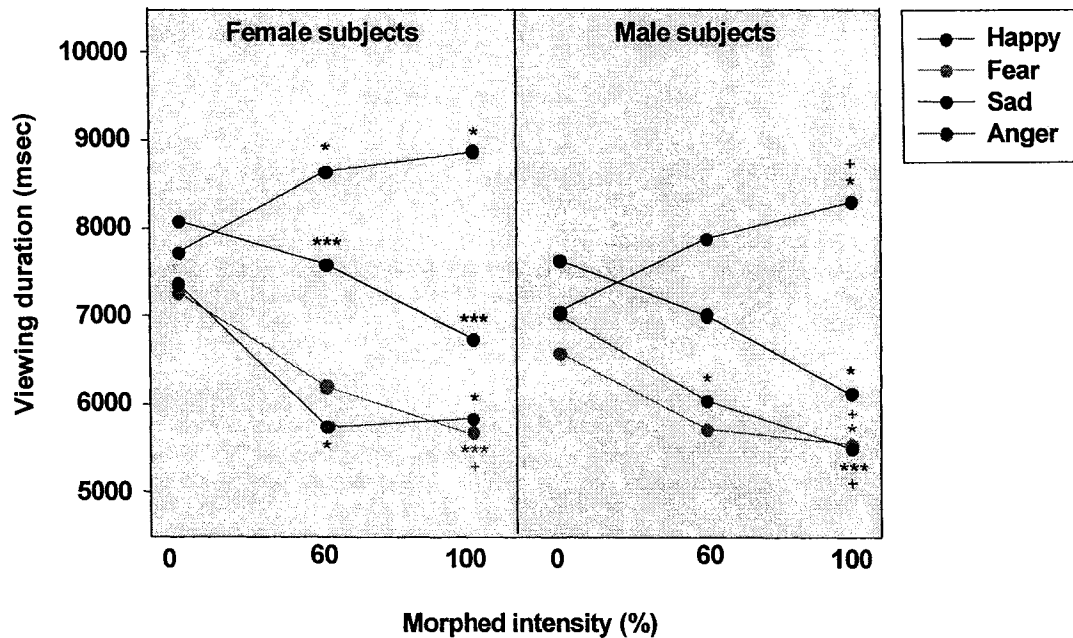
Figure19. Total viewing duration, combined sample. Female (n=11) and male (n=8) subjects were compared.
Significant change from viewing duration at 0% intensity: *p<0.05; ***p<0.005.
Significant change from viewing duration at 60% intensity: $^+$p<0.05.

There were no significant effects of subject gender on viewing durations for the emotional expressions. Both the baseline levels of response and changes in response with stimulus intensity were similar for male and female subjects, as shown by the lack of a significant main effect of subject gender and the lack of significant interactions between subject gender, emotion and intensity (Table 13.).

77

Factor	F	df	p-value
Emotion	14.2	3,51*	.000
Intensity	17.1	2,34	.000
Emotion x Intensity	10.1	6,102*	.000
Subject Gender	0.5	1,17	.487
Subject Gender x Emotion	0.2	3,51*	.703
Subject Gender x Intensity	0.2	2,34	.812
Subject Gender x Emotion x Intensity	0.4	6,102*	.731

*Greenhouse-Geisser corrected significance

Table 13. Mixed ANOVA (between factor = Subject Gender; within factors = Emotion, Intensity) comparing total viewing durations between female (n=11) and male (n=8) subjects in the combined sample.

78

	Subject Gender	Mean	Std. Deviation
hap0	f	7,718	1,749
	m	7,040	1,620
hap60	f	8,639	2,555
	m	7,871	3,043
hap100	f	8,874	2,934
	m	8,297	2,984
fear0	f	7,277	1,107
	m	6,576	1,561
fear60	f	6,205	1,130
	m	5,724	785
fear100	f	5,669	1,422
	m	5,550	950
sad0	f	8,070	1,782
	m	7,621	1,600
sad60	f	7,588	2,022
	m	7,011	1,435
sad100	f	6,732	1,391
	m	6,115	860
anger0	f	7,370	1,954
	m	7,013	1,455
anger60	f	5,752	1,537
	m	6,034	989
anger100	f	5,842	1,719
	m	5,499	892

Table 14. Descriptive statistics of total viewing duration (msec) by subject gender, combined sample (female subjects = 11, male subjects = 8).

79

7.6. TOTAL VIEWING DURATION BY STIMULUS SEX

In contrast to the lack of significant effects for the gender of the subjects, the sex of the

stimulus faces had significant effects on viewing durations.
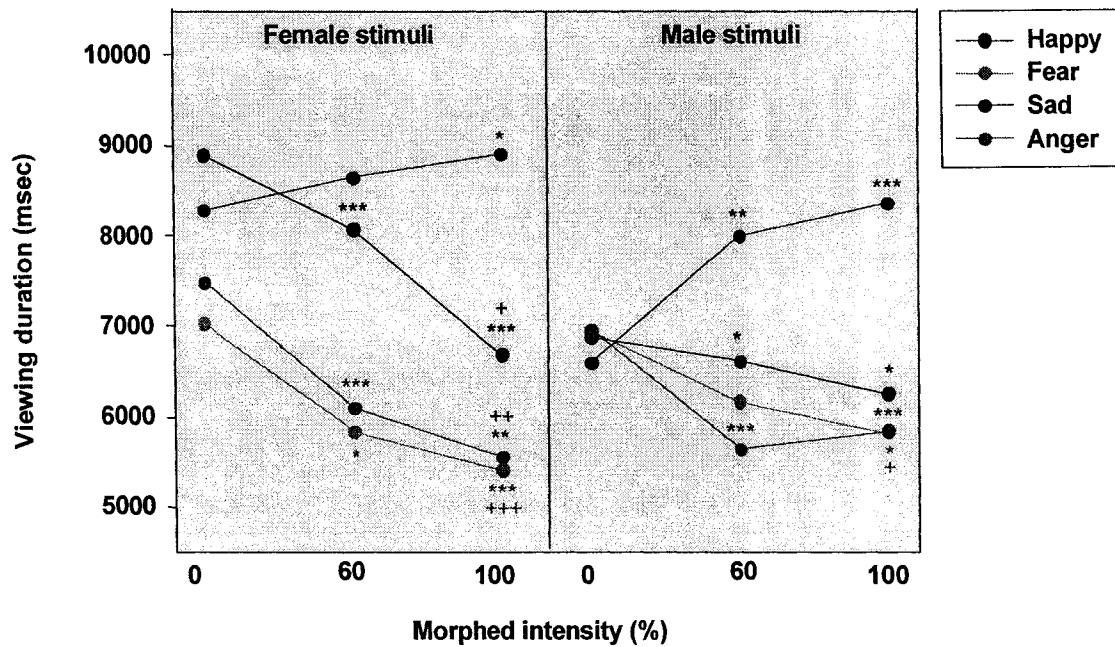
Figure 20. Total viewing duration compared for female and male stimuli, combined sample (n=19).
Significant change from viewing duration at 0% intensity:*p<0.05;**p<0.01;***p<0.005
Significant change from viewing duration at 60% intensity: ⁺p<0.05;⁺⁺p<0.01;⁺⁺⁺p<0.005

The overall RMANOVA showed a significant main effect of stimulus sex and

interactions between stimulus sex and emotion and between stimulus sex and intensity

(Table 15.). There were differences in viewing duration for the female and male neutral

(0%) intensity stimuli (Figures 20. and 21.), with subjects viewing female stimuli from

80

the happy and sad stimulus sets for significantly longer than male faces from the happy

and sad stimulus sets, respectively.

Factor	F	df	p-value
Emotion	15.6	3,54*	.000
Intensity	18.9	2,36	.000
Emotion x Intensity	10.9	6,108*	.000
Stimulus Sex	33.0	1,18	.000
Stimulus Sex x Emotion	13.1	3,54*	.000
Stimulus Sex x Intensity	11.7	2,36	.000
Stimulus Sex x Emotion x Intensity	1.4	6,108*	.245

*Greenhouse-Geisser corrected significance

Table 15. RMANOVA (within factors = Emotion, Intensity, Stimulus Sex) of total

viewing durations in the combined sample (n=19).

Figure 21. Total viewing duration for the neutral (0% intensity) stimuli from the female
and male stimulus sets. Combined subject sample (n=19).
Significant difference between viewing durations for female and male stimuli,
***p<0.005.

81

In addition to baseline differences for the neutral stimuli, stimulus sex also affected how viewing time changed with emotional expression intensity. An RMANOVA of changes in viewing time from baseline showed a significant main effect of stimulus sex and a significant interaction of stimulus sex with intensity (Table 16.).

Factor	F	df	p-value
Emotion	12.1	3,54*	.000
Intensity	18.9	2,36	.000
Emotion x Intensity	10.9	6,108*	.000
Stimulus Sex	12.2	1,18	.003
Stimulus Sex x Emotion	1.0	3,54	.396
Stimulus Sex x Intensity	11.7	2,36	.000
Stimulus Sex x Emotion x Intensity	1.4	6,108	.223

*Greenhouse-Geisser corrected significance

Table 16. RMANOVA (within factors = Emotion, Intensity, Stimulus Sex) of changes in total viewing durations from those for the 0% intensity stimuli in the combined sample (n=19).

Comparisons of change in viewing duration with stimulus intensity between female and male stimuli showed significant effects (Stimulus Sex x Intensity) for fear expressions (Figure 23., Table 18.) and for anger expressions (Fig. 25., Table 20.).
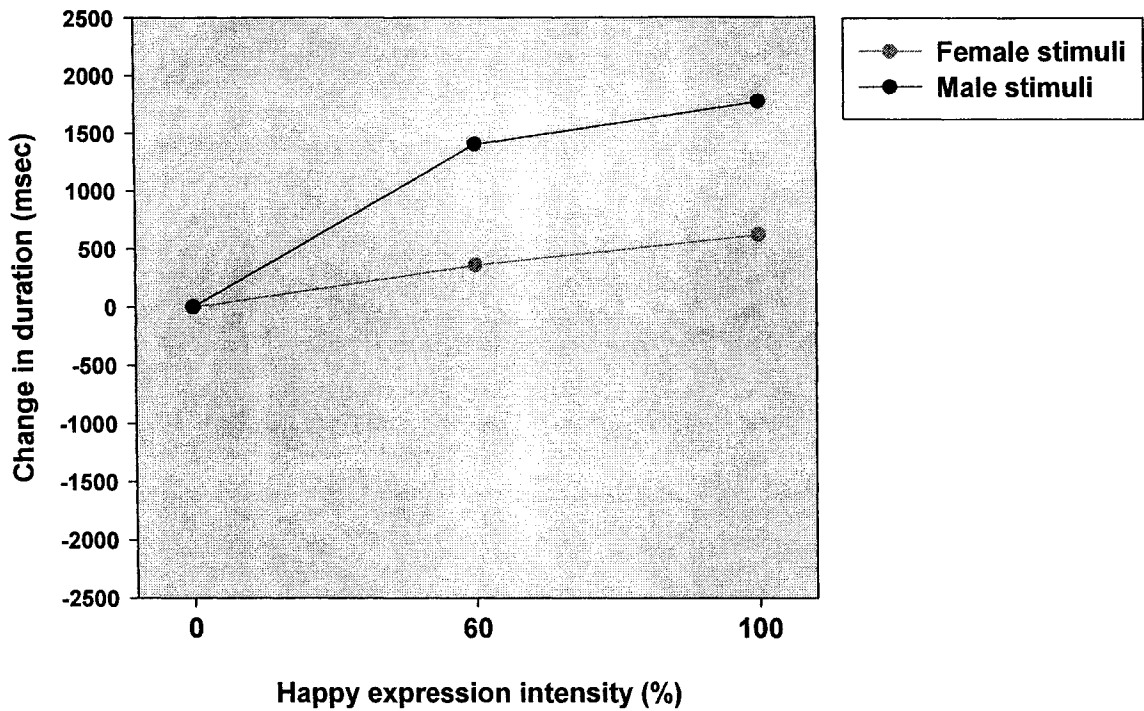
Figure 22. Change in viewing duration with increasing happy expression intensity for female and male stimuli, combined sample (n=19).

Factor	F	df	p-value
Intensity	9.6	2,36	.066
Stimulus Sex	3.8	1,18*	.002
Stimulus Sex x Intensity	2.7	2,36	.079

*Greenhouse-Geisser corrected significance

Table 17. Happy expressions. RMANOVA (within factors = Intensity, Stimulus Sex) of changes in total viewing duration from those for the 0% intensity stimuli, combined sample (n=19).
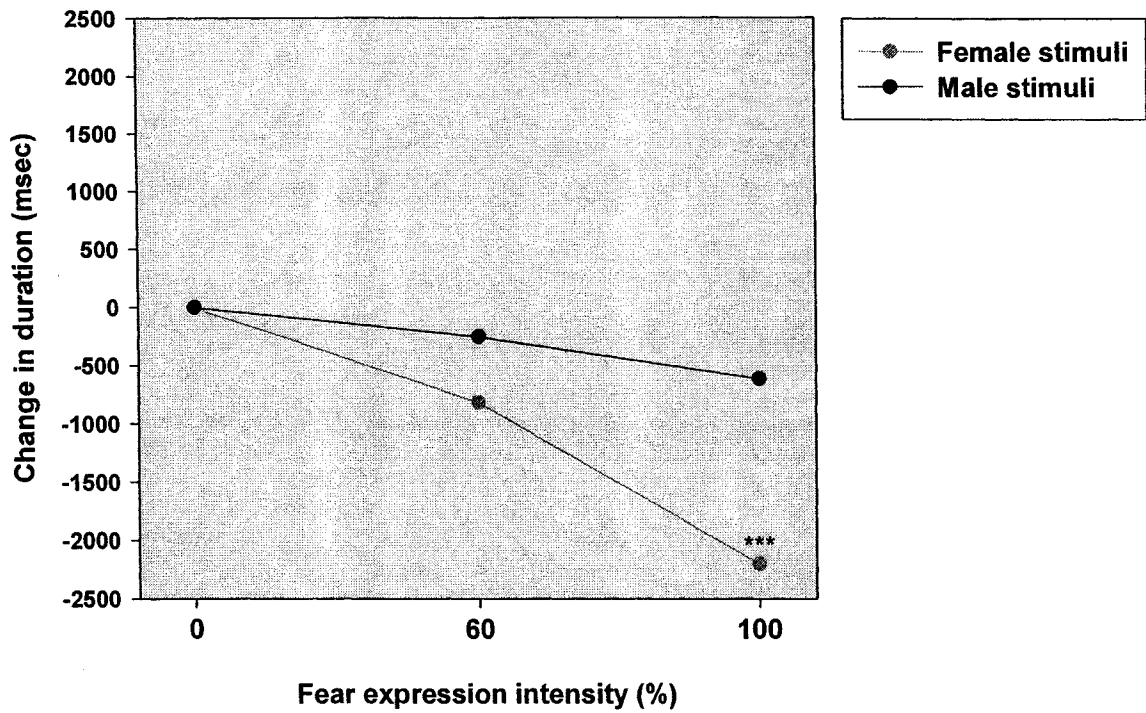
Figure 23. Change in viewing duration with increasing fear intensity for female and male stimuli, combined sample (n=19). Significant difference between female and male stimuli: ***p<0.005.

Factor	F	df	p-value
Intensity	12.7	2,36	.002
Stimulus Sex	11.5	1,18	.000
Stimulus Sex x Intensity	9.7	2,36	.000

*Greenhouse-Geisser corrected significance

Table 18. Fear expressions. RMANOVA (within factors = Intensity, Stimulus Sex) of

changes in total viewing duration from those for the 0% intensity stimuli, combined

sample (n=19).

84
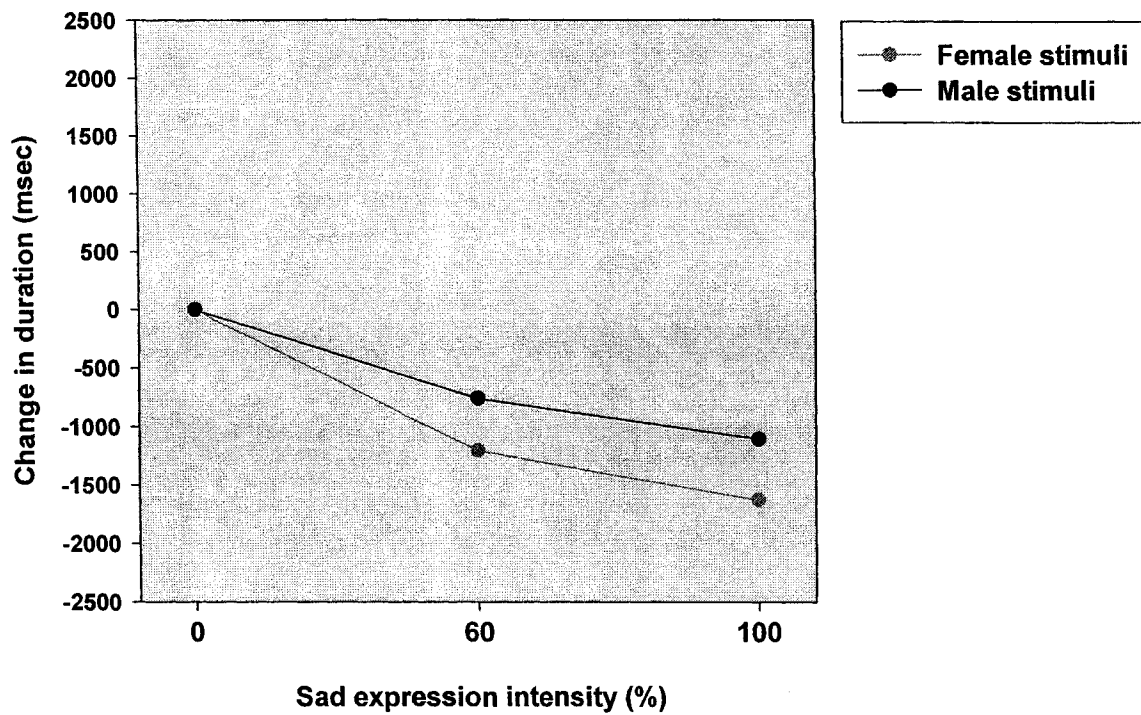
Figure 24. Change in viewing duration with increasing sad expression intensity for female and male stimuli, combined sample (n=19).

Factor	F	df	p-value
Intensity	2.0	2,36	.177
Stimulus Sex	15.4	1,18	.000
Stimulus Sex x Intensity	1.5	2,36*	.232

*Greenhouse-Geisser corrected significance

Table 19. Sad expressions. RMANOVA (within factors = Intensity, Stimulus Sex) of changes in total viewing duration from those for the 0% intensity stimuli, combined sample (n=19).
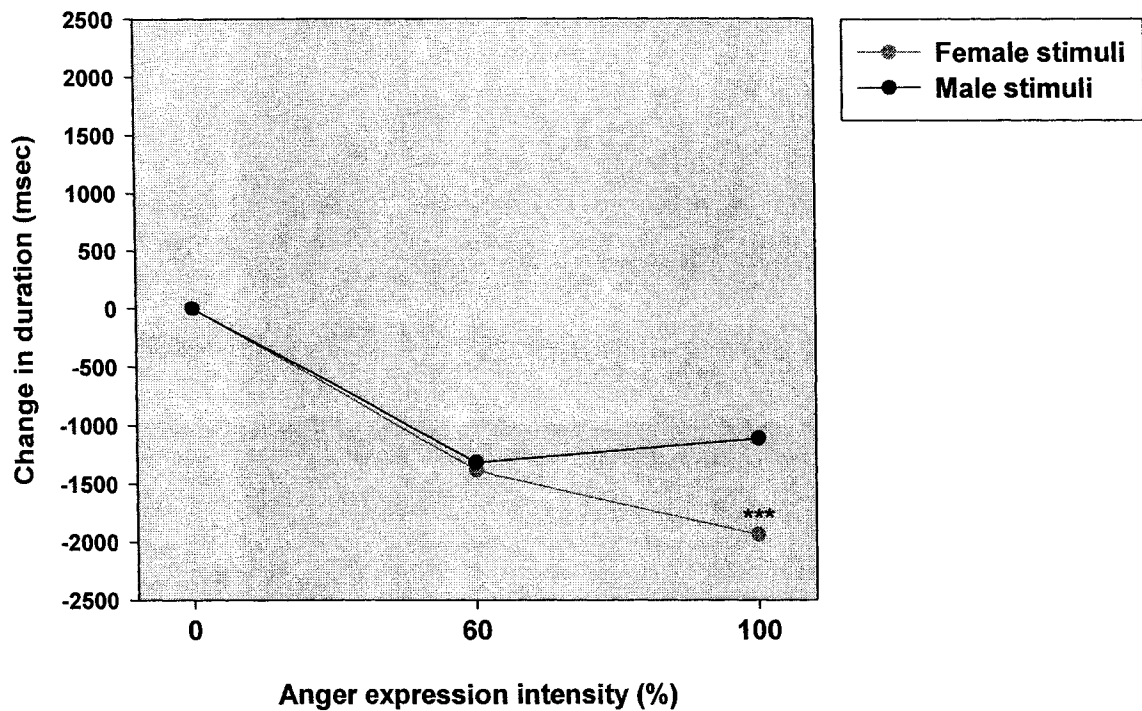
Figure 25. Change in viewing duration with increasing anger intensity for female and male stimuli. Combined sample (n=19). Significant difference between female and male stimuli: ***p<0.005.

Factor	F	df	p-value
Intensity	3.4	2,36	.083
Stimulus Sex	13.7	1,18*	.001
Stimulus Sex x Intensity	5.6	2,36	.008

*Greenhouse-Geisser corrected significance

Table 20. Anger expressions. RMANOVA (within factors = Intensity, Stimulus Sex) of

changes in total viewing duration from those for the 0% intensity stimuli. Combined

sample (n=19).

86

7.7. TIME ADDED TO VIEWING DURATION

Total viewing duration can be modified by adding time or subtracting time. It was predicted that subjects would add viewing time for the positive, happy expressions, whereas viewing time would be subtracted from the negative expressions.

The analysis of added time showed a significant emotion x intensity interaction (Table 21.). Subjects added significant additional time to view the 60% happy expressions and further additional time to view the 100% happy expressions (Table 22., and Figure 26.). Subjects also stopped adding time to view stimuli from the sad expression set as intensity increased, with a significant reduction in added time at 100% intensity. For fear and anger expressions, increasing intensity did not significantly alter time added. Time added at baseline (0% intensity) was significantly greater for the sad expression stimulus set than for the happy ($p = 0.011$) and fear ($p = 0.002$) stimulus sets, and was not significantly ($p = 0.058$) longer than for the anger stimulus set. The negative expression stimuli no longer showed significant differences in time added at 100% intensity, at which point time added tended towards zero.

87
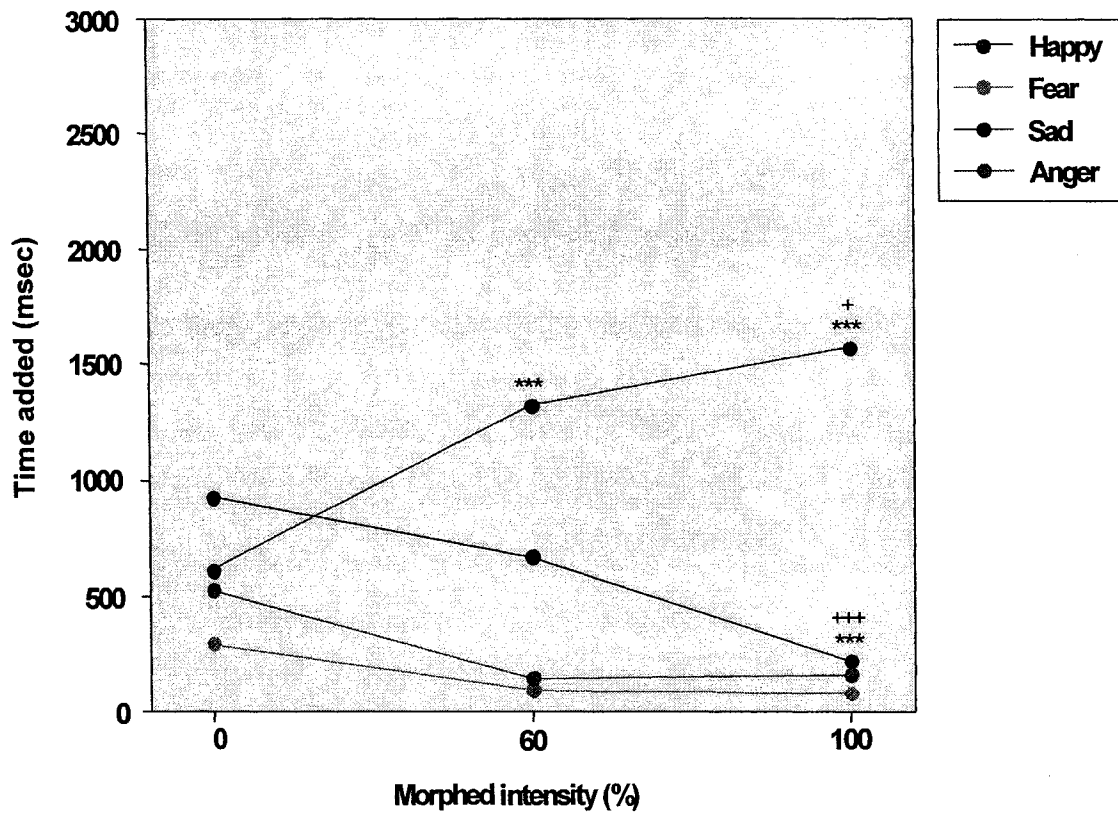
Figure 26. Time added to total viewing duration, combined sample (n=19).
Significant changes from time added at 0% intensity: ***p<0.005.
Significant changes from time added at 60% intensity: $^+$p<0.05;$^{+++}$p<0.005.

Factor	F	Df	p-value
Emotion	8.4	3,54*	.000
Intensity	0.8	2,36*	.467
Emotion x Intensity	8.5	6,108*	.000

*Greenhouse-Geisser
corrected significance

Table 21. RMANOVA (within factors = Emotion, Intensity) of time added to total
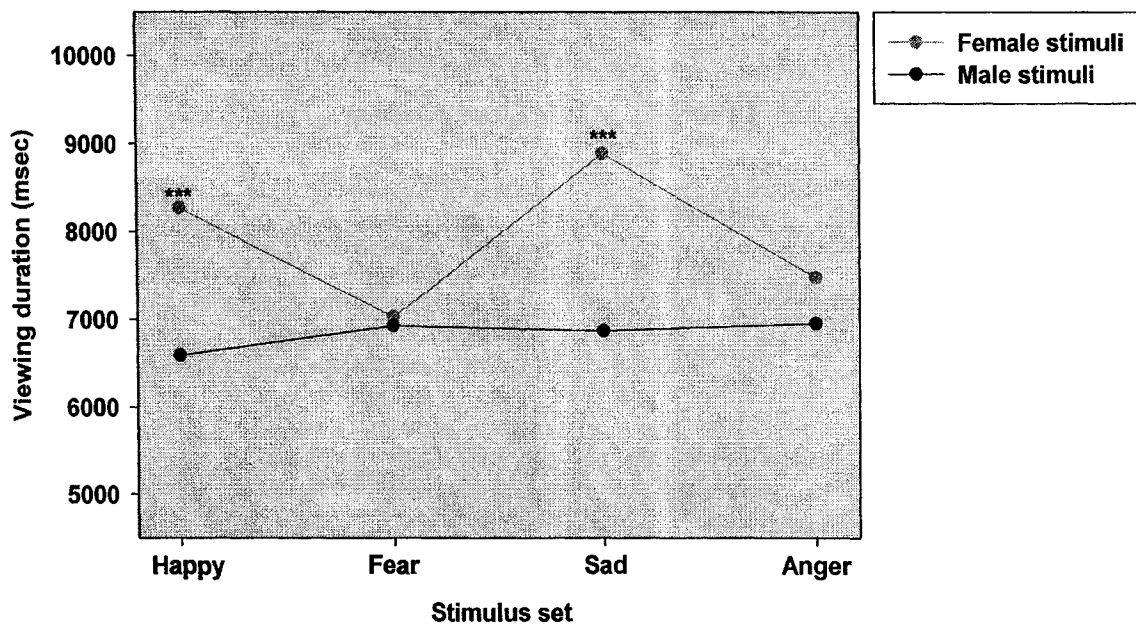
viewing duration, combined sample (n=19).

88

Emotion	F	Df	p-value
Happy	12.2	2,36*	.000
Fear	2.1	2,36*	.137
Sad	7.5	2,36	.002
Anger	3.2	3,36*	.053

*Greenhouse-Geisser corrected significance

Table 22. RMANOVAs (within factor = Intensity) comparing time added to total viewing duration across different intensities (0%, 60% and 100%) for each individual emotion. Combined sample (n=19).

7.8. TIME SUBTRACTED FROM VIEWING DURATION

It was predicted that subjects would subtract viewing time from the negative expressions. The overall RMANOVA showed a significant emotion x intensity interaction (Table 23.), and the RMANOVAs for the individual emotions showed significant effects only for the negative expressions, and not for happy expressions (Table 24.). For all of the negative expressions, significantly more time was subtracted at 60% and at 100% intensity than at baseline (0% intensity). Increasing intensity from 60% to 100% also increased the amount of time subtracted (Figure 27.).

89
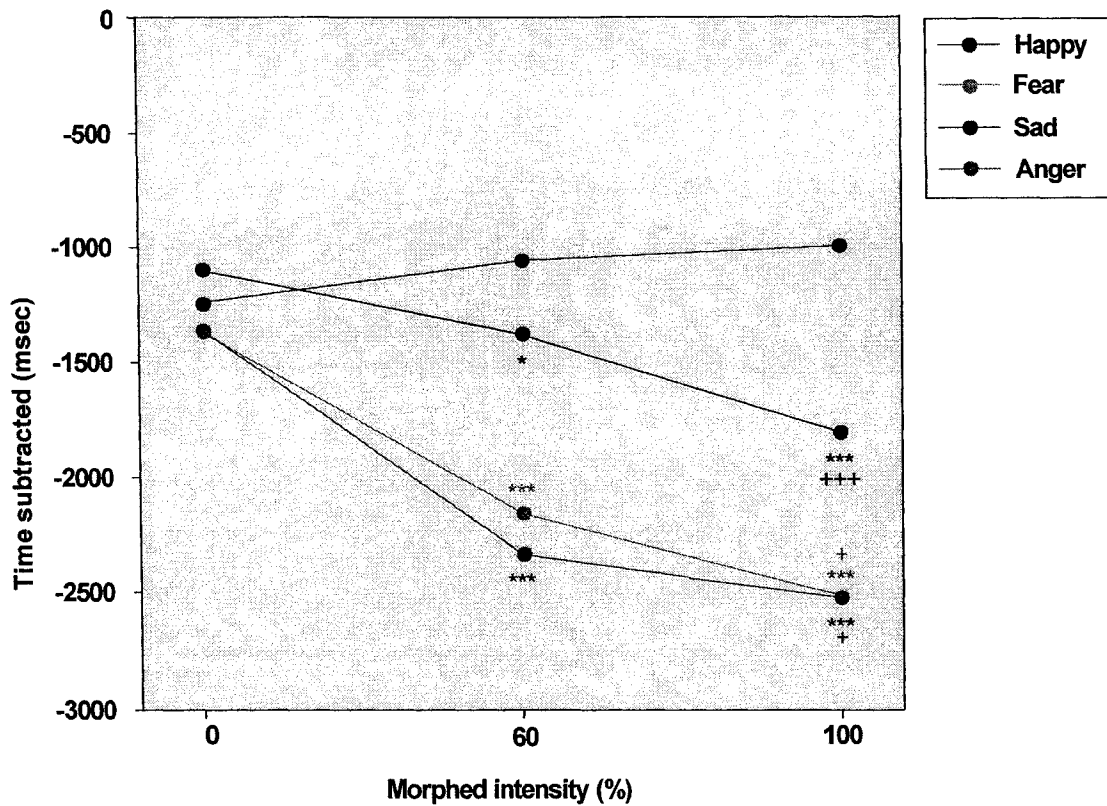
Figure 27. Time subtracted from total viewing duration, combined sample (n=19).
Significant change from time subtracted at 0% intensity: *p<0.05;***p<0.005.
Significant change from time subtracted at 60% intensity: +p<0.05;+++p<0.005.

Factor	F	Df	p-value
Emotion	20.7	3,54*	.000
Intensity	27.8	2,36*	.000
Emotion x Intensity	9.9	6,108*	.000

*Greenhouse-Geisser corrected significance

Table 23. RMANOVA (within factors = Emotion, Intensity) of time subtracted from

total viewing duration, combined sample (n=19).

90

Emotion	F	Df	p-value
Happy	2.3	2,36	.114
Fear	19.7	2,36	.000
Sad	10.7	2,36	.000
Anger	19.6	3,36*	.000

*Greenhouse-Geisser
corrected significance

Table 24. RMANOVAs (within factor = Intensity) comparing time subtracted from total viewing duration across different intensities (0%, 60% and 100%) for each individual emotion. Combined sample (n=19).

7.9. BASELINE DIFFERENCES FOR NEUTRAL STIMULI

In most analyses there are baseline differences between the emotional stimulus sets for the neutral (0% intensity) stimuli. For the sad expression stimulus set, the total viewing duration and added time are greater than for the other stimulus sets (e.g. Figures 16 and 26.).

One reason for these baseline differences could be facial attractiveness. A separate group of 14 young healthy Caucasian adults was therefore asked to rate each of the neutral (0% intensity) stimuli on a Visual Analogue Scale (0-100mm), with 0 = least and 100 = most attractive. They were asked to rate how they thought people would generally judge the appearance of each face.

The RMANOVA showed significant effects of Emotion (i.e. which set the image came from, not what emotion was displayed for these neutral images), Stimulus Sex and an Emotion x Stimulus Sex interaction (Table 25.).

91

Factor	F	Df	p-value
Emotion	31.6	3,39	.000
Intensity	8.6	1,13	.012
Emotion x Intensity	6.7	3,39	.001

Table 25. RMANOVA (within factors = Emotion Set, Stimulus Sex) of Visual Analogue

Scale attractiveness ratings. Independent sample of healthy subjects (n=14).

Faces from the sad stimulus set were judged to be significantly more attractive than those

from the other three sets, which did not differ from each other. This finding parallels the

findings for total viewing duration in the combined sample, in which baseline viewing

duration was significantly longer for the sad stimulus set than for the other three sets,

which did not differ from each other (see Figures. 18.,and 28.).

8500

8000

Viewing duration (msec)

7500

7000

6500

50

VAS attractiveness (mm)

45

40

35

30

Happy ●
Fear ●
Sad ●
Anger ●
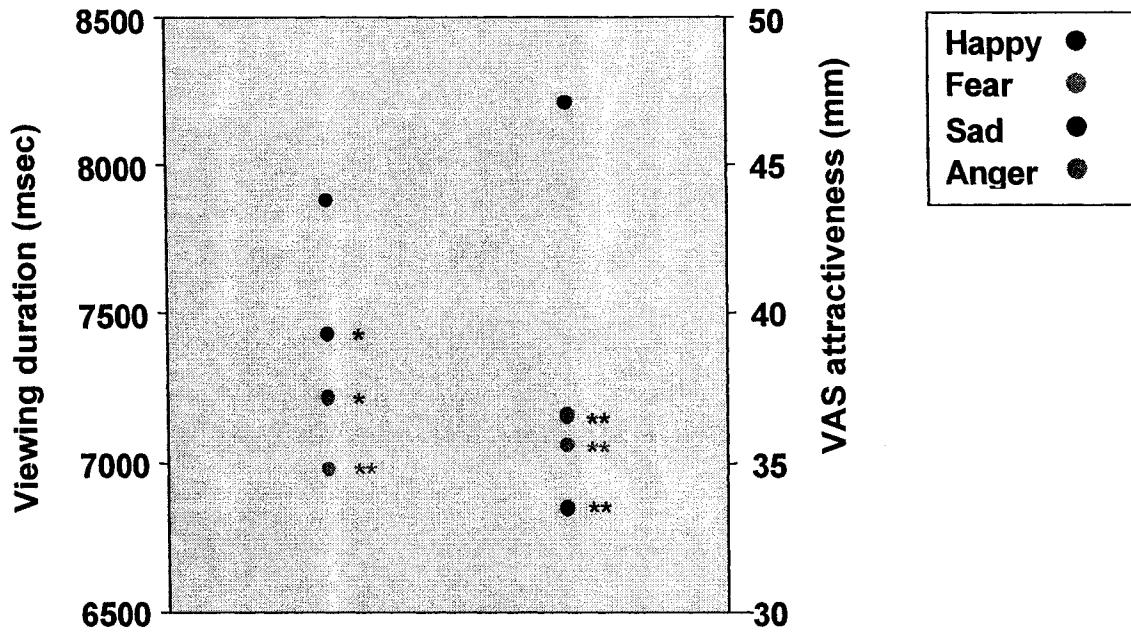
Figure 28. Left column and axis: total viewing duration for the neutral (0% intensity) stimuli from the four facial emotion sets in the combined sample (n=19).
Right column and axis, judgments of facial attractiveness of the neutral (0% intensity) stimuli from the four facial emotion sets, made by an independent sample of healthy subjects (n=14).
Significantly different from sad expression set, *p<0.05; **p<0.001.

Female faces were judged significantly more attractive than males overall, although the magnitude of this difference was small (Table 26.). The difference mainly derived from the female happy and anger face sets, which showed significantly higher attractiveness ratings than the male sets. There were no significant differences between the female and male sets for fear and sad faces. These differences do not clearly explain differences in baseline viewing duration between sexes, which were greatest for the happy and sad stimulus sets, rather than the happy and anger sets.

93

Stimuli	Mean	SD	T	df	P
hf0	37.3	12.6	2.213	13	.045
hm0	29.6	14.9			
ff0	33.2	15.3	-1.985	13	.069
fm0	37.8	12.3			
sf0	46.9	12.9	-.190	13	.852
sm0	47.2	10.0			
af0	41.6	11.8	4.471	13	.001
am0	31.4	15.2			
female	39.7	12.2	2.930	13	.012
male	36.5	11.9			

Table 26. Descriptive statistics and paired t tests comparing VAS attractiveness ratings between female and male stimuli. Independent sample (n=14).

CHAPTER 8   *DISCUSSION*

8.1   MAIN FINDINGS OF THE STUDY

The main findings of this study were, first, that subjects viewed positive emotional

expressions (happy faces) for longer durations, and each of the negative emotions (anger,

fear, sadness) for shorter durations than neutral expressions shown by the same actors

(see 7.1., 7.2. and 7.4.). Second, the extent to which subjects increased viewing durations

for positive expressions or decreased viewing durations for negative expressions varied

with the morphed intensity of the expressed emotion (see 7.4.). Third, subjects mainly

tended to add time to the viewing durations for positive expressions and to subtract time

from the viewing durations for negative expressions (see 7.7. and 7.8.), with minor

exceptions. Fourth, the sex of the stimulus pictures, or possibly associated factors,

influenced viewing durations, but the gender of the subjects viewing the stimuli did not

(see 7.5. and 7.6.). Fifth, there were some baseline variations in viewing duration (of the

neutral, 0% intensity stimuli) between the different emotional stimulus sets, which may in

part have been influenced by facial attractiveness.

95

8.2. TOTAL VIEWING DURATION

The main results on total viewing duration were obtained by combining the data from two subject groups performing two slightly different experiments, with the second group exposed to additional stimuli at 30% morphed intensity. For both subject groups, the analyses showed significant emotion x intensity interactions. However, for the second group, there were no significant effects associated with the 30% intensity stimuli. When these were removed from the data set, comparisons between the first and second subject groups showed no group x emotion, group x intensity or group x emotion x intensity interactions. These data showed that both subject groups responded to increasing positive and negative emotional expressions in the same way. There was a significant group effect, with the second group viewing stimuli overall for shorter periods. Analysis of the viewing durations for individual subjects suggested that although the second group viewed the baseline stimuli for shorter durations on average, the distribution of viewing durations was strongly overlapping and if the samples were combined, the viewing durations were normally distributed. Although it appeared on this basis that the data from the two experiments could reasonably be combined for subsequent analyses, the findings from these combined analyses should be seen as preliminary. The differences between the two groups could simply have arisen from sampling error, given the small sample sizes, but viewing durations for the second group might also have been shorter because they had to view more stimuli.

96

For the combined sample, the analysis of the emotion x intensity interaction confirmed the main prediction that the valence and intensity of emotions would influence viewing durations. Post hoc tests showed increasing effects of stimulus intensity for happy, fear and sad expressions. For anger expressions there may have been a floor effect: viewing durations did not decrease to a significantly greater extent with the increase in stimulus intensity from 60% to 100% (7.4.). In the analysis of time subtracted (see below) there was a significant effect of increasing anger expressions from 60 to 100%, which suggests that the different measures have somewhat different sensitivities. If the key-press rate is taken as a measure of motivation, operationalized as the work or effort that subjects are willing to expend to increase or decrease viewing durations, then emotional valence and intensity both influenced motivation.

If the valence and intensity of emotional expression had been the only factors to affect viewing durations, it would have been predicted that viewing durations for the neutral stimuli would be the same across all stimuli. This was not the case. One possible explanation for these baseline differences could be that the neutral stimuli were not completely neutral and that the actors showed slight positive or negative expressions in the supposedly neutral stimuli. This explanation cannot be ruled out, because a limitation of the stimulus materials used is that emotional type and intensity ratings of the neutral stimuli have not been reported, in contrast to the numerous studies reporting on ratings of the full emotional expressions. Another possible explanation for the baseline differences is that the stimuli may have varied in facial attractiveness. This was supported by the finding that the faces from the sad expression set, which were viewed for the longest

97

durations at baseline intensity, were also judged to be significantly more attractive than the other stimuli by an independent group of raters. On average, the subjects tended to subtract some time from the viewing durations for the baseline stimuli (7.8.), which were viewed for less than 8,000 msec, which is the default viewing duration (7.4., 7.9.). It can be speculated that this might be related to the finding that the mean VAS attractiveness ratings for the baseline stimuli were below 40 mm, on a scale where 50 mm represents average attractiveness. Some raters commented spontaneously that the appearance and style, for example hairstyles, of the actors were old fashioned and unattractive. An alternative explanation could be that to direct gaze at someone whilst making a completely neutral expression can be interpreted as being hostile: social contacts are usually facilitated by smiles (Phillips et al., 1997). However, in a recent study, Strauss et al. (2005) also showed that subjects reduced viewing durations for neutral faces on a similar keypress task, but did not rate the faces as being unpleasant, threatening or anxiety-provoking. This suggests that neutral faces are not consciously interpreted as being hostile.

There are limitations in the method used to assess whether facial attractiveness might have influenced responses. The main limitation is that asking independent raters to estimate the general attractiveness of the stimuli to others does not account for the individual preferences of the subjects who were participating in the key-press task. However, for this initial study it was preferred to make attractiveness ratings and key-press responses independent, in case making one type of response or viewing the faces with emotional expressions would subsequently influence the other type of response.

These relationships can be tested experimentally in future studies. A second limitation is that ratings of facial attractiveness might have been influenced by mild intensity emotional expressions in the neutral stimuli, as well as by facial features. The relative importance of these two different factors was not assessed, and both should be rated in future studies.

8.3. ADDED & SUBTRACTED TIME

The hypotheses were that subjects would add time to view positive and subtract time to view negative expressions. These predictions were largely supported, with two exceptions. The first is that for sad faces, subjects had added time to the viewing durations at baseline, but stopped adding time as the intensity of sad expressions increased above baseline (7.7.). This latter effect appeared potentially to be explained again by differences in attractiveness for the baseline stimuli, since the actors in the sad expressions set were also judged to be more attractive than those in the other stimulus sets (7.9.). The second is that subjects did subtract time from the 60-100% happy stimuli (7.8.). However, this appeared to be a baseline effect, since the amount of time subtracted did not change significantly as the intensity of happy expressions increased. With these exceptions, the data supported the hypothesis that positive and negative expressions both engage active effort, as assessed by the work involved in key-pressing, rather than passive avoidance. Subjects worked to add viewing time to the positive expressions and also worked to subtract time from the negative expressions. Furthermore, in both cases,

99

the degree of effort, as measured by key-pressing, was related to the emotional stimulus intensity.

8.4.   SUBJECT GENDER & STIMULUS SEX

In the analysis of total viewing durations in relation to the subject gender of the study participants, there was no significant main effect of subject gender and no significant 2 or 3-way interactions. However, although there were no differences between subject gender groups, the sample size for this comparison was very small, only 8 males and 11 females, which limits generalizability of the findings. Studies designed specifically to assess subject gender effects in larger, representative samples are required to address this.

In contrast to the gender of the study participants, the sex of the actors in the stimuli exerted significant effects on viewing durations. There were significant main effects of stimulus sex and significant stimulus sex x emotion and stimulus sex x intensity interactions. There was a clear baseline effect, with female stimuli in the happy and sad stimulus sets being viewed for longer. Stimulus sex also influenced the degree to which viewing time decreased with emotion intensity for fear and anger expressions, with a greater decrease in viewing times for female than male stimuli. This could not be explained by ceiling or floor effects, because the baseline viewing durations for these two emotional stimulus sets did not differ. This finding, however, was not hypothesis-driven and resulted from an exploratory analysis. It should be replicated before making interpretations.

100

8.5 ROLE OF POSITIVE & NEGATIVE AFFECT ON MOTIVATED BEHAVIOR

A great deal of research has been directed towards determining how emotions influence decision making (Loewwenstein & Lerner, 2003). It is generally agreed that when individuals are given choices associated with either positive and negative affect, they tend to opt for the choice with the greatest positive affect (Cabanac et al., 2002). The present study considerably extends this notion beyond decision making and preference to incentive and motivation. Subjects' different preferences for positive and negative expressions led to differences in approach (viewing positive stimuli longer) or avoidance (viewing negative stimuli less). Furthermore, subjects expended effort, in terms of key-pressing, both to approach or avoid stimuli, i.e., avoidance was active, rather than passive. Finally, the amount of effort expended was related to the intensity of the emotional stimulus. The key-press task therefore appears to be a useful addition to methods available to assess preference and motivation.

Other recent research has demonstrated that positive affect may act as an implicit motivator on the unconscious operation of behavioural goals (Custers & Aarts, 2005). In those studies, presentation of positive, negative or neutrally valenced words, in association with phrases describing behavioural goals, influenced the effort that participants would expend subsequently to achieve those goals. The measure of effort was the rate at which subjects would click a mouse in order to be able to reach the

behavioural goal more quickly under time pressure. These effects were present to a similar degree when the affective words were presented subliminally at very short duration as when they were presented supraliminaly and subjects were conscious of the associations. In the present study, stimuli were presented for long periods, such that subjects would be aware of the contingencies, although subjective awareness of wanting to approach or avoid stimuli was not assessed directly. In future studies, it would be possible to assess whether facial expressions can influence preferences and motivation at an unconscious level. This would require the repeated presentation of emotional faces at very short durations, whilst masked by the presentation of neutral expressions within the intervals. In prior neuroimaging studies, this type of masking approach has been used to show that subliminally presented fear faces activate the amygdala more than happy faces (Rauch et al., 2003, Williams et al.,2006).

The most comparable work to the present study is that reported by Strauss et al. (2005). Their investigation explored various responses to images of angry, happy, fearful and neutral faces, including a rating procedure (bipolar visual analogue scale) and a similar keypress paradigm. Of the four emotion sets, only the happy expressions elicited positive ratings of pleasantness versus unpleasantness, comfort versus threat, and relaxation versus anxiety. The happy expressions led subjects to work to increase their viewing duration on the keypress task. The negative expressions of anger and fear were judged to be significantly more unpleasant, threatening and anxiety provoking, and led subjects to decrease their viewing durations on the keypress task. Ratings for the neutral faces did not differ significantly from the mid-points of the scales for pleasantness, comfort and

102

relaxation. However, despite these neutral evaluations, subjects significantly decreased viewing time for the neutral faces from the default 8,000 msec, which is similar to the finding in our present study. Whatever factors influenced this decrease in viewing time, it was not captured by the VAS ratings. Neither attractiveness nor low intensity emotional expressions in the neutral stimuli were specifically evaluated, however.

There were several differences between the keypress paradigm used in the Strauss et al study and that employed in the present study. First, the images chosen were black and white photographs from the Ekman and Friesen (1976) "Pictures of Facial Affect" series, in which each of the four types of expression was expressed by the same eight actors. This approach has the advantage of preventing baseline differences in viewing time for different emotions, since each emotion has the same neutral baseline. A possible disadvantage would be if repetitive exposure to the same actors led to decreasing motivation over time. However, when the task was repeated for a second time, the only stimuli for which viewing time decreased on the second occasion, compared with the first, was for anger expressions. This argues against a generalized reduction in motivation to view the images with repetitive exposure. The images included only full emotional expression and were therefore not able to assess the intensity that was shown using morphed images as in the present study. Second, the parameters for the key-press response were set differently, with a similar default duration of 8,000 msec, but different extreme times of zero and 16,000 msec. The effect of this would be to produce greater changes in viewing duration for the same key-press rate as in the present study. One potential disadvantage of this would be to increase the discrepancy between the amount

103

of work that subjects have to expend for approached and avoided images. Since the amount of work (total keypresses) is the product of the rate of work and the duration, subjects have to expend more work to view approached images, which stay on the screen longer, than they do to view the avoided images. This may be counterbalanced by more negative stimuli being included in the tasks than positive stimuli, but the effects of these discrepancies in work between the different stimuli have not been evaluated in detail. A third difference was that the effects of keypresses in the present study were set relative to the participants' maximal keypress rates, in contrast to the Strauss et al study, where absolute keypress rates were used. The disadvantage of the latter approach is that individual differences in maximal keypress rates would lead subjects to be on different parts of the keypress-response slope. Since the latter slope is exponential, then they would have to work at different rates to produce the same effect. Overall, the present study replicates the basic findings of Strauss et al (2005) and extends them to show negatively reinforcing effects of sad faces and motivational effects of increasing emotional intensity.

8.6 ATTRACTIVENESS & KEYPRESS RESPONSES

As described in the RESULTS section, there were significant differences between some of the stimulus sets with regard to baseline viewing durations, with faces from the sad set being viewed for longer durations at baseline than those from the other stimulus sets. Faces from this group were judged to be significantly more attractive than faces from the other stimulus sets by an independent set of raters. In previous related work using the

104

keypress task, Aharon et al (2001) have shown that healthy male volunteers will work to view images of female attractive faces significantly more than they will work to view images of less attractive males or females, or similarly attractive males. Furthermore, viewing the same images during a fMRI experiment led to activation of the ventral striatum, a brain region that is strongly associated with reward and motivation in animal studies (Aharon et al., 2001). Given that male participants responded differently on the keypress task to male and female faces that they rated as similarly attractive, Aharon et al, (2001) suggested that the findings distinguish preferences (expressed as aesthetic judgements) from reward (expressed as the amount of effort or work expended to view the stimuli). Given that effort was measured, motivation or incentive motivation might be a better term than reward. Similar analyses could not be made for the present data set, since we did not counterbalance the neutral baseline stimuli across sexes for levels of attractiveness, nor did we obtain VAS ratings of attractiveness for the stimuli from the participants in the keypress task.

Using the same stimuli and keypress task as Aharon et al (2001), Elman et al. (2005) probed reward function in posttraumatic stress disorder (PTSD). Male heterosexual war veterans with and without current PTSD were asked to rate images of males and females and to respond to the images using the keypress paradigm. There were no significant group differences in the attractiveness ratings; however, PTSD patients expended less effort to extend the viewing duration of the beautiful female faces. This suggested a possible reward deficit in PTSD (Elman et al., 2005). In the absence of negatively valenced stimuli, however, it could also be explained by impaired motivation irrespective

105

of valence. Furthermore, the control subjects had 50% higher keypress numbers during the task than the PTSD patients, raising the possibility that maximal keypress rates may have differed between the groups. Despite these limitations, these initial findings in PTSD suggest that the keypress paradigm may be useful in the experimental assessment of alterations in motivation in patient populations.

8.7. FACTORS WHICH INFLUENCE ATTRACTIVENESS

8.7.1 What is Attractive?

The study of facial attractiveness has been of increased interest to modern researchers of late. Much of this can be credited to the advancements in technology and computer graphics, which allow researchers to objectively investigate features of attractive faces. Averageness, symmetry and sex-specific traits have all been associated with attractiveness (Cellerino, 2003). The chimeric face task consists of faces with two halves that differ in various parameters, and typically when blended the composite is rated more attractive then most of the faces used to create it, exemplifying the effect of averageness (Cellerino, 2003). Average faces do not, however, directly equate to beautiful faces. If the female-specific features of a female face composite are enhanced, the resulting face is perceived as more attractive than the composite (Cellerino, 2003). Traits associated with female attractiveness tend to be higher forehead, smaller nose, and smaller chin, all of which are traits that are also associated with a favourable estrogen/testosterone ratio and possible clues of fertility (Cellerino, 2003). In general, female preferences for male faces

106

tend to be more variable than male preferences for female faces, and different facial traits

are preferred depending on the sexual goals (short vs long-term partners) of the rater

(Little et al., 2002). Preferences for short-term relationships are influenced by hormonal

status and changes across the menstrual cycle (See 7.7.3) and these preferences can be

altered by contraceptives and hormonal treatment (Little et al., 2002). Other

psychological factors such as self-perceived attractiveness and status in the relationship

have also proven influential in attractiveness preferences (Little et al., 2002).

8.7.2 Gaze and Attractiveness

Recent research has implicated gaze direction as a possible mediator of face preference.

Knut et al. (2001), through the use of fMRI and facial images, demonstrated that the

ventral striatum processes reinforcing stimuli and is involved in the evaluation of stimuli

with relevance to social interactions. Activation of this region was found when subjects

viewed images of attractive female faces where the gaze of the image was not averted,

but oriented directly at the subject. Based on the primate work of Schulz and colleagues

(1997), Knut et al. (2001) suggested that the activity of dopaminergic neurons that project

to the ventral striatum is associated with reward prediction and that the firing rate of those

neurons follow a specific pattern, increasing when an unexpected reward is seen and

decreasing when an expected reward fails to materialize, thereby predicting error in

future rewards. Knut et al. (2001) found no ventral striatal activation associated with

attractiveness per se, but only as an interaction with eye gaze. Knut et al. (2001) contend

that, assuming the dimension of attractiveness is rewarding, especially when social

107

interaction is initiated, returned eye gaze from an attractive face represents a more

favourable result, leading to enhanced responses, whereas failing to make eye contact

with an attractive face may be a disappointing outcome leading to reduced activity in the

dopaminergic target system. Conversely, eye contact from an unattractive face may be

disappointing and less rewarding, whereas missing eye contact with an unattractive face

may be a relief, and more rewarding, thus resulting in enhanced activity (Knut et al.,

2001).

Jones et al. (2006) were able to demonstrate that expressions differentially qualify the

strength of attractiveness preferences for faces with direct and averted gaze.

Attractiveness preferences were stronger for faces with a direct gaze and a happy

expression compared to those for a neutral expression (Jones et al., 2006). For

judgements of faces with averted gaze, attractiveness ratings were higher for faces with

neutral expressions compared to happy ones. Jones et al. (2006) contend that because

expressions can differ in meaning depending on whether they are directed toward or away

from oneself, it is only through the integration of gaze direction, facial expressions and

physical attractiveness that one can best identify the most attractive individuals who are

likely to reciprocate one's own social interest. Gaze was not an independent variable in

this thesis, as the image set was constructed to have a direct gaze. The interactive effects

of emotional expression and gaze direction on motivation to view images would be an

interesting topic for future studies.

108

8.7.3 Menstrual Cycle and Attractiveness

The menstrual cycle has also been shown to alter face preference. In general women tend to show a preference towards slightly feminized male facial shapes. However, in the follicular phase, where the probability of conception is highest, women prefer more masculinized images. Research by Penton-Voak et al., (1999) showed that female preference for secondary sexual traits in male face shapes varied with the probability of conception across the menstrual cycle. Similar findings by Danel et al. (2006) showed that women assess males' facial attractiveness differently in the follicular and luteal phases. In general, during the high conception risk phase (follicular), women give higher scores to male faces than when they were in the luteal phase. This group also tested for anthropomorphic facial traits or indices that influence male attractiveness and found that ratings of attractiveness were correlated with mouth height (positively) and the angle between the middle of the mouth and the middle of the eyes (negatively) (Danel et al., 2006). Evidence also suggests that women's preference for attractiveness may be dependent on a combination of factors including sexual dimorphism in height with respect to their partner, their sexual strategy (short-versus long-term relationships) as well as their menstrual cycle, all of which vary depending on the phase that they are in (Pawlowski et al., 2005). No data were collected with respect to the menstrual cycle of the subjects in this thesis, and this could be addressed specifically in future studies.

109

8.8 INFLUENCE OF ATTRACTIVENESS ON MOTVATED BEHAVIOR

Motivation is not likely to be simply a function of the affect and attractiveness displayed in the images. Participant factors, including trait dispositions and short term goals during the test, will also influence motivation. For example, prior research has shown a dissociation between aesthetic and behavioural responses to attractive facial images. Positive aesthetic judgments alone are not enough to motivate someone to work for attainment of a goal. Simply put, just because one likes something does not necessarily mean they want it, or are willing to work for it.

Distinct neural populations are thought to code male and female faces (Little et al., 2005) and face perception has also been shown to be modified by sexual preference (Kranz & Ishai, 2006). Thus, motivation to view facial expressions may in part be dependent on the sexual orientation of the viewer. Response to facial feedback information is modulated by numerous factors such as emotion, attention, gender and sexual orientation. Kranz and Ishai (2006) had 40 heterosexual and homosexual men and women view photographs of male and female faces and rate their attractiveness, while being assessed via fMRI. Irrespective of their gender and sexual orientation, subjects had comparable ratings of facial attractiveness (Kranz & Ishai, 2006). Similar patterns of activation were found with respect to both subjects (in response to both male and female faces) within multiple, bilateral face-selective regions in the visual cortex, limbic system and prefrontal cortex.

110

There was, however, a significant interaction between stimulus gender and the sexual preference of the subject with regard to activation in the thalamus and medial orbitofrontal cortex. Heterosexual men and homosexual women responded more to female faces and heterosexual women and homosexual men responded more to male faces, suggesting that sexual preference may modulate face-evoked activation in reward circuitry (Kranz & Ishai, 2006).

Hofmann et al. (2006) studied sex differences in the recognition of human faces with different facial expressions by having participants learn to associate names with various male and female neutral faces. Participants were then asked, during the recall phase, to name the same person depicting the different emotional expressions of neutral, happy, angry and fearful (Hofmann et al. 2006). The results demonstrated that opposite-sex faces required less processing time and that all participants were faster at naming neutral or happy female faces (Hofmann et al. 2006).

Although the present study noted some differences in the viewing durations between baseline intensity male and female stimuli, the study was not designed to detect differences in motivation in response to stimulus sex as a major research hypothesis, which would require much more careful matching of stimulus sets on the basis of factors such as attractiveness or low level emotional expressions. The differences noted in response to female and male stimuli, and in response to changes in the intensity of these stimuli, and should therefore be seen as exploratory and preliminary. .

111

8.9. STRENGTHS & LIMITATIONS OF THE STUDY

The present study had both strengths and limitations. The main strengths were the use of well-validated emotional stimuli of graded intensity, the use of a behavioural paradigm that operationalizes motivation as effort expended to achieve a goal and that dissociates the components of valence and effort in measuring motivation. These design features enabled the study to be successful in supporting the main hypothesis that the valence and intensity of emotional expressions would both influence motivation to view pictures of faces. Furthermore, the task appeared to be relatively sensitive, with highly significant effects demonstrated with sample sizes on the order of 10 subjects. On this basis, the study achieved its initial goal to support the further development of the task as a probe of incentive and aversive motivation.

One major limitation of the study was that two experiments were performed, using different numbers of stimuli, from which the data were then combined. Although there was reasonable justification for this approach, the findings should be replicated in samples in which the test parameters are identical for all participants.

One difference between the positive and negative stimuli that has not been considered in detail is that motivation to add time to view positive stimuli leads to more work being expended overall than motivation to subtract time from negative stimuli. Whether or not

112

this influences responses should be explored by varying the response functions, to alter the amounts of added or subtracted time, and varying the relative numbers of stimuli.

The study did not assess explicit emotion recognition for the stimuli or subjective responses such as judgments of attractiveness or pleasantness, which would have enabled assessment of the relationships between the keypress measures and explicit awareness of motivational contingencies.

The study used stimuli in which only specific actors posed certain emotional expressions since they were selected from the original sample of photographs by Mastumoto and Ekman (1988) to have the most reliably rated examples of the expression. This could lead subjects to learn associations between specific actors and the emotional expressions shown, which might bias their perceptions of those actors' expressions (Little et al., 2005). However, if this were the case, it might be expected that subjects would have shown the highest preference and motivation to view the neutral faces from the happy expression set, whereas in fact, faces from the sad set were preferred. Using faces that posed every single expression could also lead to repetition effects, since repeated exposure even of a nonreinforced stimuli results in an increased preference for that stimulus i.e., the mere exposure effect (Robinson et al., 2005). In general, it appeared that to the extent any of these effects were present, they were only minor effects that were strongly outweighed by the designed effects of varying emotional expression type and intensity. A clear limitation of using different actors across expressions was the introduction of baseline differences in viewing duration, which in part appeared to relate

113

to differences in facial attractiveness. This could be addressed using stimuli in which each actor poses every expression, such as the Ekman and Friesen (1976) series, or in which the neutral stimuli are equated for attractiveness across groups. One reason why the Ekman and Friesen series continues to be used is that it fulfills this need, despite the photographs being black and white and old-fashioned in style and appearance. A further limitation of the Ekman and Friesen and Ekman and Matsumoto facial expressions series are that the expressions are achieved by posing specific muscle groups to match those of natural expressions. This has led to criticism that although the expressions are recognized reliably, there are differences from spontaneously occurring expressions, which might influence responses to them. Finally, the stimuli used are all static facial expressions, whereas emotional displays in day-to-day life are dynamic, multifaceted, with aspects of intonation, gestures, speech and expressions, and most importantly, they are presented within behavioural contexts. The construct of emotion recognition in simplified tasks and research settings, using static images devoid of contextual information, may not necessarily have external validity or apply to real world situations.

Ishi et al. (2005) investigated the differences between static and dynamic presentation modes on the perception and evaluation of smiling faces using computer-morphed animations of facial expressions. A main effect of presentation mode was *not* noticed during the emotion intensity ratings task (weak or strong smiles), but there were interactions between dynamic presentation, smile intensity and ratings of attractiveness (Ishi et al., 2005).

Although the above are all potential limitations of the study, it has to be recognized that producing new stimulus series, with full sets of highly reliably recognized expressions, particularly with spontaneously produced expressions or dynamic expressions, or with control for additional factors such as attractiveness, would represent a large and difficult undertaking. Nevertheless, considerable work has demonstrated that basic emotional expressions have universal common meanings. The stimulus set used in the study reported in this thesis appeared sufficient to address the main goals of producing effects on motivation that varied as a function of intensity and valence.

In all stimuli the actor's gaze was directed at the camera and therefore at the viewer as a target of the emotional expression. Although the findings have been interpreted as the motivational effects of emotional expressions, this should be more strictly limited to the motivational effects of emotional expressions directed targeted on the viewer. The same expressions with a different gaze may have different effects on motivation.

Although the study explored effects of the gender of the participating subjects, the sample size for these comparisons was small and non-representative, so that no interpretations should be drawn for more general populations. In addition, the study did not control for menstrual phase effects, which have been demonstrated to affect attractiveness ratings and may therefore in turn affect motivation to view different facial images.

115

CHAPTER 9   *CONCLUSION*

Facial expressions of emotion were found to have variable reward value. Positive emotions motivated subjects to view the images, whereas negative emotions motivated subjects to reduce the viewing duration of the images. In addition to effects of valence on motivation, different intensities of emotional expression were related to different degrees of motivation. Although not completely free of contamination by other effects, for example due to facial attractiveness, the designed effects were robustly detected in small samples of 10 subjects.

With further development, the key-press task may be a useful research tool in the assessment of motivational states in health and disease. The specific nature of the responses shown in the task need further clarification, as it is unclear as to whether or how these behaviours might generalize to external settings and social interactions. In this regard, studies might compare results on this task with other measures in disorders that involve altered motivation, in order to enhance the face validity and concurrent validity of the task.

116

CHAPTER 10   *REFERENCES*

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124

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125

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