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FACULTY OF MEDICINE, HEALTH AND LIFE SCIENCES

School of Psychology

Initial Perceiver Reaction to Facial Disfigurement

by

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ABSTRACT

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Ten experiments were designed to address the question of what response is elicited by facial disfigurement in the initial seconds of perception. The theoretical frameworks and methodology of attention to facial emotion was adopted to provide a framework in an under-researched area. Three different paradigms were utilised to determine whether or not the response to facial disfigurement mirrored the response to facial anger, and thus indicative of a threat response. Experiments 1 to 4 used the rapid serial visual presentation design, revealing the effect of faceness under temporal constraints. Specifically, these experiments showed that whilst angry faces exhibited a threat effect, disfigured faces did not. The exogenous cueing paradigm was then adopted in Experiments 5 - 9. These experiments demonstrated that angry faces elicited an aversion threat effect for high anxious. Again, however, no threat effect with disfigured faces was revealed. Finally, Experiment 10 revealed tentative evidence of a similar response to both angry and disfigured faces. Both faces elicited a fast response by participants when the image approached the perceiver compared to receding in an approach-avoid task. This thesis therefore provided an exploratory examination of initial responses and has indicated that disfigured faces elicited a similar response to angry faces but only under certain conditions. Whilst angry faces elicited an aversion response when presented both in the centre of fixation and in the periphery, disfigured faces appeared to elicit an avoidance response only when direct gaze was established. The underlying explanation for the similarities and differences are discussed in terms of a cognitive-evolutionary model in relation to physical and contamination threat responses.

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Author's Declaration

I, Tannaze Tinati, declare that the thesis entitled Initial Perceiver Reaction to Facial Disfigurement and the work presented in the thesis are my own work, and have been generated by me as the result of my own original research. I confirm that this work was done while in candidature for a research degree at this University. Where I have consulted the published work of others, this is always clearly attributed. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work. I have acknowledged all main sources of help.

Experiment 3 was presented at the BPS Cognitive Conference, Lancaster University, September 2006. Experiment 6 was presented at the EPS and Psychonomic Society Conference, Edinburgh, July 2007 and at the XXIX International Congress of Psychology, Berlin, July 2008. Experiment 3 was published in the PsyPAG Quarterly (Tinati, T. (2006). The effect of angry face targets in the rapid serial visual presentation design. *PsyPAG Quarterly, 61*, 9-17). Experiment 2 of this thesis is currently under review (Tinati, T., & Stevenage, S. V. Attention! Using the RSVP paradigm with upright and inverted faces. *Perception*).

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Abbreviations

2AFC	Two-alternative forced choice
AB	Attentional blink
ANOVA	Analysis of variance
DDA	Delayed disengagement of attention
EEG	Electroencephalograph
ERP	Event related potentials
fMRI	Functional magnetic resonance imaging
GSM	Guided search model
IFG	Inferior frontal gyrus
IOR	Inhibition of return
PCC	Posterior cingulated cortex
PET	Positron emission tomography
PPA	Parahippocampal area
RSVP	Rapid serial visual presentation
SD	Standard deviation
SE	Standard error
SMA	Supplementary motor area
SOA	Stimulus onset asynchrony
STS	Superior temporal sulcas
T1	Target 1
T2	Target 2

Chapter 1
Theoretical review on human attention, threat and facial disfigurement

Imagine yourself sitting on a train and realising that even though it's the busy morning rush hour, the people around you do their best to avoid sitting in the empty seat next to you. As the train enters the tunnel, you see your reflection in the window, and once again you know that the only reason you are avoided is because you look different. Over 500,000 individuals in the UK have some form of facial disfigurement, and the majority of the social psychological literature indicates the personal and social problems associated with 'looking different.' This can range from depression and isolation (Clarke, 1997; Frances, 2000; Kent & Keohare, 2001; Lockhart, 2003), to avoidance in public places (Houston & Bull, 1994) and poor job recruitment (Stevenage & McKay, 1999). Whilst this negative reaction to individuals with facial disfigurement is well documented, very little is known about the basis of the reaction upon initial perception. Central to this thesis is addressing the issue of what reaction facial disfigurement elicits within the first seconds of perception. Whilst this will push our theoretical and empirical knowledge of face processing forward in a relatively under-researched area, it may also provide groundwork in facilitating positive social interactions. The body of research in this thesis is set within a well-established attentional literature that has examined the response to emotional expression, especially angry faces. This body of literature has concluded that angry faces elicit a threat response, and therefore this thesis attempts to adopt and extend this literature to determine whether or not facial disfigurement also elicits a threat response.

The thesis has two main aims that the empirical chapters will address. First, it aims to further demonstrate the behavioural reaction to emotional faces, and specifically to demonstrate a threat response to angry faces. Second, it aims to determine whether or not it is possible to generalise our present understanding of the threat reaction to angry faces to show a threat reaction to disfigured faces. Finally, the thesis also aims to investigate in an area that has little controlled or systematic research to examine the issue of why negative reactions are reported by those with facial disfigurement. This will be achieved by providing systematic empirical investigation of the two main aims. Thus, the studies conducted throughout this thesis facilitate an examination of the central hypothesis of whether the reaction to facial disfigurement is comparable to that exhibited by angry faces, and therefore one of threat.

The thesis is divided into three main parts. The first part provides a literature review of current research in the area and the questions that remain unanswered. Chapter 1 explores the theoretical literature, whilst chapter 2 examines two prominent attentional paradigms. The second part contains the empirical studies designed to address the research questions (chapters 3-13). The final part provides an overall framework and final conclusions that align the empirical with the theoretical work (chapter 14).

The present theoretical chapter is divided into four main sections. The first section presents a discussion of the present understanding of human attention, and the role of both top-down and bottom-up influences. The second section examines the theoretical literature on the human tendency to attend, and respond, to threat. Section three focuses specifically on the human face, arguing that it is a special and significant stimulus, and when displaying a negative expression like anger, can elicit a threat-based reaction. Finally, section four presents the limited literature on the implications of, and reactions toward, facial disfigurement, arguing that our initial response may similarly mimic a threat response to an angry face.

This thesis hopes to contribute to our understanding of how we react to facial disfigurement in the initial seconds of perception. Importantly, it aims to understand *why* this reaction occurs.

1.1 Attention

1.1.1 Definitions

This section will present an overview of the human attention system. Attention is a complex concept, with multiple components and processes. Below are two definitions that have been proposed that illustrate the complex nature of attention.

'Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what would seem simultaneously possible objects or trains of thought. Focalisation, concentration, of consciousness are of

its essence. It implies withdrawal from some things in order to deal effectively with others.' (William James, 1890, 403-404).

'…information processing that involves procedures of selection and evaluation of motivationally relevant input, similar to that occurring in animals as it forages in a field, encounters others, pursues prey or sexual partners, and tries to avoid predators and comparable dangers.' (Lang, Bradley & Cuthbert, 1997, p.97).

Lang *et al.'s* (1997) definition roots attention within an evolutionary framework. In this sense, the attention system is fundamental to accurate environmental awareness, facilitating survival of the species (Berger, Henik & Rafal, 2005; Campell, Wood & McBride, 1997; Egeth & Yantis, 1997; Le Doux, 1998). An important property of the attention system is its responsiveness to danger in the environment. Le Doux (1998) maintains that the human fear system evolved as a danger detection function, which facilitates attentional response to danger even before conscious and affective feelings. Lang *et al.* (1997) further contended that attention is driven by primary motivational needs, such as fear, sex, and hunger.

Based on the different definitions available, this thesis defines attention as a multi-faceted processing mechanism that selects, analyses, and brings to conscious awareness stimuli in the environment, in preparation for identification, consolidation and possible behavioural response. This thesis will concentrate on visual attention, and whether the saliency, significance and appearance of a stimulus can affect a subsequent behavioural response.

Although attention can be divided between two stimuli or tasks, for example shadowing two conversations, it is a limited resource that has finite capacity (Posner, 1980). This is demonstrated in dual-task experiments that tap into the same resources. Performance on one task will be impaired compared to performance on a second task when both tasks require resources from the same modality (e.g. auditory or visual) as the competition for resources increases (Styles 1998). Not everything in the environment can be attended to, and therefore a selection process must take place. There is some debate as to when this selection occurs, either at the point of initial attending, or at the point of conscious report (Styles, 1998). The latter indicates that all input is attended to, but the sensory input eventually reaches a bottleneck because only some of the information can be processed given limited attentional resources. Hence, since attention is a limited resource, selection of input is necessary. This selection may be guided by external properties of the stimulus and personal or motivational goals. These will be discussed in the next section.

1.1.2 Top-down and bottom-up processing

Attention is often likened to a spotlight that selects part of an array for subsequent processing. This metaphor was presented by William James (1890), when he described attention as having a focus, margin and fringe. Visual information in the centre of the spotlight will be in focus and may then have much more of a chance of being attended to compared to information that is more peripheral. Given this, the issue of how the spotlight can be moved, and re-focused becomes important. For example, Muller and Hubrier (2002) argued for a doughnut-shaped lens, as they showed that central information could be ignored if peripheral information required attention. In other words, participants were able to ignore stimuli in the centre of the visual field that were irrelevant to the task. This indicates the flexible nature of attention.

The flexibility of attention is revealed by the fact that two prominent influences drive attention. These are (i) the external environment, and (ii) the internal drives and motivations of the individual. Juola, Bowhuis, Cooper, and Warner (1991) argued that the spotlight can be easily directed by cues in the environment, which facilitate selective attentional processing. In a similar vein, Posner, Snyder and Davidson (1988) believed that the spotlight is the mechanism of attentional allocation to certain parts of the array. A sudden change in the environment, for example through movement or abrupt onset of a stimulus (Jonides & Yantis, 1988), may capture attention in an unstoppable fashion, indicating the importance of environmental cues in directing attention. This is referred to as bottom-up processing. Bottom-up influences capture attention involuntarily, and typically do so rapidly (Posner, 1980; Posner, Snyder & Davidson, 1988). Exogenous cues are bottom-up influences (Posner, 1980). These cues are outside the individual's control and automatically shift attention so that they cannot be ignored. The attentional system is unable to resist exogenous cues such as abrupt onsets in the environment (Posner, Snyder &

Davidson, 1988) and this is often referred to as covert orienting. From an evolutionary point of view, this makes adaptive sense as sudden changes in the environment (such as a moving animal) require rapid attention.

In contrast to this, endogenous orienting requires the individual to interpret a signal in order to orient attention to a specified location in preparation for a new event (Cheal & Lyon, 1991). Although this signal is external to the individual, the need to interpret its direction influences an individual's orienting goal. Influences on our attention that are shaped by our goals and intentions are said to be top-down, and voluntarily controlled (Cave & Wolfe, 1990). It is evolutionarily adaptive to have an attention system that responds automatically by default, but has the flexibility to be modified by top-down goals.

The role of bottom-up and top-down influences has been developed into a theoretical framework in order to conceptualise the specific processing being undertaken. The next section discusses this model.

1.1.3 Guided Search Model

The Guided Search Model (GSM) developed by Cave and Wolfe (1990) endorsed the role of both bottom-up and top-down influences in terms of the control of attentional selection. They argued that visual processing occurs in two stages: an initial parallel stage, and a late serial stage. The parallel stage rapidly identifies features of the array, whilst the serial stage integrates these features through a process of consolidation. In the GSM, the serial stage is guided by the parallel stage, and both contribute to activation locations of an activation map. The higher the activation area in the map, the greater the likelihood the stimuli occupying that area will be processed. The parallel stage is typically guided by our top-down motivations so that activation maps are created to identify a particular item. The serial stage can also be guided by our top-down knowledge, such as motivational goals.

Folk, Remington and Johnston (1992) provide an extension of the GSM by proposing that attention is, by default, unconsciously and environmentally driven by attentional control settings. When we have specific selection goals, such as searching for a particular person in a crowd, the default mode can be overridden (Folk *et al.,* 1992; Folk & Remington, 2006, 2007) and thus driven by top-down motivations. However, the default mode of the attentional control settings is designed to orient attention to a change in the environment, to sudden movement, or to an environmental threat (Le Doux, 1998).

This indicates that a stimulus may draw attention in one of several ways: if it is new in the environment, if it is evolutionarily significant, or if it is significant to the individual's current goals. As Le Doux (1998) argued, one of the main faculties of attention is its responsiveness to threat to elicit a fear response if necessary. This default mode of processing is important in our understanding of how we react to faces of different appearance in the first stages of perception before full cognitive appraisal can take place. If a face signals threat, it may by default grab our attention. This issue of how attention is intimately linked to human threat detection is examined in the next section.

1.2 Human threat detection and the fear response

1.2.1 Fear and evolution

This section discusses our theoretical understanding of the human threat response. This will present the argument that humans have an evolutionarily-developed threat response system, and are biologically predisposed to fear certain stimuli.

The theoretical literature indicates that attention is drawn to novel events in the environment, and one of the most fundamental facets of the attentional system is its predisposition to orient toward threat-related stimuli. This is an adaptive property of the attentional system, evident in both animals and humans, as it motivates the organism to respond to a potential threat. Although the expression of fear may be triggered by different stimuli (for example predators, other humans), Le Doux (1998) argued that the underlying neuronal functioning is similar across species and elicits one of a limited number of defence behaviours. Le Doux (1998) asserts that the attention system is primarily involved in threat and fear detection, and can accomplish this under high task demands and even without full conscious awareness. He refers to this as the danger detection system. Ohman (1997) also agreed that humans have evolved a danger detection system that elicits orienting of attention toward and upon the stimuli that has been appraised as threatening. The physiological response underpinning this is primarily centred on the amygdala, providing a biological basis for this hypothesised system (Ohman & Mineka, 2001). Before this detection system is reviewed, it is necessary to understand what fear is, and its eliciting effects on behaviour.

Rosen and Schulkin (1998) described fear as an emotional state elicited by the expectation of an encounter with danger. They argued that fear is an adaptive emotion as it motivates safety-seeking behaviour, with perceptual, behavioural and motivational components. Thus, attention to threat motivates the organism to respond quickly (Dijksterhuis & Aarts, 2003). Rosen and Schulkin (1998) also hypothesised that pathological anxiety evolves directly from the normal fear response, producing an exaggerated vigilance for threat. In support, Le Doux (1998) suggested that fear is at the heart of many psychiatric problems, including anxiety, phobias, obsessive compulsive disorders and panic disorder.

Rapid threat perception can elicit several basic responses, including the startle response, which is noted across different species (Graham, 1975), the defence reflex, which involves increased heart rate, and the orienting response (Ohman, 1997). The orienting response is characterised by physiological changes such as increased body temperature, and importantly, inhibition of ongoing behaviour. This would allow assessment of the potential threat. Ohman (1997) proposed that the orienting response would be elicited by biologically significant stimuli. For humans, he argued that this included harmful creatures such as snakes and spiders, as well as other humans displaying signs of threat. Indeed, attentional studies have shown that attention rapidly orients to faces of a threatening nature, compared to positive and neutral ones (Bradley, Mogg, Falla & Hamilton, 1998; Cooper & Langton, 2006; Pratto & John, 1991) suggestive of an automatic vigilance bias to detect threat without conscious intention. They speculated that humans paid greater attention to negative compared to positive information in the environment. Negative events signal a need to change current behavioural goals, and therefore rapid processing and immediate response are evolutionarily advantageous.

The cross-species response to a threat has been described as a 'fight or flight reaction' (Cannon, 1939; Le Doux, 1998). The animal may either stay to defend him/herself, or may flee. More recently, a third reaction called the freeze response has been added (Lang, *et al.,* 1997), also referred to as the 'stop, look and listen' reaction (Bracha, 2001). This occurs when the animal becomes rigid and still, with a decrease in heart rate, in an attempt to monitor the environment and to facilitate defensive behaviour (Azevedo *et al.,* 2005). Le Doux (1998) argued that such responses promote safety-seeking behaviour, and proposed that threat detection was a fundamental requirement of any animal's attentional system. Pictures of mutilations, for example, have elicited a freeze response in healthy male adults (Azevedo, *et al.,* 2005). Like Ohman (1997), Le Doux (1998) also argued that although the experience of fear may be conscious, the brain mechanisms generating fear and the appraisal of stimuli as threatening are unconscious and often automatic.

1.2.2 The physiological basis of fear

Physiological data support the hypothesis that the fear response to threat is automatic. The amygdala is central to the fear response, receiving input from fear-inducing sensory information, and facilitating subsequent motivational response (Carlsson, Petersson, Lundqvist, Karlsson, Ingvar & Ohman, 2004; Rosen & Schulkin, 1998). It is situated in the medial anterior temporal lobe and mediates input from cortical and thalamic sites to hypothalamic and brain stem nuclei. Rosen and Schulkin (1998) suggested that in clinical anxiety, the amygdala becomes hypersensitive to threat through neural sensitisation whereby external stressors have sensitised the fear circuits resulting in enhanced perception and response to subsequent threat.

Ohman and Mineka (2001) suggested four main functions of the amygdala. First, it activates the experience of fear in both humans and animals. Second, it can be activated without full conscious awareness of the stimulus. Third, this pre-conscious processing of threat takes place without the involvement of the cortex. Finally, the neural circuitry centred on the amygdala is activated by threat only. Electro-stimulation of the amygdala produces fear behaviour such as freezing in animals (Applegate, Kapp, Underwood & McNall, 1983). Fendt and Fanselow (1999) also argued that the amygdala was central in the process of conditioned fear learning, and argued that lesions to this structure extinguish conditioned fear. Although the amygdala is highly responsive to fear stimuli, it also appears to respond to other negative stimuli, especially when the stimulus is presented under restricted awareness. For example, Phillips *et al.* (1997) found that the amygdala also responded to objects of disgust, as well as objects of fear, when presented under restricted awareness, but this reactivity was extinguished as the disgust objects were overtly presented. This indicates the generality of amygdala response to negative stimuli when full conscious awareness is not available.

Given such results, Le Doux (1998) proposed two fear routes via the amygdala. He argued for a higher-level fear pathway and an amygdala-thalamus pathway. The higher-level fear pathway constitutes higher brain activation involving both the thalamus and the cortex, which provides elaborate, conscious cognitive appraisal. This is a top-down route to threat detection. Conversely, the amygdala-thalamus pathway processes threat much faster, without calling on the cortex, but this processing is at a more basic, bottom-up level with relatively little conscious cognitive control. Complex appraisal of the threat is unlikely by this route. For example, in the case of the amygdala-thalamus circuit, the fear elicited by a snake will not respond to cognitive control because of the circuit's relative immunity to conscious input (Ohman & Mineka, 2001). In support of this rapid process route, humans can rapidly appraise natural scenes for threat, even when presented at under 50 msecs each, indicating our ability to extract threat-meaning very rapidly (Braun, 2003; Fabre-Thorpe, Delorre, Marlot & Thorpe, 2001; Li, van Rullen, Koch & Perona, 2002). Le Doux (1998) argued that the two routes exist alongside each other in humans. Although the amygdala-thalamic route is evolutionarily older, and is also found in more primitive animals, he contends that it has not been made redundant by the more advanced system in humans because it serves the purpose of a rapid response to danger to elicit immediate action. 'It is a quick and dirty processing system' (Le Doux, 1998, p.163).

The amygdala also receives input from the hippocampus, which is involved in memory formation. The input from the hippocampus to the amygdala may elicit fear-inducing memories, and therefore this neural circuit has been implicated in fear conditioning situations (Le Doux, 1998). In addition, the medial prefrontal cortex inputs into the amygdala, which has been implicated in the extinction of a conditioned fear response (Le Doux, 1998). It is clear, therefore, that the amygdala is central to danger detection and fear response. It also illustrates how the attention system can be driven by a threat-based detection system that can appraise threat very rapidly, albeit crudely.

To summarise, the review so far has shown that attention is a limited resource, that is guided by top-down and bottom-up influences. Although attention is a flexible mechanism, it appears to be automatically affected by threat as this is evolutionarily advantageous. In support, different approaches in the empirical literature have converged on this hypothesis. These empirical studies will be discussed and reviewed in chapter 2 in much detail. The vast majority of the literature converges to indicate that attention orients toward biologically threatening stimuli such as snakes and spiders, and the next section will show that this also occurs when the stimuli is more socially important as in the case of threatening human faces.

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1.3 Significance of faces

1.3.1 Face processing

This section presents the argument that particular faces can influence patterns of orienting due to their importance in signalling potential threat. Darwin (1859/1985) proposed that understanding human facial expression has developed through evolution and is a universal and cross-cultural ability of the human race (Ekman, 1999). This facilitates communication regardless of verbal language. As a consequence, participants are generally unable to ignore irrelevant distractor faces even when they are explicitly told to do so, demonstrating the significance of faces on attentional processing (Jenkins, Burton & Ellis, 2002; Lavie, Ro & Russell, 2003; Young, Ellis, Flude, McWenney & Hay, 1986). It would seem natural, therefore, to ask whether faces in general, and threatening facial expressions in particular, can modulate attention in the initial stages of perception by virtue of their social significance.

Since there is a large body of research on face perception alone, an extensive review would be a thesis in itself. However, it is necessary to understand how faces are processed before we discuss how our attention is affected by different expressions and appearance. Thus, the literature on face perception will be briefly reviewed.

Face perception involves featural, configural and holistic processing. Featural processing is the processing of individual features of the face, such as the eyes, nose and mouth (Bruce & Young, 1998; Cabeza & Kato, 2000). Configural processing involves computing the spatial dimensions between features of the face, whilst holistic processing is the representation of the face as a whole rather than as individual parts (Cabeza & Kato, 2000; Tanaka & Farah, 1993; Young, Hellawell & Hay, 1987). One of the most robust findings is that we are extremely poor at face identification and detection when the face is inverted (see Valentine, 1988, for a review), indicating that we have become attuned to upright face perception (Maurer, Le Grand & Mondloch, 2002; Rousselet, Macé & Fabre-Thorpe, 2003). Inversion disrupts configural processing (Itier & Taylor, 2004; Leder & Bruce, 2000; Rossion, *et al.,* 2000; Rossion & Gauthier, 2002; Thompson, 1980; Yin, 1969). Similar disruption resulting in poor identification performance is also found when the top and bottom half of two different faces are aligned (chimeric face effect) due to abnormally disrupting spatial configurations. Brain activation studies have shown that face perception is centred on a specific brain area called the fusiform face area (FFA) located in the ventral temporal lobe (Kanwisher, McDermott & Chun, 1997; Tong, Nakayama, Moscovitch, Weinrib & Kanwisher, 2000). To note, its specialisation with faces is debatable, and instead is argued to be an area that processes visually similar stimuli when the participant reaches an expert level of classification (Gauthier & Tarr, 1997; Gauthier, Behrmann & Tarr, 1999; Gauthier, Tarr, Anderson, Skudlarski & Gore, 1999). At a theoretical level, several models exist that help explain our understanding of the processes involved in face perception, for example Bruce and Young's (1986) face recognition model, and Valentine's (1991) face-space theory. This latter model has accounted for much of the face perception findings, and so will be briefly discussed.

Valentine (1991) proposed a theoretical account of how faces are encoded and stored within a Euclidean framework. The face-space theory (Valentine, 1991) argues that faces exist within the multi-dimensional space framework (see Figure 1.1), and the location of the face is defined in terms of its properties along each dimension.

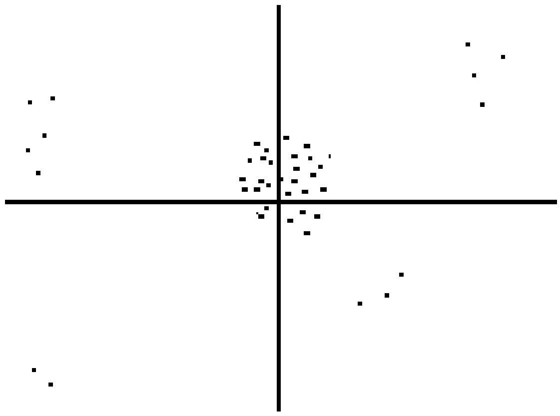

Figure 1.1. Schematic representation of the face-space framework (Valentine, 1991). Typical faces cluster at the centre, while distinct faces are further apart.

Although it is not yet known how many dimensions there are, nor how they are operationally defined, the dimensions may be related to certain features of the face, such as eyes, nose, and configural distances between parts (Bruce & Young, 1998) and the particular dimensions may be dependent upon the race or gender of the face (Johnston, Milne, Williams & Hoise, 1997).

At a theoretical level, Valentine (1991) makes a distinction between a norm-based model and an exemplar-based model of face encoding. In a norm-based model the dimensional space has an encoded norm (or prototype) face, and other faces are encoded with respect to their degree of deviation from the prototypical face. The norm will most likely be located at the centre of the space. Therefore, the distance between each face will be relative to the degree to which it differs to the norm face, calculated in terms of vector values. Typical (similar) faces will assume a small distance from the norm, whilst distinctive faces, by definition, are further from the norm. In contrast, an exemplar-based model does not contain a prototypical face (Byatt & Rhodes, 1998; Valentine, 1991). Instead, faces are encoded with respect to absolute values based on their defining dimensions. The distance between each face and its neighbour is therefore the important measure, without reference to a central norm. The latter model does not require conceptualization of how a norm face is constructed initially. Therefore, rather than the cluster of typical faces being toward the centre of the space as would be predicted by a norm-based model, this cluster may be at another location. Although this is a matter of theoretical debate, Johnston, Milne, Williams, and Hosie (1997) contends that current empirical data lends support to both models.

The face-space metaphor has been used to make many predictions concerning typicality, distinctiveness, caricature, and race effects (Stevenage, 1995; Valentine, 1991; Valentine & Bruce, 1986; Valentine & Endo, 1992). Face recognition is based upon comparing the externally presented face with the stored mental representation. Although each face is unique in terms of its defining properties, faces with similar properties tend to group near each other within the framework, creating an area of high exemplar density. Such faces are defined as 'typical'. A typical face is easier to classify as a face than a distinctive face because the typical face possesses dimensional values that are shared by many other faces. Conversely, a typical face is more difficult to recognise than a distinctive face because its location is in an area of high exemplar density, and therefore an area of high exemplar confusability (Bruce & Young, 1998; Johnston, Milne, Williams & Hosie, 1997; Valentine, 1991; Valentine & Bruce, 1986).

Furthermore, the face-space has been used to account for the own-race bias in face perception (e.g. Chiroro & Valentine, 1995; Valentine, 1991; Valentine & Endo, 1992). This may occur because the dimensions are more developed for own-race faces, and are therefore not sensitive enough to distinguish between the subtle variations of other-race faces. Chiroro and Valentine (1995) found an own-race effect for both Black and White participants in a recognition task, but this was significantly smaller for those defined as having high contact with the other race. High contact participants also had a significant recognition advantage when faces were distinct. Conversely, the low contact group showed a significant main effect of distinctiveness only in their own-race faces. Chiroro and Valentine (1995) argued that this supported the Contact Hypothesis, which increased perception sensitivity between faces. In support, Byatt and Rhodes (1998) suggested that familiarity with other-race faces either facilitates the construction of another multi-dimensional face-space for that particular race, or that the current framework is expanded to account for the variations of the other race.

Valentine's (1991) face-space theory is thus a powerful framework that has been used to account for a range of face processing phenomena. There have also been attempts to map facial emotion into face-space. Faces are not static, and this indicates that the face-space needs to be fluid and dynamic. Calder, Young, Rowland and Perrett (1997) suggested that emotional expression may in fact occupy its own face-space, separate from that described by Valentine (1991) which is for face identity. Calder *et al. (*1997) argued that the emotional face-space would have few dimensions, although this is an area for theoretical debate considering the many subtle variations of expression. Alternatively, Shah and Lewis (2003) contend that previous attempts at defining an emotional face-space are methodologically flawed due to their use of imposing pre-defined emotional labels to the dimensions, rather than letting the expressions define themselves. Hence, in their study, Shah and Lewis (2003) presented emotional face pairs and asked participants to make a same/different judgement to the faces. Analysis of the data using multi-dimensional scaling found a 2 dimensional circular structure. They argued that these dimensions represented pleasantness and intensity of expression. However, the debate about the emotional face-space continues since the position of the neutral expression is still ambiguous (Shah & Lewis, 2003). Nonetheless, recent advance in computer technology are facilitating an attempt to graphically represent the face-space, which can also take into account human emotion (Di Paola, no date). It is clear, therefore, that human emotional expression is a complex and research-worthy area.

1.3.2 Emotions and facial expression

Emotional expression is a fundamental aspect of human interaction. Researchers such as Ekman (1982) support Darwin's (1859/1985) early view that basic human emotions have evolved from non-human primates, and indeed many of the facial expressions we display are seen in primate interaction (Chevalier-Skolnikoff, 1973). After decades of research, Ekman and colleagues (Ekman, Friesen & Ellsworth, 1982) concluded that six basic facial expressions exist: happiness, anger, sadness, disgust/contempt, surprise and fear. Cross-cultural research with individuals from both literate and pre-literate cultures has shown universal recognition of these six basic expressions (Ekman, 1999; Ekman & Friesen, 1971; Ekman, Sorenson & Friesen, 1969; Ekman *et al.,* 1987). Although emotional expression is shaped by our social milieu, cross-cultural universality indicates an evolutionary influence in the ability to display and communicate information using our faces (Chevalier-Skolnikoff, 1973; Darwin, 1859/1985; Ekman, 1999; Izard, 2002).

Dimberg, Thunberg and Elmehed (2000) showed that we are biologically predisposed to react to facial expressions. They presented participants with pictures of facial expressions and measured their facial response. Happy faces elicited movement of the zygomatic major muscles, which pulls the corners of the mouth up to produce a smile. The corrugator supercilu muscles of the face, which pull the eyebrows together, responded to the presentation of angry faces. Importantly, participants were unaware that their expressions were being measured. Their reactions were spontaneous and involuntary, supporting the hypothesis that basic emotional expression and detection are biological predispositions. Further, this spontaneous response occurred even when the faces were masked and therefore not consciously perceived. Recently, Achaibou, Pourtois, Schwartz and Vuilleumier (2008) found similar results when participants where viewing short movie clips of happy and angry faces.

Emotional expression also has an impact upon early neuropsychological responding. Humans are more responsive to negative faces, specifically those portraying threat. Batty and Taylor (2003) took ERP (event related potential) recordings of individuals viewing the six basic emotions. They found that the P1 wave was activated for all faces, indicative of an awareness of a visual input. The P1 has been associated with awareness of face stimuli (Itier & Taylor, 2004). Interestingly, the N170 was activated for longer in response to fearful, disgust and sad faces. The N170 has been conceptualised as face specific neural processing, in the occipital area (Allison, Puce, Spencer & McCarthy, 1999; Bentin, Allison, Puce, Perez & McCarthy, 1996). Negative faces appear to affect this activation more so than positive faces. Further, the N170 *amplitude* was also larger for fearful compared to other faces.

Breiter, *et al.* (1996), using fMRI, showed that when viewing faces, fearful and happy faces activated the amygdala significantly more so than neutral faces. Whilst viewing fearful compared to neutral faces, Morris, Friston and Buechel (1998) took PET scans of participants and found enhanced activation of the extra striate areas interconnected with the amygdala, which is already known to be involved in emotion processing (Le Doux, 1998). These studies provide further support for the early recognition of faces, especially ones displaying negative emotion.

This is mirrored in the attentional literature, which will be discussed in the next chapter (chapter 2). Threatening faces appear to capture and hold attention compared to positive and neutral faces (Cooper & Langton, 2006; Eastwood, Smilek & Merikle, 2001; Fox, Lester, Russo, Bowles, Pichler & Dutton, 2000; Koster, Crombez, Verschuere & de Houwer, 2004; Milders, Sahraie, Logan & Donnellon, 2006; Ohman, Lundqvist & Esteves, 2001; Yiend & Mathews, 2001). It has been shown that even just eyebrows in the configuration of an angry face can capture attention (Lundquist, Esteves & Ohman, 1999, 2004; Lundqvist & Ohman, 2005), indicating the salience and importance of such stimuli.

Taken together, this illustrates an intimate link between specific brain activation and the amygdala in response to emotional and specifically fearful faces, and the subsequent behavioural response. This demonstrates that emotional expression computation is well-organised physiologically and further additional orientating to such stimuli facilitates the evolutionary-adaptive processing. As Izard (2002) stated, it would be evolutionarily adaptive to recognise anger quickly as angry faces are assumed to convey some degree of danger.

1.3.3 The link between attention and emotion

Vuilleumier, Armony, Driver and Dolan (2001) used fMRI to detect whether neural responses to emotional faces were affected by direction of spatial attention. They presented participants with a display of four boxes, in a 2 x 2 array. Paired faces (of neutral or fearful expressions) and houses appeared in vertical or horizontal positions, per trial. Participants were cued on each trial to make a same/different identity judgement to either the vertical or horizontal pictures. In terms of the behavioural results, house matching judgements were significantly slower in the presence of fearful compared to neutral faces. This indicates that even irrelevant fearful faces can affect attentional resources. However, eye saccades did not differ regardless of whether houses or faces were attended to, indicating that attention can covertly/pre-attentively orient to fearful faces. The fMRI data provided further support. Cued houses activated the parahippocampal gyrus, retrosplenial cortex and lateral occipital regions. However, attending to faces at cued locations produced an increase of activity in the fusiform gyrus. Irrespective of where attention was directed, fearful faces also activated the left amygdala and left temporal pole. Thus, they argued that fearful faces, even when out of attentional focus, activate the amygdala. This certainly fits with Le Doux's (1998) argument presented earlier that the amygdala can process threat information in a crude yet rapid fashion.

Similarly, Pourtois, Schwartz, Seghier, Lazeyras and Vuilleumier (2006) used fMRI scanning to determine the effect of responding to probes when irrelevant faces also appeared on screen. They found increased responses in bilateral temporo-parietal areas and right occipito-parietal cortex for fearful faces compared to happy faces even when they appeared in the opposite location to the probe. This indicates again that threatening faces have the power to capture and engage attention above other face types.

The physiological evidence showing the important status that threatening faces have concurs with much of the behavioural data that will be discussed shortly in chapter 2. Based on all the research findings, the cognitively old system of human threat detection is likely to be automatically driven, unstoppable, and continuing for reasons of biological adaptiveness.

1.4 Facial disfigurement

1.4.1 Social psychological research

A considerable amount of research has examined the effect of expressions on attention in terms of our initial cognitive reactions. To energise and stimulate this research further it is proposed that it is now necessary to look at the effects on attention of different facial appearance. Specifically, within this thesis the focus is turned to how facial disfigurement is perceived. Little is understood in terms of the initial cognitive reaction to facial disfigurement. Addressing this issue is important when one considers that the negative effects of disfigurement for those with facial differences are well-documented (Grandfield, Thompson & Turpin, 2005; Lansdown, Rumsey, Bradbury, Carr & Partridge, 1997; McGrouther, 1997). For example, for both adults and children with facial disfigurement, there is an increased chance of depression, anxiety and social isolation (Bull & Rumsey, 1988; Clarke, 1997; Frances, 2000; Kent & Keohare, 2001; Lockhart, 2003), an overall dissatisfaction with appearance not related to the severity of the disfigurement (Hunt, Burden, Hepper & Johnston, 2005), attachment problems (Hunt *et al.,* 2005), and rejection by others that spans across cultures (BBC, 2006). This may be in part due to society's negative reaction to abnormalities in appearance considering the aesthetic modern world that we live in. If we understand how disfigurement is perceived, we may be able to understand why initial reactions are often negative and may then be able to develop ways to ameliorate such negative responses. This is an important issue given that appoximately half a million people in the UK alone have some form of facial disfigurement (Changing Faces website). Severe facial disfigurement has also been classified as a disability by the Disability Discrimination Act, 1995. Thus, this thesis has a vision beyond its empirical research in the hope that it will provide better understanding so as to develop ways to reduce negative reactions, inform those with disfigurements why negative reactions may occur, and promote greater public awareness concerning the issues of facial disfigurement.

Personal accounts of individuals with facial disfigurement (e.g. Cole, 1998; Grealy, 2004; Partridge, 1990) illustrate the often negative responses they have received from the general public. Social psychological research has shown that there is indeed negativity toward individuals with facial disfigurement. People are less likely to sit near or help an individual with a disfigurement (Bull & Stevens, 1981; Houston & Bull, 1994; Johnston, 2002; Rumsey, Bull & Gahagan, 1982). Both children and adults often respond negatively to disfigurement (Cole, 2004; Crystal, Watanabe & Chen, 2000; Grandfield *et al.,* 2005). Recruiters also have a bias against individuals with facial disfigurement compared to those with physical disabilities or no disabilities (Stevenage & McKay, 1999). What is the reason for this? Part of this negativity may be attributed to modern society's preoccupation with aestheticism. Media saturation of beautiful people has internalised the aspiration by many to achieve physical perfection (Hawkesworth, 2001). Beauty itself appears to attract positive regard. For example, in a classic study by Dion, Berschied, and Walster (1972), it was found that attractiveness was equated with positive qualities. This is often referred to as the halo effect or 'what is beautiful is good' norm. Nonetheless, a definition of beauty or attractiveness has been difficult to operationalise. It is often equated with symmetry (Perrett, Burt, Penton-Voak, Lee, Rowland &

Edwards, 1999), and preference for an ‘attractive’ face from different races, ages and genders is evident from a few months old (Langlois, Ritter, Roggman & Vaughn, 1991; Langlois, Roggman, Casey, & Ritter, 1987). Edler (2001) suggested that there is a common belief about what constitutes beauty, and this often guides surgeons in making decision about how to operate on facial deformities. The main implication from facial attractiveness research, therefore, is that any deviation from the attractiveness norm will decrease the amount of associated positive qualities. Disfigurement, by definition, deviates from the norm.

One must also be aware that different types of disfigurement may attract different reactions (Grandfield *et al.,* 2003). The more visible the disfigurement, the more negativity it may attract (Park, Faulkner & Schaller, 2003). Further, the perceived cause of the disfigurement (genetic or acquired) may also be influential. Cultural milieu may also be important, for example, some individuals in developing-world countries may regard disfigurement as an act of black magic (BBC, 2006). Therefore, the perceivers’ understanding of disfigurement may also play a role in the appraisal of disfigurement (Grealy, 2004; Partridge, 1990). At an empirical level, type and location of the disfigurement may also be influential and so this needs to be controlled for when conducting studies. This thesis is suggesting that such negative cognitions most likely occur in the first seconds of perception and may prevent further interaction. This is based on the rationale that disfigurement may be appraised as a negative stimulus, much in the same way as a threatening facial expression, and as we have seen, this appraisal occurs rapidly and crudely by the sub-cortical pathway of the amygdala (Le Doux, 1998). However, there is minimal research that has systematically examined initial reaction to disfigurement, so this thesis attempts to determine why and indeed whether, negative appraisal occurs in the first stages of perception, and what the underlying cause of this appraisal may be.

1.4.2 Cognitive appraisal of disfigurement

We may be unable to suppress a negative reaction to disfigurement by virtue of our evolutionary background. Kuzban and Leary (2001) argued that stigmatisation of an individual or a group is a human process. The adaptive purpose of this process, especially for our ancestors, was to prevent out-group members from accessing resources, and to engender parasite avoidance. These facilitate self and group member survival relative to others, and may in part explain present-day prejudice (Schaller, Park & Faulkner, 2003). It is proposed that the reaction to facial disfigurement may be a function of our evolutionarily-developed parasite-avoidance behaviour (Park, *et al.,* 2003; Schaller, *et al.,* 2003). The more visible the cue of contagion, the easier it is to detect and avoid. In support of this proposition, research has shown that symmetry is preferred relative to asymmetry (Park, Faulkner & Schaller, 2003). This extends to a preference for facial symmetry. Although this has been a matter of debate, symmetry and attractiveness are often equated, with symmetry defined as a marker of good genes, and by implication, parasite-resistance and fertility (Perrett, Burt, Penton-Voak, Lee, Rowland & Edwards, 1999). Therefore this preference is evolutionarily-shaped (Chen, German & Zaidel, 1997). Facial disfigurement may be perceived as having the ability to contaminate the perceiver and therefore may be perceived as a potential threat. Given the social psychological literature, the initial perceiver response may be exhibited as staring to allow the perceiver to monitor what is initially perceived as a threat or exhibited as attentional avoidance to the threat. Threat detection can be rapid and crude with little input from higher level functioning (Le Doux, 1998), and so by virtue of our physiology and evolution, we may come to initially respond negatively to disfigurement. This could be a cognitively similar process as when responding to angry and fearful faces.

Park, Faulkner and Schaller (2003) recently claimed that avoidance of visible signs of disease is an unconscious process, occurring without rational thought. They argued that even when a stimulus is not harmful, such as disfigurement, it may still be appraised as contagious as a bias for false positives is evolutionarily safer than a bias for false negatives. That is, it is safer to label something as harmful and avoid it even if it is safe, rather than label it as safe, and come into contact with it, when it is actually harmful. Thus, disease- or parasite-avoidance elicits certain emotional, cognitive and behavioural responses and these responses may also be elicited by facial disfigurement. For instance a negative appraisal (cognitive), disgust and anger (emotional) and increased cardio-vascular activity are associated with the perception and evaluation of threat, and could also be revealed in response to facial disfigurement (Blascovich, Mendes, Hunter, Lickel & Kowai-Bell, 2001).

In terms of our theoretical understanding, it may be possible to link the evolved disease model of parasite-avoidance with the perception of threat and associated responses. Contagious or parasitic stimuli may elicit a threat response in humans, which would facilitate threat avoidance as a way of increasing survival chances. This response would need to occur early to motivate rapid safety behaviour. Hence, the negative reaction to facial disfigurement may be a product of the threat response system eliciting fear, and it may be rooted in an evolved parasite-avoidance mechanism. Reaction by the attentional system would thus be an automatic and involuntary response, a by-product of our human threat response system.

In support, Blascovich, Mendes, Hunter, Lickel and Kowai-Bell (2001) measured physiological responses when participants interacted with actors who had been made up with a port wine stain, and found an increase in cardiovascular activity. Participants also generated fewer words in a word finding task compared to participants interacting with non-disfigured actors. Blascovich *et al.* (2001) therefore argued that this demonstrated the elicitation of a threat response by participants when interacting with someone who appeared to have a facial disfigurement. This study has thus revealed threat responses occurring during social interaction. It is now important to determine whether early cognition, upon first sight of facial disfigurement, also exhibits a threat response by the perceiver, as little is known about this stage of the reaction.

1.4.3 Intended research on facial disfigurement

One limitation of many of the social psychological studies is that they did not use controlled experimental methods, minimising the ability to replicate the studies. This can be remedied and refocused through using methodology from the attentional paradigms. One of the aims of this thesis is to carry out well-controlled and replicable studies on attention to facial disfigurement. Due to the established literature on emotional expression, this thesis will use emotional face stimuli as well as disfigured face stimuli within all the experiments. This will provide an opportunity to compare results of experiments using disfigured face stimuli with that of emotional face stimuli. Are reactions to disfigured faces comparable to reactions to angry faces? That is, do disfigured faces affect attention and elicit a behavioural response in the same way as angry faces? To explore these issues, we must be somewhat eclectic in our approach. This is because little controlled, empirical research exists in this area of perceiver reaction and it must therefore be extended to and applied from other related areas. This thesis will adopt a cognitive-evolutionary approach towards attention to facial disfigurement. This is based on the rationale that some cognition may be driven by evolutionary pressures to survive, and this is the level of cognition involved in face processing at an early stage.

The review will now move onto examine the behavioural evidence which shows that our attentional system is responsive to threat. Specifically, it will show the importance of threatening facial expression in affecting human attention. The next chapter will not only discuss these results in depth, but it will also provide a detailed account of the methodologies used within this thesis.

Chapter 2
Methodological Review on Attention to Threatening Faces

In this chapter a range of prominent methodologies will be examined that have revealed an association between attention and threatening stimuli. Primarily, the foci will be on how threatening faces affect attention at an early stage of processing and on what behaviours are elicited. The final part of the chapter will attempt to unite these two areas, indicate how the reviewed methodologies will be applied, and present the current research questions of this thesis.

2.1 Faces as threatening stimuli.

2.1.1 Physiological evidence

Recent physiological studies converge with behavioural results to show that angry and fearful faces affect attention. Phillips *et al.* (1998), using fMRI, found that fearful facial expressions, as well as vocal expressions of fear, activated the amygdala. Whalen, Rauch, Etcoff, McInerney, Lee and Jenike (1998) found greater amygdala activation to fearful compared to happy faces, even when the faces were presented subliminally. This shows rapid processing of emotions as faces were presented for 33 msecs followed by a 167 msecs neutral face mask. However, it also shows differential amygdala activation in response to different facial expressions.

Schupp, Ohman, Junghofer, Weike, Stockburger and Hamm (2004) also agreed that evolution has ensured that we are responsive to angry faces. They presented nearly 300 faces displaying threatening, friendly and neutral expressions and told participants to simply view the faces. By taking EEG recordings, they found increased early posterior negativity to threat faces in the temporal-occipital sites compared to other faces, which emerged 200 msecs after the face and lasted for 120 msecs,. They argued that this indicated the early tagging of threat faces, and therefore facilitating early processing. Increased late positive potentials were also observed 400 msecs after threat faces in the centro-parietal sites, lasting 100 msecs. This is suggestive of more elaborate processing of the faces, perhaps to assess the relative significance of the threat. This again supports the dual-route processing of fear by the amygdala (Le Doux, 1998).

One caveat to these results is the recent finding that the perception of fear may be culturally defined, which is reflected in physiological response. Moriguchi *et al.* (2004) took fMRI scans of Japanese and Caucasian participants whilst viewing neutral and fearful faces of both ethnicities. Caucasian participants reported seeing both fearful and neutral faces. Although Japanese participants reported seeing the neutral faces, they never reported seeing fearful ones, and instead labelled them as expressions of surprise. Rather than an issue of semantics, the fMRI scans also reflected these differences (Moriguchi *et al.*, 2004). For Caucasian participants, the response was an emotional one to fearful faces (relative to neutral) activating the right supplementary motor area (SMA), the right posterior cingulated cortex (PCC), and the right primary visual cortex. The SMA and PCC are both known to be activated in the presence of threat-related information (Moriguchi *et al.*, 2004). Conversely, for Japanese participants, response to fearful faces was less emotional, and did not activate these brain areas. Instead, it appeared to involve a template matching system to identify the expression. Greater activation of the right dorsal pre-motor area, the right inferior frontal gyrus (IFG) and the left fusiform gyrus was found. The activation of the IFG is associated with template matching of facial expression (Moriguchi *et al.,* 2004). Furthermore, Caucasian participants exhibited greater left lateral amygdala activation than Japanese participants when viewing fearful faces, which indicated that such faces were assessed as threatening by Caucasian individuals only. This is an important finding in terms of methodological design. More research is clearly required on cross-cultural differences in terms of the perception of facial expressions.

In summary, physiological evidence has provided us with the understanding that threatening faces can affect the activation of certain brain areas. Although this is instructive, it is also necessary to determine the *behavioural* responses to emotional faces to determine whether the two literatures converge.

2.2. Attentional paradigms

This section will examine in-depth two prominent paradigms that have been used to assess deployment of attention over time at a behavioural level in relation to the stimulus significance. These two paradigms form the basis of the empirical work conducted in the second part of this thesis (chapters 3-12), hence their importance here. The rapid serial visual presentation design will be discussed first, followed by the dot-probe cueing task.

2.2.1 Rapid serial visual presentation

The rapid serial visual presentation (RSVP) design assesses the temporal constraints on attentional processing through the presentation of rapidly appearing stimuli. Participants are typically asked to identify a specific first target (T1) and detect the presence or absence of a second target (T2) among distractor items in an RSVP stream. Items rapidly replace each other in the same spatial location at around 80 to 120 msecs presentation per item. T2 appears at different temporal lags after T1. T2 can appear immediately after T1 (lag 1 position) or at any other lag position, typically up to lag 7 when performance asymptotes. When T2 appears around 200-400 msecs after T1, identification of T2 is dramatically reduced. This has been defined as the attentional blink (AB, Raymond, Shapiro & Arnell, 1992). Previous studies showed that the attentional system temporarily stops processing new information when processing old information, which is conceptualised as a ‘blink’ (Volkman, Riggs & Moore, 1980).

In one of the earliest studies, Lawrence (1970) presented an RSVP of lower case words at a rate of 6 to 40 items/second. Participants were instructed to identify the uppercase word (single task design) that could appear in the first or last position, or embedded within the RSVP. Lawrence (1971) found that single item processing took approximately 100 msecs to complete (10-13 items per second). Similarly, Lawrence’s study indicated that processing of item information was rapid. However, it tells us little about attentional capacity limitations since only one item required processing, and therefore there were few demands on the attentional system.

Lawrence’s (1971) early study was later modified by Broadbent and Broadbent (1987) to include a dual-task design that would reveal attentional capacity limitations. Broadbent and Broadbent (1987) required participants to identify and report two words (T1 and T2) embedded within an RSVP of non-target words. Each word was displayed for 80 msecs, and T2 appeared at lags 1 to 4. Thus, T2 could appear between 0 to 400 msecs after T1. The results revealed that the probability of T2 detection given T1 identification was less than 10 % at all lags (experiment 1). Preliminary conclusions by Broadbent and Broadbent (1987) suggested that whichever target is encoded first will gain priority processing. This may well present a circular argument as it begs the question as to how the item is selected and encoded. Nonetheless, the results indicated that processing of one item could take up to 400 msecs, hence the poor detection of T2, since resources were still occupied with T1. This seems incompatible with Lawrence's earlier finding that processing took around 100 msecs.

Taken together, these results indicate that even though 100 msecs may be enough to identify a target as Lawrence (1971) found, more time is required to consolidate this information to provide a response. Indeed, participants often reported being unaware that T2 appeared when it was in the 200-400 msecs interval after T1 (Broadbent & Broadbent, 1987), even though they were informed that T2 would always be present. This is suggestive of a two-stage process of identification and consolidation.

Research was quick to establish that an item appearing within 400 msecs of T1 would receive low detection rates, yet at longer lags, T2 detection increased (Ross & Jolicoeur, 1999). For instance, Raymond, Shapiro and Arnell (1992) presented an RSVP with white letters as T1 and a black X as T2 with black letter distractors. In experimental trials, when X appeared between 180 – 450 msecs after T1 (lags 2 to 3), accurate reporting fell to below 60% compared to 85% correct in the control condition where only T2 was to be reported. Raymond *et al.* (1992) also revealed a second finding of significance within their design. Interestingly, when T2 followed immediately after T1, it was detected approximately 80% of the time. This relatively good performance when T2 is presented immediately after T1 has become known as lag 1 sparing (Raymond *et al.,* 1992). The results therefore produce a U-shaped curve, with T2 detection being impaired only when it appeared 200-400 msecs after T1 (see Figure 2.1), and no further deficits in performance. This therefore provides an operation definition of the attentional blink as requiring lag 1 sparing, followed by a deficit in performance, and then a return to a performance level significant better than the deficit. This definition is based on the aforementioned empirical data, which typically generates the AB curve (Figure 2.1). This definition will therefore be applied throughout this thesis.

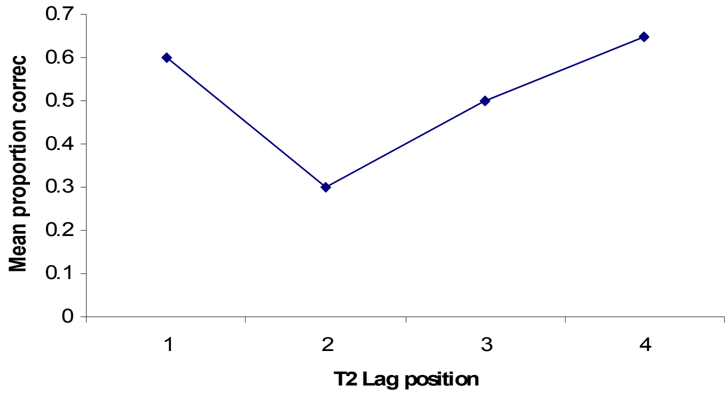

Figure 2.1. A hypothetical U shaped curve for T2 detection, showing lag 1 sparing and an attentional blink.

In summary, it is clear that early research showed that 100 msecs may be enough time to identify a target, but more time is required to consolidate this information (Broadbent & Broadbent, 1987; Lawrence, 1971). If there is not sufficient time, a second target item is unlikely to be processed completely. This is suggestive of a two-stage process of identification and consolidation and this is how the AB phenomenon has been conceptualised into psychological models.

2.2.2 Attentional blink models

The majority of the models that have been developed to account for the AB indicate limited processing capacity of the attentional and memory system (Duncan, Ward & Shapiro, 1994; Jolicoeur, Dell'Acqua & Crebolder, 2000; Potter, Straub & O'Conner, 2002).

Raymond, Shapiro and Arnell (1992) proposed an attentional suppression mechanism that could suppress processing of items until T1 processing was complete. They argued that this was like a 'shut and lock' gate of attention. This would indicate that it takes around 400-500 msecs to fully process a target. The attentional gate opens when target defining features (e.g. colour) are detected, and processing continues until identification is over. The lag 1 item may also enter through this gate due to its temporal closeness, however, the gate quickly shuts to prevent subsequent item access. The AB is therefore the result of item suppression until about 500 msecs after T1.

Chun and Potter (1995) were not satisfied with this suppression account of the AB, and proposed an alternative model. They used letters (T1 and T2) among digits in their dual-task RSVP. They found lag 1 sparing, and an AB at lags 2 and 3 (200-400 msecs after T1) followed by performance recovery. Importantly, Chun and Potter (1995) ruled out the possibility that a T2 detection deficit could be attributed to a difficulty in task switching between targets (Ross & Jolicoeur, 1999) by using a letter-based task for both T1 and T2, rather than digits and letters. The fact that they also found an AB defeats an explanation of task demands. Again, this provides support for the operational definition of an AB exhibiting both lag 1 sparing, a deficit, and performance recovery.

Chun and Potter (1995) presented a two-stage model to account for their AB results. They proposed that in the first stage, the target must be detected and identified through feature searching. However, it produces only a transient representation of the detected item, which is held in a temporary buffer (Giesbrecht & DiLollo, 1998) and requires further processing to create a more durable representation. Items will deteriorate either if there is a delay in passing them to stage two, or if there is competition by an incoming item. The second stage involves consolidation of the item (Chun & Potter, 1995; Jolicoeur, 1999). This is a serial process, and is therefore of limited capacity. In common with Raymond *et al*. (1992), Chun and Potter (1995) suggested that the first item after T1 may enter stage 1 alongside T1, before the attentional gate is closed. This would explain lag 1 sparing. Once closed, items cannot enter stage 1 until resources occupied with T1 processing are freed, and thus the representation of items temporally close behind T1 will fade (Giesbrecht & DiLollo, 1998).

Potter, Straub and O'Conner (2002) also agreed with a two-stage model, arguing that the attentional gate is a 'sluggish mechanism' which would explain lag 1 sparing of T2. Hommel and Akyurek (2005) are also in favour of a sluggish attentional gate. Further, Akyurek and Hommel (2002) hypothesised that the gate may be sensitive to task demands. What now needs to be addressed therefore is whether significance of the stimuli can affect the closing of the attentional gate or indeed its re-opening after T1. These issues will be investigated by the current thesis, specifically in chapters 3-6.

2.2.3 Physiological evidence of a two-stage model

Physiological data most convincingly support the two-stage model over Raymond *et al.'s* (1992) suppression model. Take, for example, the study presented by Vogel, Luck, and Shapiro (1998). They presented a typical RSVP paradigm with basic T1 and T2 stimuli and they measured brain wave activation. They looked specifically at positive and negative electrical wave forms, focusing on P1 and N1 which are activated on presentation of a visual stimulus. As predicted, T2 detection decreased by 15-20 % when at lag 3 compared to the other lags. However, both P1 and N1 were activated in response to T2 irrespective of lag, indicating that the T2 stimuli are perceived even without conscious reporting. They argued that this supports a two-stage model, and that the AB is a post-perceptual phenomenon. In other words, T2 is perceived, but requires further processing to consolidate it, and facilitate verbal reporting.

Vogel and Luck (2002) examined the time course of brain activation in terms of response to T2, looking specifically at the P3 wave, which is a positive wave that peaks around 300-400 msecs post stimulus for a visual target and is typically associated with classification of an item. Vogel and Luck (2002) found an AB for T2 in both the behavioural and physiological data at around 200-400 msecs after T1 in a normal RSVP design. There was no P3 activation when T2 was at lag 3, although it was elicited when T2 was at lag 7. Absence of the P3 wave for T2 when at lag 3 (i.e. when it was unseen) suggests that T2 failed to receive consolidation. This provides support that the AB is due to T1 still requiring consolidation with limited resources available for T2 processing. The representation of T2 in the buffer will thus fade without the attentional resources required for consolidation.

In further support of a two-stage model, Marois, Yi and Chun (2004) argued that most cognitive processes have two stages: i) perceptual analysis, involving rapid and efficient detection and categorisation of information, and ii) an attentional stage, involving identification, consolidation and conscious reporting. They investigated whether there were neural substrates underlying these processes. To demonstrate this, Marois *et al.* (2004) focused on the activation of the parahippocampal (PPA) area situated within the medial temporal cortex when participants were presented with a dual-task RSVP of faces (T1) and visual scenes (T2). The PPA is responsive to canonical visual scenes (Epstein & Kanwisher, 1998) but not to faces, and thus activation of this region would indicate that T2 had been detected (rather than the residual processing of T1). They found that although the PPA was activated more when T2 was detected, it was still activated even when T2 went unreported, compared to when no scene was present. This suggests that the scene was subconsciously presented but not consolidated. An item can be registered in the brain but with no conscious reporting, typically when being processed under high attentional load (Luck *et al.,* 1996; Shapiro *et al.,* 1997). Marois *et al.* (2004) advocated that the PPA still requires attention in order for it to be activated (O'Craven & Kanwisher, 2000). Epstein *et al.* (2003) argued that the PPA is involved in high level processing, and may therefore be involved in the first phase of processing within the hypothesised stage two. They also found that the activation of the lateral frontal cortex was contingent upon whether or not T2 was consciously reported. It may be surmised that the lateral frontal cortex, which is associated with visual spatial attention (Corbetta, Miezin, Shulman & Petersen, 1993; Kastner, Pinsk, de Weerd, Desimone & Ungerleider, 1999; Nobre *et al.,* 1997), is also involved in item consolidation, but can only be activated if resources are available.

2.2.4 Skeletal RSVP

As well as the full RSVP design, a skeletal design has recently been used in an attempt to reduce the length of the task. Duncan, Ward and Shapiro (1994) designed a skeletal RSVP that presented only two distractors, one after each of the targets. They presented T1 for 45-60 msecs, followed by a distractor (scrambled image) for 250 msecs. T2 was then presented for 45-60 msecs and then followed by a second distractor. This sequence functioned as a single trial. T2 could appear between 0 to 900 msecs after T1 to simulate the RSVP lag requirements. The design produced results equivalent to the RSVP methodology, that is, an AB when T2 was presented 200-400 msecs after T1. There was an indication of increased performance after this, and of lag 1 sparing. This suggests that a stream of items may not be necessary to induce and investigate an AB. This pattern of results again supports the operational definition of the attentional blink having lag one sparing, followed by a deficit in performance and then recovery, and is evident even with the skeletal RSVP version. The skeletal design has not however attracted as much use as the conventional RSVP methodology. Hence, studies are limited and evaluation of its robustness is restricted.

2.2.5 Target-distractor similarity

In a recent use of the skeletal design, Visser, Bischof and DiLollo (2004) revealed the importance of target-distractor similarity. For example, they revealed that if the targets and distractors were both letters, detection of both T1 and T2 was significantly impaired relative to when distractors were digits (experiments 1 and 2). Visser *et al.* (2004) argued that the sharing of some featural parts impaired detection of T2. Conversely, when the distractors were random dot patterns, identification accuracy of both targets increased significantly compared to when distractors were pseudo-letters or digits (experiment 3). Visser *et al.* (2004) argued that these results supported the idea that item detection is a process of both bottom-up and top-down influences. In terms of bottom-up influence, items with similar features are more difficult to distinguish between, especially under conditions of limited processing capacity. Simultaneously, top-down influence was apparent in as much as participants knew which targets to look for, and so the attentional gate was more receptive to certain features. With this in mind, Visser *et al.* (2004) proposed a filtering function within stage 1. They argued for a filtering mechanism that could be tuned to the attributes and characteristic of the to-be-detected targets. Stimuli that matched this input filter would be tagged and thus more likely to gain entry into stage one processing. However, only one item at a time could be processed at stage two, as proposed by Chun and Potter (1995). Thus, when target-distractor similarity increases, the probability of a distractor matching the input filter will increase, and so too will its chances of entering stage 2 inappropriately, thus reducing true target detection. Although this study shows how early processing influences the AB, more research is needed to determine the processes involved in late selection, i.e. the task performed at stage two.

2.2.6 Manipulating stimulus salience

If the AB is a function of the time it takes to process information, it would be logical to hypothesise that when T1 is difficult to process, the AB will be magnified. Similarly, the importance or salience of the T2 stimulus may also affect the speed of the attentional gate closing. Accordingly, current research has begun to focus on the issue of whether item salience has any influence on the time course and magnitude of the attentional blink. The question being asked is whether all items take the same amount of time to process. This issue will be specifically addressed in the current thesis in chapters 3-6 using emotional and disfigured faces.

Much of the established AB literature used simple words and digits that had no apparent significance to the participant. However, examination of other areas of rapid processing suggests that target salience is important. For example, when using auditory stimuli in a dichotic listening task, participants could detect their own name in a stream of to-be-ignored auditory information in one ear, whilst shadowing the information presented to the other ear (Cherry, 1953; Moray, 1959). It was argued that one's own name required less processing due to its significance, and thus was attended to even in conversations that were only subconsciously monitored. If salient auditory information can gain rapid attention, it is plausible to consider that salient visual information will also attract rapid attentional resources.

In support of this prediction, a series of visual search studies by Harris, Pashler and Coburn (2004) showed that search times were more efficient for the participants' own names compared to other's name, indicative of name salience. This leads to the question of whether our names also 'pop out' in an AB paradigm. That is, they may have the ability to reduce the AB when functioning as T2 by virtue of their salience to the participant. Shapiro, Caldwell and Sorenson (1997) found that names had a significant influence when embedded within an RSVP stream of nouns. In Experiment 1, T1 was a noun, and T2 was the participant's name, another's name or a noun. Participants were to identify T1 and report the presence/absence of T2. As expected, a typical AB curve was observed when T2 was a noun, indicative of an attentional blink as defined by this thesis. However, the AB was reduced when T2 was the participants' own name. Conversely, in Experiment 3, the targets were reversed (names now in the T1 position), and this did produce an attentional blink even when T1 was the participant's own name.

Two conclusions follow from these results. First, semantic meaning of a word is being processed. These behavioural data therefore converge with the physiological data presented earlier. Second, and more importantly, the results indicate that names have a low threshold of recognition when they are in the second target position. When one's own name appears as T1, a process of detection and consolidation must still occur, resulting in an AB comparable to when T1 is another name or noun. However, when the name appears as T2 at 100-400 msecs after T1, no AB is produced. Although attentional and consolidation resources are preoccupied with T1, the name is significant to the individual, having a lower threshold of activation, and so it is detected with fewer resources as compared to other words. Hence the detection task (for T2) appears to be less cognitively demanding than the identification task (for T1). Thus, one's own name is not without processing demands but its significance to the self does lower its threshold of detection. This can be accounted for by Chun and Potter's (1995) two-stage model, but with the added extension that item saliency needs to be incorporated. Visser *et al.'s* (2004) concept of attentional control settings may be applicable here. One's own name has a greater likelihood of being detected as visual attention has been informed by both bottom-up and top-down processes to be receptive to such stimuli. Participants employed a top-down strategy to search for their own name as they know it will appear. In addition, the name itself is a salient item and therefore bottom-up activation would be responsive to such stimuli. Hence, these combined strategies serve to reduce the AB of one's own name when in the second target position.

2.2.7 Threat in the AB

Although one's own name is an important stimulus, it is now essential to investigate more socially significant stimuli using the RSVP. This will facilitate our understanding of the ability of threat stimuli to affect attention using a well-established paradigm with theoretical grounding. It is therefore important to determine whether threat words, compared to neutral and positive, elicit the AB effects when viewed under the temporal constraints imposed by the RSVP. This will have both theoretical and methodological importance in terms of developing our understanding of the AB phenomenon, and the influence of target salience on the AB.

'The AB procedure could provide some information about the influences of affective significance through a somewhat different path than previous reaction time studies'. (Ogawa & Suzuki, 2004, p. 22).

To initiate this approach, Anderson and Phelps (2001) used emotionally aversive words as T2 stimuli in a typical RSVP design. They found reduced AB at all lags, indicative of a lowered threshold of activation for threat-related words. On the other hand, no benefit of emotionality was evident in an individual with amygdala lesions. This lends further support to the hypothesis that the amygdala is important in assessing the emotional value of incoming information at an early stage of processing (Le Doux, 1998).

Arend and Botella (2002) also examined the effect of emotionality within the RSVP, but instead of just varying emotionality of the targets, they also examined the role of anxiety of the participants (Beck, 1976; Beck & Clark, 1988). Arend and Botella (2002) presented an RSVP stream of neutral words and asked high and low anxious participants to identify the emotional or neutral T1 word (e.g. thief/tree), and to detect the presence or absence of a neutral word (theatre) which functioned as T2. They found no main effect of group or target emotionality on T1 detection accuracy. However, on T2 detection (given T1 detection) there was a significant three-way interaction. Whilst the authors did not statically test between lags to explore their data in-depth, the pattern of results for all groups indicated lag 1 sparing, followed by a deficit in performance and then recovery of performance in the T2 detection task across conditions. For the low anxious group, the size of the AB was the same regardless of whether T1 was negative or neutral. However, for the high anxious group, the AB was reduced when T1 words were negative compared to when neutral. This indicated that for anxious participants, threat words had a lowered threshold, requiring fewer processing resources, and thus T1 negative words did not place limitations on T2 processing. This would suggest that threat is significant, at least in anxious participants here, and thus took less processing resources to consolidate. It is reasonable to conclude therefore that salience and significance of an item does have an influence on processing, and therefore not all items are processed in the same way. These results indicate that the two-stage model may require some modification to take account of stimuli significance.

One limitation of Arend and Botella's (2002) study was that they only used negative and neutral words, and therefore the effect of positive words was not examined. Without such a condition, it is difficult to conclude whether they found a true effect of threat or an effect of emotionality per se. To reconcile this, Kihara and Osaka (2008) used positive, as well as negative and neutral words (Chinese ideographs). With a neutral T1, detection performance was less impaired when T2 was negative compared to positive. This strengthens the claim for a threat rather than emotionality effect. Interestingly, when T1 was a negative word, detection performance of the neutral T2 word decreased, compared to when T1 was neutral (positive words were excluded in this particular experiment). This indicates that although negative words grabbed attention as a second target they still took up significant resources when presented as a first target. Hence, even negative stimuli are not processed capacity free, but they do act differently compared to positive stimuli.

That being said, albeit given the youth of this research, a threat effect is not consistently found in the literature. Keil, Ihssen and Heim (2006) manipulated the valence of the T2 word with a neutral T1. They found a reduced AB for pleasant and unpleasant T2 words compared to T2 neutral. Whilst this is not a strict threat effect, and can only be regarded as an emotion effect, it does indicate the potency of an emotional word to reduce the AB.

In terms of a theoretical understanding, one may argue that negative words are processed almost automatically, requiring fewer resources. Such words may receive consolidation processing through priority access to stage two as facilitated by an individual's attentional control settings. This would push out any distractor items that may otherwise slow down processing. Alternatively, this thesis suggests that salient threat words may be processed by another mechanism which is similar to stage two but is reserved for stimuli that are significant to the self, especially in terms of safety. Indeed, this latter explanation may account for why one's own name as T2 in the RSVP reduces the AB and why threatening words affect processing in the T1 and T2 position. In support, Ogawa and Suzuki (2004) commented that

'… *organisms are dispositionally prepared for negative inputs in their surrounding environments and that this propensity for negative information can be found at a preattentive level'* (p. 28).

Given the emerging literature, the effect of anxiety on influencing attention to threat using the RSVP is not clear. Kihara and Osaka's (2008) results held with a non-clinical sample, whilst other studies have found no effects of anxiety levels (Ogawa & Suzuki, 2004). This would suggest that if it can be shown that negative words have an effect on the AB due to their salience, even for individuals who are not clinically anxious, it is possible that stimuli with even greater social significance will also have an influence on the non-clinical population. As this review has shown, faces represent such a stimulus group.

2.2.8 Faces in the RSVP

As already reviewed, a large body of literature has shown that negative faces can capture and hold attention, over and above positive or neutral ones. Consequently, it may be predicted that faces will have an effect on the AB magnitude, and this may be further influenced by the emotional expression of the face in question. The influence of emotional faces on attention and their eliciting behaviour within the RSVP is investigated in chapter 5.

Awh *et al.* (2004) were among the first to examine the influence of a face on the AB. Rather than use the traditional RSVP design, they used a design similar to Duncan *et al.'s* (1994) skeletal RSVP. They asked participants to report the number of the digit presented (T1) and to determine which of three faces they saw (T2). The distractors used were scrambled faces to maintain sufficient similarity between target and distractors. Interestingly, no attentional blink was found for faces (experiment 2). Detection of the faces as second targets was not impaired, regardless of the lag after T1. In experiment 4, Awh *et al.* (2004) presented the faces as T1, and digits as T2. This time, there was an impairment of T2 (digit) processing showing a typical AB curve as defined earlier. Awh *et al.* (2004) argued that this indicates that faces take up significant processing resources, creating a delay in T2 processing. One interpretation of these results is that processing faces is cognitively more difficult due to the amount of resources required compared to processing digits. Therefore, digit processing at T1 did not impair face processing at T2 because digit processing required fewer resources. However, digit processing at T2 was subject to an AB because of the resources needed to process the face at T1.

Awh *et al.* (2004) proposed a multi-channel model of AB interference to account for their results. They suggested that there are two routes to processing items in the RSVP: a featural route and a configural/holistic route. They contended that digits are processed by a featural route only. However, faces are processed by both routes, therefore evoking 'multi-representational codes' (Awh *et al.,* 2004, p.112). Hence, when T1 is a digit, featural processing resources are required, yet this leaves open configural resources, which facilitate processing of the face when presented as the second target. Conversely, when the face is the first target, both featural and configural resources are required, thus preventing the second target from receiving access to any resources. In support, when faces were used as both targets (experiment 6), a long attentional blink was found, arguably because both configural and featural resources were required to process both targets (Awh *et al.,* 2004). The two-stage model proposed by Chun and Potter (1995) could be adapted to accommodate the configural and featural routes of processing, which may be crucial during the second stage of processing.

Whilst the study by Awh *et al.* (2004) provides us with a lot of novel insights into how the AB works, and the effect of faces, they used the skeletal RSVP task rather than the traditional RSVP stream, and thus conclusions as yet cannot be generalised. Furthermore, they only examined neutral faces. Admittedly, this was a preliminary study into the effects of faces. One may predict, based on early work with words, and the use of faces in other attentional paradigms, that emotion would have some impact on processing and detection accuracy. A particular emotion may either increase or decrease accuracy of processing, and this may further depend on whether the emotional face is the first or second target. Both the influence of faceness and emotional expression are addressed in chapters 3-6 of this thesis.

A recent study by Fox, Russo and Georgiou (2005) used pictures (neutral pictures of mushrooms and flowers) as T1 targets, and happy and fearful faces as T2 targets in a dual-task RSVP with neutral faces as distractors. They argued for an AB for both happy and fearful T2 faces with low anxious participants. This was demonstrated by deficit in performance in the initial lags followed by recovery in performance, although their design meant they could not examine lag 1 sparing as they did never placed T2 directly after T1. They contended that attentional resources were required to process both happy and fearful faces for such individuals. Given Arend and Botella's dual-route processing explanation, one may assume that both pictures and faces took up configural and featural processing capacity. Conversely, Fox *et al.* (2005) found a weak AB for T2 fearful faces compared to happy faces for anxious participants. They argued that anxiety reduced the level of resources needed to process threat, and therefore an AB of reduced magnitude followed for fearful compared to happy faces. Hence, as this thesis has suggested before, perhaps there is a mechanism that can bypass the limited resources available when the stimulus is significant and/or threatening. Indeed, this fits with the idea of rapid, yet crude, processing of threat (Le Doux, 1998). The above study, however, suggests that the threat effect is limited to highly anxious individuals due to a lowered threshold of threat detection.

With this in mind, the study arguably has several limitations. First, T1 was a pictorial target, yet all other targets were faces. This means that there were no shared visual features of T1 and T2 and this factor may have made the overall task easier than previous AB studies. As Visser *et al.* (2004) stated, targets need to retain some similar features within the RSVP to create processing demands. Second, the distractors were neutral, intact faces which may have interfered with the ability to detect T2, thus enhancing the AB. Third, because they did not use neutral faces as T2s as well, there is no baseline AB effect from which to compare the effect of happy and fearful T2 faces. Furthermore, they used fearful faces, and thus it is still not known what the effect would be with angry faces.

Milders, Sahraie, Logan and Donnellon (2006) went some way to address these concerns by using neutral faces as first targets, and happy and fearful faces as second targets, with scrambled face distractors. The participants were instructed to classify the gender of T1 and the presence/absence of T2. Each item was presented for 80 msecs in a traditional RSVP design. T1 items (neutral male and female faces) were presented with a green tint to distinguish them from other items. They found that overall, fearful faces received better detection rates than happy faces, and this was further indicated by a reduced AB for fearful faces. They therefore argued that it was not only emotion that affected attention, but the valence of the emotion, indicating that meaning can be assessed very quickly upon item presentation. They suggested that emotional, specifically threatening, stimuli have preferential access to attentional resources, even when they are limited.

These results go beyond Fox's *et al.'s* (2003) study as there is no effect of anxiety and this therefore is indicative of a threat effect in a non-clinical sample. Further, these results are again suggestive of dual-route processing of configural and featural properties. When resources are exhausted an AB is evident as shown with neutral and happy faces. However, fearful faces, by virtue of an attentional mechanism that can process them rapidly, can survive the effects of limited resources.

Although Milders *et al.* (2006) compared emotional valance of faces in the RSVP, one limitation of the study is the use of scrambled face distractors, which were made from scrambling the internal features of male and female faces. This therefore makes the degree of face-like information between the real faces targets and the distractors incompatible. Furthermore, the presentation of T1 neutral faces with a green tint may have made the T1 classification task a lot easier as the face may have been more luminous than the other images. This could have artificially yielded higher than expected T1 accuracy. Again, unfortunately the effect of angry faces was not explored.

More recently, de Jong and Martens (2007) improved upon the design by manipulating T1 and T2 emotionality, presenting happy and angry faces in a mixed design. Socially anxious and non-anxious participants were asked to detect the expression of T1 and T2. Overall, they found that T1 detection was better for angry faces compared to happy faces. Further, at the time of the AB, there was better detection of angry T2 faces compared to happy T2 faces. T1 expression, however, appeared not to have any influence on T2 performance. This indicates that even when T1 was angry, this did not free-up resources for T2 processing, This result is also consistent with Arend and Botella's (2002) finding of a null effect when T1 is one's own name compared to a neutral noun. These results are counter to the idea that threat stimuli are processed without capacity, but it does indicate that even if threat processing is quick, it is not completely resource-free. De Jong and Martens (2007) argued that angry faces enjoy a lower threshold for identification and have priority access to cognitive resources, even under temporal constraints, although they are not entirely resource free.

That being said, there are some methodological criticisms of their study that need to be addressed. First, there were no neutral targets and so no baseline response was available as a comparison. Second, although they presented male and female face targets, only female participants were recruited which limits the ability to generalise the results. Finally, only three lags were investigated (lags 2, 3 and 8) which ignores the issue of lag 1 sparing and the degree of recovery after the AB.

With these criticism in mind, it is an aim of this thesis to improve upon both previous studies and extend the AB and attention to threat literature by (i) using faces of emotional expression as both T1s and T2s, (ii) using neutral faces as targets and (iii) using artificially scrambled faces as distractors so as to retain complexity but reduce ‘faceness’. To take this one step further, disfigured face targets will also be used within the RSVP design. This will allow an assessment of how disfigurement is processed, and whether or not it is equivalent to how anger is processed. These issues will be examined in chapter 3 to 6.

2.3 Dot-probe cueing task

The RSVP allows for an examination of the temporal constraints of processing. However, Posner (1980) argued that, as well as attention being a limited resource, attention is also multifaceted, with different stages of capture, engagement and disengagement of attention, and inhibition of location, which all occur in the initial stages of attention. These issues can be empirically investigated using the dot-probe cueing paradigm (Berger, Henik & Rafal, 2005; Posner, 1980) which is a measure of spatial allocation of attention. It also enables an analysis of what is being attended to, rather than how long it is being attended to.

In a typical exogenous cueing task, participants are presented with a display containing two boxes either side of a central fixation cross (see Figure 2.2)

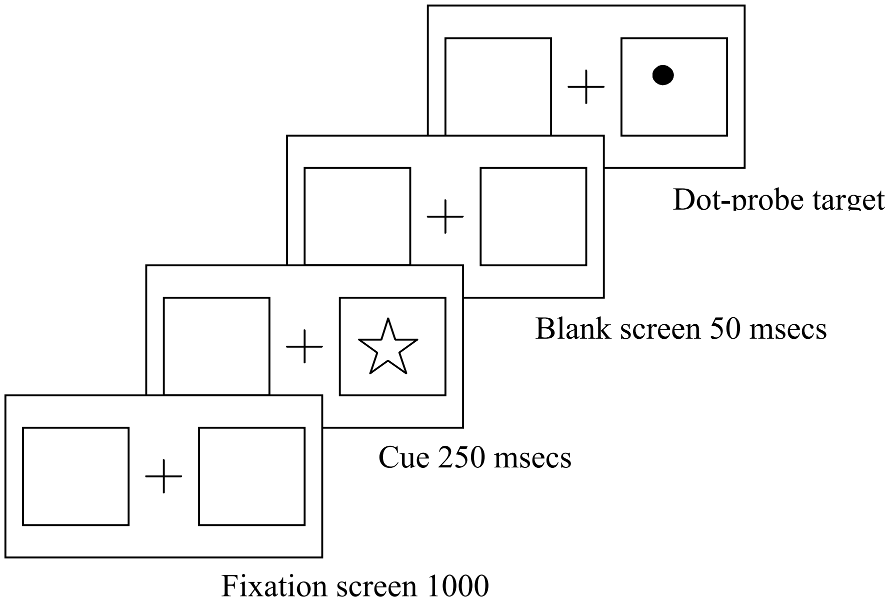

Figure 2.2. A typical dot-probe sequence. The trial is described as 'valid' as the dot-probe target (the circle) appears in the same location as the cue (a star).

A cue is presented in one of the two boxes. Participants are told to maintain their focus of attention at fixation, but invariably the cue attracts attention. The crucial measure is how long it takes for participants to respond to a subsequent dot-probe that follows the cue. This is therefore also known as a dot-probe task.

The probe can appear either in the same location as the cue ('valid' trial), or in the opposite location to the cue ('invalid' trial). The basic paradigm shows that on valid trials response is very quick since attention has already been drawn by the cue to the correct location of the subsequent probe. On invalid trials however, response is slower since attention was drawn by the cue to the wrong place, requiring a shift of attention back to the probe location. This shift of attention is costly in terms of response time.

Even when instructed to ignore them, exogenous cues attract attention as they represent something new and changing in an otherwise static environment (Berger, Henik & Rafal, 2005). As discussed in chapter 1, the pull of an exogenous cue is outside of the control of the individual. This illustrates the control of attention through a bottom-up influence; there is little control over their orientation of attention in this case (Styles, 1998). A point to note here is that in dot-probe experiments, the response should be a classification task (such as identifying whether the probe is a circle or square) rather than responding merely to the location of the probe. The latter could be completed simply by monitoring one side of the screen and making a present/absent judgement (Fox, Russo, & Dutton, 2002). When the classification task is used, however, the dot-probe task is able to investigate the factors affecting attention at the stages of capture/aversion, delayed disengagement of attention and inhibition of return. Studies using the dot-probe methodology have attempted to investigate Posner's proposed three stages of attention separately (Posner, 1980; Posner & Peterson, 1990). Stimulus salience has also been examined within this methodology.

2.3.1 Capture of attention, delayed disengagement and inhibition of return

Within the dot-probe task, it is possible to measure the deployment of attention over time in order to investigate initial capture of attention, disengagement, and inhibition of return of attention. These phenomena can be investigated by simply manipulating the cue-to-target duration.

The cue-to-target duration, also called the stimulus onset asynchrony (SOA) can be anything from 20 msecs to over one second. The SOA is a crucial manipulation. When the SOA is very short, the ability of the target to *capture* attention is under investigation. With no time for multiple eye movements before the dot-probe onset, it is possible to determine how effective an exogenous cue is in capturing attention. In this case, response to the probe when it appears in the same location as the target (valid trial) should be very quick as attention is already located in that area.

When the SOA is increased to 500 msecs and over it is then possible to determine whether a particular stimulus maintains attention. This would be revealed by a *delayed disengagement of attention* (DDA) from a stimulus item, which indicates that the stimulus is significant to the individual in some way (Fox, Russo & Dutton, 2002). Such DDA effects are assessed using invalid trials, when the dot-probe appears in the opposite location to that of the target. In this case, participants find it difficult to disengage attention away from a significant stimulus and attend to the probe location.

At an even longer SOA, generally over 800 msecs, a phenomenon known as inhibition of return (IOR) is evident (Posner & Cohen, 1985). This is when it takes longer to respond to the probe on a valid trial, relative to an invalid trial.

Posner and Cohen (1985) reasoned that IOR is an attentionally adaptive mechanism to release attention from a static object, and move to an alternative location in order to maintain scanning of the environment. Studies using the dot-probe task with simple alpha-numerical targets have shown that IOR is object based. That is, attention prefers not go back to any part of an object after a certain period of time so as to scan for new events (Christ, McCrae & Abrams, 2002; Klein, 2000; Theeuwes & Van der Stigchel, 2006; Tipper, Driver & Weaver, 1991). Thus attention moves away from the location of the target, and when the probe appears, there is resistance to shift back again to respond to the probe. This facilitates awareness of a changing environment that could prove to be advantageous. This attentional mechanism thus prevents humans from maintaining their attention on a given location for too long.

Each of these stages (capture, disengagement, and IOR) are better illustrated using examples where the target items are significant to the participants to demonstrate (i) the use of manipulating SOA and (ii) the importance of target item saliency.

2.3.2. Stimulus significance

One way of clearly demonstrating SOA effects is through manipulating stimulus significance. As this thesis has argued, threatening stimuli affect our attentional control and thus, by using threat-related stimuli in the dot-probe paradigm, it is possible to determine whether they can actually capture and engage attention relative to neutral or positive stimuli.

In a review of over 170 studies that have employed attentional paradigms, including the cueing method, Bar-Haim *et al.* (2007) concluded that across studies there is a small, yet robust threat effect. This attentional bias to threat has been shown in a number of ways including subliminal and supraliminal presentations, and with a range of populations (adult, children, and clinical groups) with some support for the effect even with non-anxious individuals. Nonetheless, there are studies that fail to find such threat effects demonstrating inconsistency in the data.

With regards to the cueing literature, results indicate that threatening words do capture attention, so that probes in the same location as negative words are responded to faster than probes in the same location as neutral or positive words (Williams, Watts, MacLeod & Mathews, 1997). Anxiety lowers the threshold of threat perception due to hypervigilant monitoring of the environment for potentially dangerous stimuli (Beck, 1976; Mogg & Bradley, 1998; Williams, *et al.,* 1997). As already argued, the use of words to reveal an attentional bias in non-clinical samples is debatable in terms of its ecological validity. Words do not pose an actual threat. Additionally, the threat effect found with anxious participants is often only revealed when negative words reflect a specific phobia congruent with anxiety type (MacLeod, *et al.,* 1986) rather than a general level of threat. As such, this may arise because such words are more salient in the cognitive schematic network of anxious individuals, rather than the effect being based on evolutionary threat perception *per se.* Schimmack (2005) argued that since words are encountered regularly, their meaning is readily accessible. That being said, cueing tasks have also been used to reveal attentional biases in other groups, such as smokers (Hogarth, Mogg, Bradley, Duka & Dickenson, 2003) and individuals with eating disorders (Ehrhardt *et al.,* 2003).

Movement away from word stimuli toward the use of pictorial stimuli does however provide the opportunity to examine attentional effects for rather more realistic or ecologically valid threat-related stimuli. When this is done, results suggest that threatening faces affect attention even in non-anxious participants (e.g. Eastwood, Smilek, & Merikle, 2001; Ohman, Lundqvist, & Esteves, 2001).

Studies using emotional-neutral faces pairs in a cueing task show that at SOAs of approximately 300-500 msecs, threatening faces will capture attention compared to happy or neutral faces. To note, this is generally found with anxious rather than non-anxious participants (Chen, Ehlers, Clark & Mansell, 2002; Bradley, Mogg, Falla & Hamiliton, 1998; Bradley, Mogg & Miller, 2000; Fox, Lester, Russo, Bowles, Pichler & Dutton, 2000). These studies thus indicate that attention is oriented toward threat; a view that is consistent with both Ohman (1998) and Le Doux's (1998) hypothesis that we are predisposed to orient to threat. However, to date, the literature is relatively mixed (Bradley, Mogg, Falla & Hamilton, 1998; Cooper & Langton, 2006; Mogg & Bradley, 1999; Williams, Watts & MacLeod, 1997). For example, Fox, Russo and Dutton (2002) failed to find attentional capture to angry compared to happy and neutral faces with an SOA of 300 msecs, even though 75% of trials were valid.

In response to such null findings, Cooper and Langton (2006) investigated the effects of SOA duration on attentional bias. They presented face pairs, and found that at an SOA of 500 msecs, there was a bias *away* from angry faces when paired with a neutral face for non-anxious participants. They argued that if attentional capture is to be examined, an experimental duration of 500 msecs is too long, because it allows for more than one shift of covert attention (Posner & Peterson, 1990). Thus, they argued that to reveal attentional capture to threat, especially in non-anxious groups, SOA has to be less than 500 msecs to prevent covert shifts of attention (Kowler, 1995).

To rectify this, they then reduced presentation time to 100 msecs, and found an avoidance of the happy face in the happy-neutral face pairs, and no significant vigilance for threat faces in angry-neutral pairs. Although they argued that there was no evidence for a bias to be vigilant for angry faces, they did find that at 100 msecs presentation, there was a non-significant 7 msecs bias toward the angry face, and by 500 msecs there was a significant 11 msecs bias away from the angry face. Even at this quick SOA, there is still debate as to whether angry faces can automatically grab attention, thought it seems by 500 msecs they are actually averting attention, at least for a non-clinical sample.

There are several additional limitations associated with Cooper and Langton's (2006) study that may have weakened their results. First, they did not report whether their faces were initially rated for level of expressed emotion, so it is impossible to determine whether angry and happy faces were comparable. Similarly, it is unclear whether the faces displayed teeth, which could exaggerate an expression or enhance the contrast within the display. Second, and most importantly, they presented face pairs, so it is still unclear as to whether individuals were orienting away from one stimulus thus avoiding or inhibiting it, or being captured by the other stimulus. These issues cast the tentative results into some doubt in terms of the conclusions that can be confidently drawn.

In a change of focus, it is possible to determine whether a stimulus maintains (rather than captures) attention. Fox, Russo and Dutton (2002) used schematic neutral, happy and angry faces, in a dot-probe task with an SOA of 300 msecs (Experiment 1). On valid trials, there was no evidence to indicate capture of attention by angry faces. Conversely, when they examined the invalid trials, they found that anxious participants took longer to respond to the probe when the preceding face was emotional (happy or angry) compared to neutral. These effects emerged for anxious participants only. Fox *et al.* (2002) argued that this increased 'dwell time' on the face was a function of the face being emotionally significant. However, their results indicated a delayed disengagement effect with happy as well as threatening faces, even with anxious participants. It is possible that this is attributable to the use of schematic faces which may lack realism and so may not contain the same emotional potency as a real face.

Nonetheless, their results do not enable us argue for a pure threat effect in this instance. This being said, recent research has succeeded in showing delayed disengagement from angry faces relative to happy and neutral faces by children aged 8 to 11 who had been abused compared to control children (Pollak & Tolley-Schell, 2003). The authors argued that due to their experiences, the abused children had developed hyper-sensitive selective attention to threatening stimuli, and therefore had greater difficulty in disengaging, possibly to monitor the threat. In support with a wider sample, Georgiou *et al.* (2005) also found delayed disengagement of attention from fearful facial expressions relative to happy, sad and neutral expressions using black and white photographs and an SOA of 600 msecs. Again however, this held only for high-trait anxious participants. This indicates that DDA effects may only be evident with very specific samples such as hyper-sensitive children or highly anxious individuals. Further, Georgiou *et al.* (2005) did not use angry facial expressions so it is still not clear if angry faces maintain attention compared to other facial expressions.

Finally, manipulation of methodology to create an even longer SOA enables the dot-probe task to speak to the issue of IOR (inhibition of return). In terms of inhibiting a perceived area to focus on novel information it is hypothesised that when the stimulus is significant, the IOR effect will be reduced. That is, attention will remain focused on the significant stimulus regardless of how long it has been displayed for, by virtue of its significance, and thus response to a probe in the same location will not be impaired. To investigate IOR, as previously mentioned, the valid trials are examined using SOAs of 800 msecs or over (Christ, McCrae & Abrams, 2002; Klein, 2000; Theeuwes & Van der Stigchel, 2006). Inability to inhibit the stimuli would be shown by faster response time on valid trials compared to invalid trials, indicative of a reduced IOR effect.

Importantly, reduced IOR effects have been found with threatening faces. At an SOA of 960 msecs, Fox, Russo and Dutton (2002) found a reduced IOR effect for anxious participants on valid trials when the cue was an angry face compared to a neutral or happy face. Rather than inhibit the location where the angry target was and move to the opposite location, participants instead dwelled at the location where the angry face had been presented. Therefore reaction to the subsequent dot-probe was quicker compared to valid happy and neutral trials. Moreover, these effects were found with both anxious and non-anxious participants, which Fox *et al.* (2002) argued demonstrated the power of an angry face on the maintenance of attention. This is in support of Le Doux (1998) who passionately argued that threat undergoes both rapid and crude processing by the amygdala, and then more elaborate processing by higher cortical areas. Initial capture and shifting to threat may be a function of the amygdala, whilst delayed disengagement and increased dwell on the threat may allow for elaborate appraisal to assess its threat potential.

In chapters 8-12 of this thesis, the cueing methodology will be used to investigate attentional bias to threat stimuli. This will address the question of whether certain face types capture, avert or hold attention. One of the most important limitations of existing studies is that they typically presented face pairs, so it is impossible to know whether a participant is orienting toward one stimulus, or actively avoiding the other. This is of fundamental importance when interpreting the results. Therefore, in the cueing studies of this thesis (chapters 8 to 12) all faces will be presented as single target cues preceding the probe. Second, the faces shown in the existing literature were in black and white. Although faces *per se* are ecologically valid, their presentation in monochrome weakens their realism and possibly their emotionality. Therefore, all the faces presented in this thesis will be presented in colour, and, importantly, will be rated for level of expressed emotion in order to maintain equivalent levels of emotion. Further, after being rating for level of expressed emotion, all faces that are selected will either have open or closed mouths so one expression is not exaggerated over another by the exposure of teeth. For the dot-probe studies, based on the literature, a range of SOAs will be examined to determine the deployment of attention over time, and how it is moderated by threatening stimuli.

Previous studies have also manipulated the balance of valid to invalid trials (e.g. Fox, Russo & Dutton, 2002). This has two implications. First, it may bias the results towards capture or disengagement as the participants learn a response set. Second, it leaves the researcher with fewer trials to analyse on the smaller percentage of trial type once incorrect responses are removed. This reduces the power of the statistical analysis. Therefore, the dot-probe studies in this thesis will contain 50 per cent valid, and 50 per cent invalid trials to reduce bias and maintain power.

Moreover, another dimension to the studies will also be added. Another way of conceptualising threat may be through the use of facial disfigurement. At present, this is supposition based on the available literature, and therefore, this needs to be addressed. This has theoretical importance in terms of our understanding of how participants perceive and react to disfigurement. Disfigured faces will therefore also form part of the stimuli to determine, at the initial stages of perception, how disfigurement is perceived. This thesis intends to ascertain whether the behavioural response found with angry faces in the empirical studies are also mirrored by the behavioural reaction elicited by disfigured faces. These questions are interesting both in terms of the novelty of empirical manipulation, since such research has not yet been undertaken, and also in terms of our theoretical understanding of how facial disfigurement is perceived. Thus, for all the cueing studies, as well as the other studies in this thesis, faces of emotional expression, neutral faces, and facially disfigured faces will be used as stimuli.

2.4. Present thesis contribution and research questions

The theoretical and empirical review has revealed significant research questions that will be examined in this thesis. The threat effect with angry faces is a well established phenomenon in the literature, yet the results are often inconsistent and conflicting. This thesis therefore wants to provide a further demonstration of this threat effect, and examine what stage of perception attention is affected. That being said, there is little controlled, experimental research on the perception of facial disfigurement, and thus, we do not know how such faces are appraised. Understanding the initial reaction to facial disfigurement and why it occurs is important if we are to assist with promoting better social interactions with all individuals. Therefore, the studies in this thesis will use both disfigured and emotional faces to address the central question of what behavioural reaction facial disfigurement elicits in the very initial stages of cognitive processing. It is hoped that this thesis will contribute to the existing theoretical understanding of attention to threat, as well as examine a novel area and provide a foundation upon which further research with facial disfigurement can proceed.

This thesis has three main aims that will be empirically addressed in chapters 3-13. First, the thesis aims to further demonstrate the behavioural reaction to emotional faces, and specifically demonstrate a threat response elicited by angry faces. Second, this thesis aims to determine whether or not it is possible to generalise and extend our present understanding of the threat reaction to angry faces to a threat reaction to disfigured faces. That is, to examine whether facial disfigurement elicits a threat reaction in the same way as observed with angry faces. Finally, the third aim, which is related to the previous two, is to investigate in an area that has little controlled or systematic research to examine the issue of why negative reactions are reported by those with facial disfigurement.

To explore these issues, two different attentional paradigms will be used. First, the rapid serial visual presentation design will assess whether attentional capacity is affected by expression and disfigurement (chapters 3-6). This paradigm examines processing under limited time constraints, and in a fixed location. Second, the dot-probe cueing method will be used to determine whether emotional expression and facial disfigurement affect attention, in terms of attentional capture and attentional disengagement (chapters 8-12). This will assess the effect of face type on attention over time and space, through the use of different stimulus onset asynchronies. Using both the RSVP and the dot-probe cueing paradigms will provide a way to ascertain whether there is a convergence of evidence across temporal and spatial constraints in terms of the reaction elicited by both angry and disfigured faces. In light of the results from the experiments, chapter 13 then presents a novel paradigm in an attempt to provide a clear synthesis of the results.

In terms of theoretical importance, this thesis will further our current understanding of how emotional, threatening, and disfigured faces are processed and how they are perceived in the initial stages of perception. This will first allow for an examination of how attention is affected by emotional faces. Second, we can then demonstrate how angry faces specifically affect behaviour in terms of a threat effect compared to positive and neutral facial expressions. Third, this thesis wishes to determine whether the theoretical explanations of a threat reaction to angry faces can be extended, by virtue of empirical similarities, to the reaction elicited by disfigured faces. If the results with disfigured faces mirrors the results found with angry faces, it may be hypothesised that disfigured faces are also appraised as threatening at a basic cognitive level.

These research questions have both theoretical and empirical importance and thus this thesis is seen as having the potential to provide a valuable contribution. If indeed it is found that disfigured faces are perceived as threatening in the initial stages of perception before social cognition can take place, this may help us to understand why such faces often receive initial negative reactions by perceivers. This may well be a by-product of evolution; a response associated with stimuli appraised as threatening before full cognitive elaboration of the stimulus occurs. Therefore an understanding of this may go beyond this thesis and may benefit further research into how to promote a more empathic understanding of disfigurement from the perceiver's perspective. Furthermore, results gained from this thesis may be used to inform individuals with disfigurement that initial negative reactions that they often receive may be elicited before the perceiver has time for full appraisal. Therefore, the overall framework of the studies will be conducted within a cognitive-evolutionary framework.

The second part of the thesis will now follow, which incorporates the empirical studies. The empirical chapters will be followed by the main discussion in chapter 14.

Chapter 3

Experiment 1: The use of the RSVP with upright and inverted faces

Introduction

The first study in this thesis uses the rapid serial visual presentation design (RSVP) to study the influence of faces on attention. In an effort to focus specifically on faces, neutral upright and neutral inverted faces only will be used as first and second targets. The effect of emotion will be investigated in later studies.

The RSVP paradigm consistently reveals that when two targets are to be detected (T1 and T2), there is a significant decrease in T2 detection performance when T2 follows 200-400 msecs after T1. This is a clear demonstration of an attentional blink (AB; e.g. Chun & Potter, 1995; Raymond, Shapiro & Arnell, 1992; Visser, Bischof & DiLollo, 2004; Vogel, Luck & Shapiro, 1998). However, when T2 immediately follows T1, detection is as good as performance outside of the AB. This is known as lag 1 sparing (Hommel & Akyurek, 2005).

The RSVP paradigm allows us to understand how attention is used to process items in the early stages of perception and the competition for resources when processing two items presented close together in time. The phenomenon of the AB (the deficit in T2 detection 200-400 msecs after T1) and lag 1 sparing (the preservation of T2 detection when presented immediately after T1) has led researchers to propose a two-stage processing model with an attentional gate mechanism to explain how items are processed under temporal constraints (e.g. Chun & Potter, 1995). When T1 is detected, by virtue of its features matching a known template, the attentional gate opens to allow processing resources to analyse the item (stage 1) and facilitate its movement to stage 2 for consolidation. Akyurek and Hommel (2005) argued that this attentional gate closes slowly and thus T2, when following immediately after T1, may ‘slip in’. However, once the gate is closed, nothing else can be processed until resources have finished processing the item(s) inside the gate.

In one of the first studies to use faces in the RSVP, Awh *et al.* (2004) found that when both T1 and T2 were upright faces, an extended AB was evident. That is, faces placed a lot of demand on cognitive resources so that it took longer for resources to be available to identify and consolidate a second target. However, they used a skeletal RSVP design (see Duncan, Ward & Shapiro, 1994) which is characterised by having only two targets and two distractors rather than a conventional RSVP. Second, they did not use inverted faces and so the effects cannot be attributed to facesness over some other property such as complexity or symmetry. It is the purpose of this chapter to use a traditional RSVP design with multiple distractors rather than the skeletal design used previously. In addition, the use of upright and inverted faces extends upon previous literature through systematic investigation of the effect of faceness on the attentional blink.

The rationale for manipulating orientation of faces is that humans seem to have superior processing of upright faces, but have significantly worse performance when the face is inverted. Faceness is difficult to determine when stimuli are inverted as shown through traditional classification tasks (Leder & Bruce, 2000; Maurer, Le Grand & Mondloch, 2002; Rousselet, Macé & Fabre-Thorpe, 2003; Yin, 1969) so the use of inverted faces here ensures that stimulus complexity is held constant whilst faceness is manipulated. Furthermore, the distractors are faces that are scrambled so as to retain complexity but to reduce faceness as compared to the targets.

No formal predictions of the effect of face orientation on the AB can be made, since the purpose of this chapter is to clarify the effect of faceness on attention at this early stage. It is anticipated that there will be a difference between upright and inverted faces on the AB, but the direction of this difference is not assumed. However, it may be found that when T2 is upright, the AB will not be as severe as when T2 is inverted, given the greater processing demands that inverted faces place on attentional resources. In support, Awl *et al.* (2004) showed that face processing in the RSVP is a resource demanding task, and this is likely to increase when the face is upside down. To reiterate, the AB is defined as demonstrating lag 1 sparing, followed by a deficit in performance, and then performance recovery (with no further deficits in performance), which follows existing definitions of the AB (Chun & Potter, 1995; Raymond, Shapiro and Arnell, 1992).

Method

Participants

Twenty-four students from Southampton University (2 male, 22 female) participated in the study on a voluntary basis. Their ages ranged from 18 to 22 years (mean = 19 years, SD = 1.1). All participants had normal or corrected-to-normal vision and were unfamiliar with the faces used in the experiment.

Materials

Eighty-five white, male, full-frontal faces, representing 17 individuals displaying neutral, happy and angry facial expressions were obtained from the NimStim Face Set[1]. The available Caucasian, male, full-frontal faces were selected that had open-mouthed neutral expressions, no facial hair and of a similar age (in their 20s). Six of the faces were upright (4 T1 upright faces, 2 T2 upright faces). Six other faces were fully inverted using Adobe Photoshop (4 T1 inverted faces, 2 T2 inverted faces). A further seven neutral faces were chosen as distractor faces. These faces were manipulated in Adobe Photoshop to rearrange the facial features (eyes, nose and mouth) within the face to retain the same visual information, but to minimise faceness. Three female faces were also taken from the NimStim Face Set, displaying neutral, open-mouthed expressions, to use in the practice trials. Each face measured 6cm by 8cm. (See Appendix A for faces used). The experiment was run on an IBM personal computer, using Presentation software.

Design

The experiment implemented an RSVP design, presenting 2 target faces among 7 distractor faces. The within-subjects variables were orientation of T1 face (upright or inverted), orientation of T2 face (upright or inverted) and lag position of T2 (7 positions). The dependent variables were the accuracy of identification of the T1 face in a 2AFC task (2 alternative forced choice task), and the accuracy of detection of the T2 face in a present/absent task.

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[1] Development of the MacBrain Face Stimulus set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the stimulus set.

Procedure

After providing written informed consent, participants were individually seated in a quiet cubicle approximately 60 cm from the computer screen. Participants were instructed to remember the identity of the first face they saw (T1) and to determine the presence (or absence) of T2.

The display began with a 500 msecs fixation point, followed by the RSVP. Each face was displayed for 80 msecs. A distractor face began the sequence, followed by T1. Seven lag positions followed T1 containing one T2 face, and 6 distractor faces. Each trial lasted 1220 msecs (500 msecs fixation and 720 msecs RSVP)[2]. After each trial, participants were prompted for two responses. The first response screen presented 2 faces in a 2AFC task showing the presented T1 and an alternative face of the same orientation. Participants pressed one of two marked keys to indicate which face they had seen as T1. Two of the T1 faces functioned as the actual targets, and two as the alternative choice for the 2AFC task. The second response screen presented the T2 face and participants again pressed one of two marked keys, this time to indicate whether the face had been seen as T2 or not. There was no time limit for responses. Participants were unaware that T2 appeared on every trial and speed of RSVP presentation ensured that this was not transparent. There was an ISI (inter-stimulus interval) of 1000 msecs after the response. Participants initiated each block of trials, and could take short breaks between each block.

To familiarise participants with the design, a practice block was presented first. This consisted of one block of 70 trials, using neutral female faces as targets. T2 appeared 10 times in each of the seven lag positions.

The main experiment consisted of 8 blocks of trials. The first four blocks were experimental requiring response to T1 and T2 (with full counterbalancing of T1 orientation and T2 orientation). The last four were control blocks that repeated the experimental blocks, but required a response to T2 only to ensure T2 was seen. Blocks and trials were randomised. Each block consisted of 70 trials. In each trial, T1 appeared after the first distractor. T2 appeared in each of the seven lag positions a total of 10 times, yielding 70 trials. Responses were made

[2] In the control condition, after each trial a screen saying ‘now press the space bar’ was added before the T2 response screen was presented. This was so response was not made directly after seeing the RSVP.

after each trial, and response was always required for T1 (where required) then T2. Figure 3.1 shows an example trial of the main experiment.

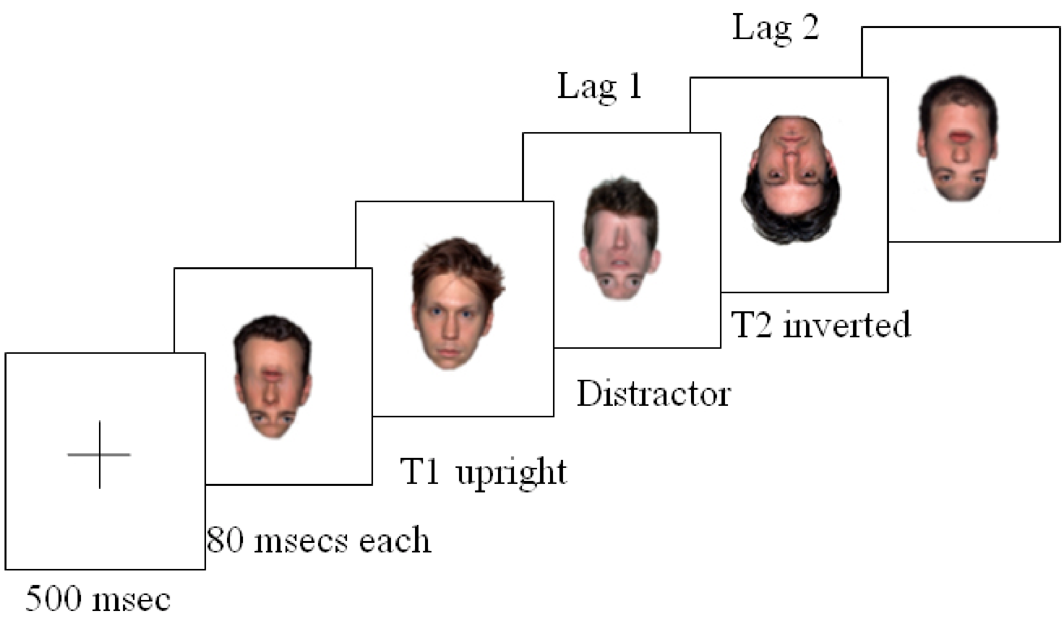


Figure 3.1. An example of the presentation display with T2 (here, an inverted face) in the lag 2 position (seven lags were actually presented).

After completing the computer experiment, participants were debriefed and thanked for their time. The experiment lasted for approximately one hour.

Results

The results are presented in three parts. Part one examines the proportion of T1 targets that were correctly identified. Part two examines the proportion of T2 targets correctly detected conditional on T1 accuracy. Finally, part three examines the performance in the control condition.

First Target (T1) Analysis

The proportion of correctly identified T1 upright and inverted faces as a function of T2 orientation of face is displayed in Table 3.1.

Table 3.1

The proportion of correctly identified T1 upright and inverted faces as a function of orientation of T2 face (with SE)

	T1 Upright		T1 Inverted	
	T2 Upright	T2 Inverted	T2 Upright	T2 Inverted
Mean	0.79	0.70	0.72	0.69
SE	0.04	0.04	0.05	0.05

The results were analysed using two repeated-measures ANOVAs (Analysis of Variance), which separated T1 orientation. This was to minimise spurious results.

Upright T1 faces. Using upright trials, an ANOVA was applied to the proportion of correctly identified T1 upright faces using lag (7) and T2 face orientation (upright, inverted) as the within-subject factors. There was no main effect of lag (F (6, 138) = 1.82, *ns*) nor of T2 orientation (F (1, 23) = .25, *ns*). There was no significant interaction (F (6, 138) = .85, *ns*). Thus, there was no influence of lag or T2 orientation on the identification of T1 upright faces.

Inverted T1 faces. Using inverted trials, the second ANOVA was applied to the proportion of correctly identified T1 inverted faces using lag (7) and T2 face orientation (2) as factors. As above, there were no main effects of lag (F (6, 138) = 1.5, *ns*), or of T2 orientation (F (1, 23) = .09, *ns*), and there was no significant interaction (F (6, 138) = 1.74, *ns*). Again, there was no influence of lag or T2 orientation on the identification of T1 inverted faces.

Second Target (T2) analysis

The proportion of correctly detected T2 faces was examined conditional on correctly identifying the T1 target face. Across all seven lags, and compressed across T1 orientation condition, 76 per cent (SD = .09) of T2 upright faces, and 70 per cent (SD = .07) of T2 inverted faces were correctly detected, conditional on T1 detection. Figures 3.2 to 3.3 shows the proportion of correctly detected T2 upright and inverted face targets across the different lag positions for each T1 orientation.

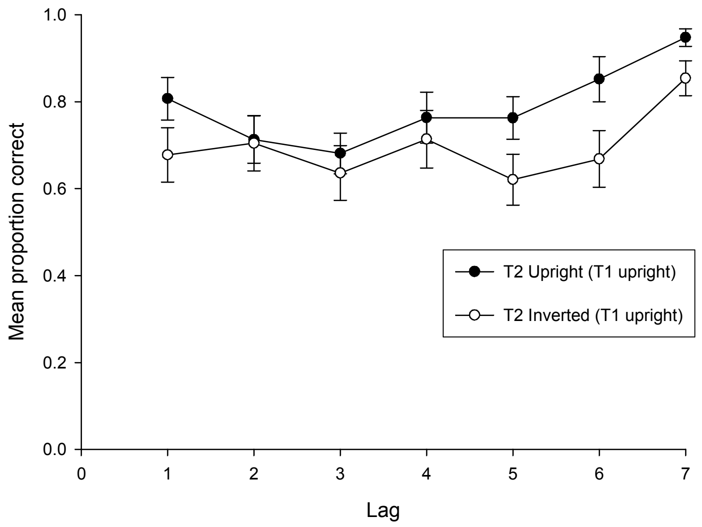


Figure 3.2. The mean proportion of correctly detected T2 upright and inverted face targets when T1 face targets were upright (with SE).

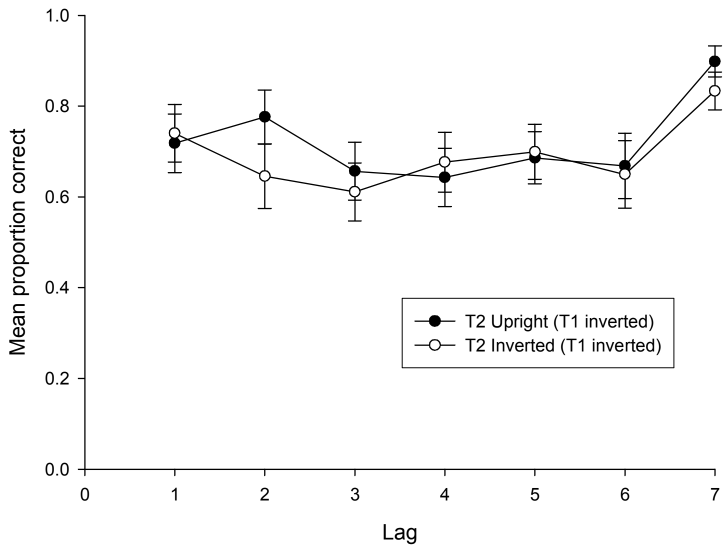


Figure 3.3. The mean proportion of correctly detected T2 upright and inverted face targets when T1 face targets were inverted (with SE).

Again, two ANOVAs are used to separate T1 orientation to minimise spurious results. A significant interaction was sought to assume an AB effect and justify post-hoc comparisons.

Upright T1 faces. A repeated-measures ANOVA on the proportion of correctly detected T2 faces when T1 was upright used T2 orientation (2) and lag (7) as within-subjects factors. This found a main effect of lag (F (6, 138) = 6.77, $p < .001$), which was explained by a quadratic fit of the data (F (1, 23) = 29.04, $p < .001$), and a main effect of T2 orientation (F (1, 23) = 4.86, $p = .038$) with significantly better detection when T2 was upright (mean = .79, SD = .17) compared to when T2 was inverted (mean = .70, SD = .2), $t(23) = 2.2$, $p = .038$. However, there was no significant interaction (F (6, 138) = 1.16, *ns*) and so there was no indication of an AB.

Inverted T1 faces. A repeated-measures ANOVA on the proportion of correctly detected T2 faces in the T1 inverted condition used T2 orientation (2) and lag (7) as within-subjects factors. This found a main effect of lag (F (6, 138) = 4.92, $p < .001$), which was explained by a quadratic fit (F (1, 23) = 14.24, $p < .001$), but no main effect of T2 orientation (F (1, 23) = .74, *ns*) and again no significant interaction (F (6, 138) = 1.17, *ns*). Therefore, there was no indication of an AB effect.

Control condition

Figures 3.4 and 3.5 show the mean proportion of correctly detected T2 faces within each condition. T1 identification was not necessary.

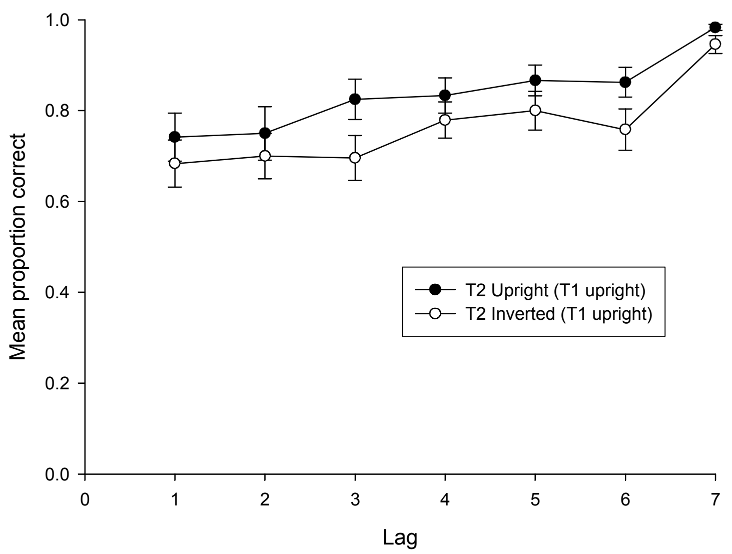


Figure 3.4. Mean proportion of correctly detected T2 upright and inverted face targets in the control conditions when T1 is upright (with SE).

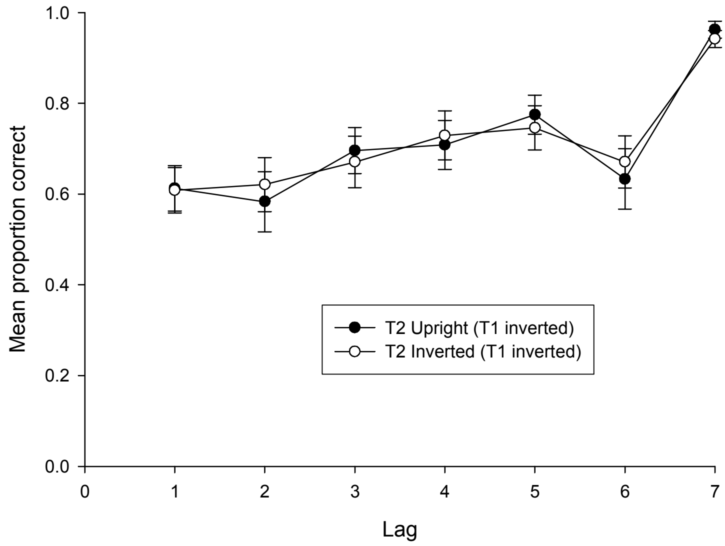


Figure 3.5. Mean proportion of correctly detected T2 upright and inverted face targets in the control conditions when T1 is inverted (with SE).

To maintain consistency of analysis, and again to minimise spurious results, T1 upright and inverted conditions were analysed separately.

Upright T1 faces. Proportion of correctly detected T2 faces in the T1 upright condition was examined with a repeated-measures ANOVA using lag (7) and T2 orientation (2) as within-subject factors. This found a main effect of lag (F (6, 138) = 14.29 $p < .001$), which was best explained by a linear fit of the data (F (1, 23) = 24.04, $p <.001$), and a main effect of T2 orientation (F (1, 23) = 5.84, $p = .024$), with significantly better performance when T2 was upright (mean = .84, SD = 1.6) compared to when T2 was inverted (mean = .77, SD = 1.7). However, there was no significant interaction (F (6, 138) = 1.02, *ns*).

Inverted T1 faces. As before, the proportion of correctly detected T2 faces when T1 was inverted was analysed with a repeated-measures ANOVA using lag (7) and T2 orientation (2) as within-subject factors. This found a main effect of lag (F (6, 138) = 17.7, $p < .001$), again, explained by a linear fit (F (1, 23) = 35.93, $p <.001$), but no main effect of T2 orientation (F (1, 23) = .007, *ns*). There was no significant interaction (F (6,138) = .46, *ns*). Thus, for the control condition, the orientation of T2 is a factor when T1 is upright given the main effect, but not when T1 is inverted. This in fact mirrors the experimental condition.

A supplementary analysis was also carried out to examine the effect of time across the experiment on identification and detection performance. This analysis can be seen in Appendix F, and is reviewed in the discussion.

Discussion

The current experiment aimed to investigate the effect of orientation of faces in the RSVP in terms of attentional and processing limitations. Overall, this study has revealed that face orientation does have some influence on attentional resources, however, the RSVP design failed to exhibit AB effects.

First, it was found that neither the orientation nor the lag position of T2 had any influence of T1 identification. This indicates that there was no influence of T2 on T1 processing. Secondly, upright T2 faces received better detection rates than inverted T2 faces, but only when the first target was upright. This indicates that a second upright target facilitated processing only when the first target was in a congruent orientation. Presenting inverted faces placed a great demand on processing resources, and therefore no T2 detection advantage was present when the first target was inverted. This fits with the research showing that inverted faces take longer to identify and detect (e.g. Leder & Bruce, 2000; Yin, 1969). Finally, with no statistically supported AB (as previously defined) effects were evident, perhaps a consequence of the design, which will be discussed shortly.

It was speculated that when a face was inverted it would be harder to process. Whilst this did not present itself as an extended attentional blink, this disadvantage did reveal itself in terms of T2 detection. That is, when both targets were upright, there was better T2 detection when upright compared to inverted. However, even detection of upright T2 faces was impaired when T1 was inverted. This is most likely a consequence of the inverted first target requiring substantial resources, first to re-orient the face, and second to make an identification judgement. This study has therefore complemented previous face research in supporting the argument that inverted faces are cognitively more demanding to process than upright faces.

Interesting, further support of this effect found in the experimental trials comes from the control condition, when only T2 was to be detected. Here again, performance was significantly better when the T2 face was upright compared to inverted. This was only evident when the first target was upright, even though participants were told to ignore this first target. This exposed (i) the difficulty of ignoring a face, and (ii) the difficulty of processing inverted faces under time pressure. These results again follow previous behavioural and physiological studies which have found inverted faces are both harder to process in terms of identification and detection time (e.g. Itier & Taylor, 2004; Leder & Bruce, 2000; Maurer, Le Grand & Mondloch, 2002; Rousselet, Macé & Fabre-Thorpe, 2003; Rossion, *et al.,* 2000; Rossion & Gauthier, 2002; Thompson, 1980; Yin, 1969).

This study has demonstrated that there was strong competition for resources when faces were presented under strict time constraints, which increased when faces were inverted. The study also indicates that under high load, even when one of the face was upright (for example, in the T1 inverted, T2 upright trials) they are not of special status as they cannot automatically grab attention and be processed with minimal resources. This is supported by the literature that has claimed that resources of sufficient nature are required to process faces; no matter how ‘special’ they are as a stimulus group (e.g. Pessoa, Mckenna, Gutierrez & Ungerleider, 2002; Lavie, 2005). Further studies may look at how different degrees of orientation affect processing under time constraints.

Awh *et al.* (2004) argued for multiple processing routes for faces in the RSVP. They suggested that faces receive both configural and featural processing to facilitate identification. However, when a face is inverted, the available configural information has been reduced, requiring extra resources to process the inverted stimulus to re-orient it to an upright position. Their theory is applicable here, and can be extended to include the increased demands a face will place on these processing routes when inverted. Hence, the inverted face may have required mental rotation back to its upright position before it could be adequately processed, which takes time and resources.

Research has also shown that disrupting the facial features (such as rotating the eyes and mouth) to make the face look grotesque, makes the face harder to identify when the face is also inverted (Thompson, 1980). These results are found with both adults and children (Bertin & Bhatt, 2004). Brain activation studies have also shown the processing difficulties of inverted faces. The N170, which is activated by visual stimuli but peaks higher for faces than objects (Eimer, 2000; Itier & Taylor, 2004) is enhanced and delayed for inverted faces but not inverted objects (Itier & Taylor, 2004; Rossion, *et al.,* 2000; Rossion & Gauthier, 2002) indicating that face configurations take longer to process when inverted.

Unfortunately, this study did not reveal clear AB effects, and therefore it did not fully address the initial question of how cognitive processing is affected by rapidly presented upright and inverted faces. One flaw of this study may be in terms of its duration, as it was a fully within-subjects design. On average, it was taking participants approximately an hour to complete, and therefore results may be confounded by fatigue effects. Although the blocks were self-paced, participants may not have taken the opportunity of a short break between blocks and so became unduly fatigued. A supplementary analysis was therefore carried out (see Appendix F). Unfortunately, because the study was fully counterbalanced across trials and blocks, an analysis comparing early blocks was not possible. However, it was possible to split the data to look at the first half of trials compared to the second half of trials. The main results from this found that the identification of T1 faces was significantly better in the first compared to the second half of data. This may therefore support the speculation that participants become fatigued during the trials, and thus their performance was affected by the second half of trials. However, regarding identification of T1 inverted faces, performance was better on the second compared to first half of the data. To resolve this conflict in results between upright and inverted T1 faces, this latter result may be due to gaining practice over time with the upside down faces which are typically rarely seen. That is, as participants became used to seeing inverted faces, they become better at the task. Finally, in the first half of the data, when T1 was inverted, but T2 upright, identification was significantly better at lag 7 compared to lag 6. This may be due to masking effects occurring in lag 6 but not in lag 7 because a face at lag 7 was never followed by a subsequent face. Thus, without the added attentional load of a subsequent face, identification of T2 in the final lag position was cognitively easier that in lag 6. This idea of masking is discussed in more depth in later chapters, and reviewed in the final discussion chapter.

Thus, in an attempt to resolve the problem of length of study, the same experiment will be repeated using a mixed design. T1 orientation will be varied between subjects so that participants will see either upright or inverted T1 faces, whilst T2 orientation and lag will remain as within-subject factors. Secondly, within each block of 70 trials, a break will also be inserted after 35 trials so that participants can rest their eyes if they wish to do so, and then can self initiate the next set of trials.

Chapter 4

Experiment 2: Demonstrating the AB with upright and inverted faces

Introduction

This chapter re-examines the issue of how upright and inverted faces are processed under strict temporal constraints. In the previous experiment, there were no statistically supported attentional blink effects when face orientation was manipulated in the dual-task RSVP. However, it was found that T2 detection was significantly better when faces were upright compared to inverted, and this may be attributable to configural disruption requiring increased resources to process. Thus, it appears that orientation does have an affect on attention and processing resources, but the previous study was unable to clearly reveal them through an AB.

One reason for not obtaining any AB effects may have been due to the design of the previous study. It took participants approximately one hour to complete the experiment, and therefore they may have been experiencing fatigue effects. Hence, rather than using a full within-subjects design, it may be beneficial to use a between-subjects design. Unfortunately, due to full counterbalancing and randomisation procedures, it was not possible to split the previous date file to examine first blocks only from the previous study, which may have excluded later fatigue effects. Nonetheless, an analysis of first compared to second half of data in each trial indicated that T1 identification attracted better performance in the first, compared to the second, half of a trial. This may suggest mental fatigue over time in the previous study. Mental fatigue effects refer to the effects that may be experienced during or following prolonged periods of cognitive activity (Desmond & Matthews, 1997). For example, Boksem, Meijman and Lorist (2005) instructed participants to perform a visual task, looking for letter targets in specific location, which was performed continuously for 3 hours. They found that participants' response times generally slowed down over the 3 hours, and expressed an aversion to remain at the task as it progressed. Physiological measures also suggested that participants were less able to resist attention to irrelevant items on screen as time passed. Thus, the study demonstrates the direct effect of fatigue on cognitive ability. However, in the previous study, the results from the supplementary analysis indicated possible effects of fatigue (although it is duly acknowledge that this is not based on an ideal block comparison analysis given the randomisation procedures preventing this), and is supported by anecdotal reports from several participants of feeling tired at the end of the experiment. This issue therefore needs addressing.

This present experiment is therefore fundamentally the same as before, except that T1 face orientation will now be varied between-subjects. It is hoped that this will reduce fatigue effects if they occurred and may reveal significant AB effects. Again, to reiterate, the attentional blink is operationally defined as demonstrating lag 1 sparing, followed by a deficit in performance, and then performance recovery, as defined by previous researchers (Chun & Potter, 1995; Raymond, Shapiro and Arnell, 1992).

Method

Participants

Thirty students from Southampton University participated in the study on a voluntary basis. Fifteen participated in the T1 upright face condition (2 male, 13 female; mean age = 19.4 years, SD= 1.2), and fifteen participated in the T1 inverted face condition (5 male, 10 female; mean age = 21.33 years, SD = 3.5). All participants had normal or corrected-to-normal vision. All participants were unfamiliar with the faces used in the current study and not taken part in any studies of this thesis.

Materials

Stimuli, apparatus and programming environment were identical to those used in the previous study.

Design

The design was essentially the same as the previous study (chapter 3). However, T1 face orientation (upright or inverted) was varied between-subjects rather than within-subjects. The within-subjects variables were T2 face orientation (upright, inverted) and T2 lag position (7) as before. The dependent variables were the accuracy of identification of T1 in a 2AFC task, and the accuracy of detection of T2 in a present/absent task. Rather than 8 blocks as before, participants received only 4 blocks (2 experimental, 2 control). Participants saw T1 as either upright or as inverted.

Procedure

All aspects of the procedure were identical to the previous experiment with the exception that participants saw either T1 upright or T1 inverted faces. This reduced the duration of the experiment from 1 hour, to approximately 30-35 minutes. Within each block, there was a break after 35 trials to provide regular rests. The trials were then self-initiated.

Results

As before, the results are presented in three parts. Part one examines the proportion of T1 target faces that were correctly identified. Part two examines the proportion of T2 faces correctly detected conditionalised on T1 accuracy. Finally, part three examines the performance in the control condition.

<u>First Target (T1) Analysis</u>

The proportion of correctly identified T1 upright and inverted faces as a function of T2 face orientation is displayed in Table 4.1.

Table 4.1
The proportion of correctly identified T1 upright and inverted faces (with SE) as a function of T2 orientation

	T1 Upright		T1 Inverted	
	T2 Upright	T2 Inverted	T2 Upright	T2 Inverted
Mean	0.61	0.46	0.48	0.45
SE	0.04	0.04	0.04	0.04

As before, the results were analysed using two ANOVAs, using lag and T2 orientation as factors, to separate out T1 orientation. This was to minimise spurious results and maintain consistency of analysis

Upright T1 condition: A repeated-measures ANOVA for the T1 upright group used T2 orientation and lag as the within-subjects factors. This found a significant main effect of T2 orientation (F (1, 14) = 4.78, p < .05), with better identification of T1 when T2 was upright compared to when T2 was inverted. There was no effect of T2 lag (F (6, 84) = .45, *ns*) as would be predicted since T1 was always in the same temporal position. However, there was a significant T2 orientation by lag interaction (F (6, 84) = 2.73, p = .025).

To explore this, a series of paired t-tests were conducted to compare proportion of correctly identified T1 upright faces when T2 is upright compared to inverted specifically at lags one to three. These lags were chosen on the basis of the AB timing as stated by previous literature, and to minimise spurious results through many multiple comparisons. Additionally, results were Bonferroni corrected to take account of multiple tests. At lag 1, there was no significant difference between T2 orientation (upright mean = .53, SD= 1.92; inverted mean = .54, SD = 2.23; t(14) = -.078, *ns*). However, there was a significant difference at lag 2 (t (14) = 3.4, p < .005), and at lag 3 (t (14) = 2.76, p < .025), with better T1 identification when T2 was upright than inverted in each case (Lag 2: upright mean = .7 SD= 2.03; inverted mean = .42, SD = 1.74; Lag 3: upright mean = .63, SD = 1.7; inverted mean = .41, SD = 2.17).

Inverted T1 condition: A similar analysis was applied using a repeated measures ANOVA with T2 orientation and lag as the within-subjects factors. This found no main effect of lag (F (6, 84) = 1.59, *ns*), or T2 orientation (F (1,14) = .45, *ns*). There was no significant interaction (F (6, 84) = .73, *ns*).

Second Target (T2) analysis

The proportion of correctly detected T2 faces was examined conditional on correctly identifying the T1 target face. In the T1 upright condition, compressed across all seven lags, 76 percent (SE = .07) of T2 upright faces and 69 percent (SE = .07) of T2 inverted faces were detected when T1 upright was identified. In the T1 inverted condition, 60 percent (SE = .07) of T2 upright faces and 62 percent (SE = .07) of T2 inverted faces were detected. Figures 4.1 to 4.2 show the proportion of correct decisions to upright and inverted T2 faces across the different lag positions for each T1 orientation.

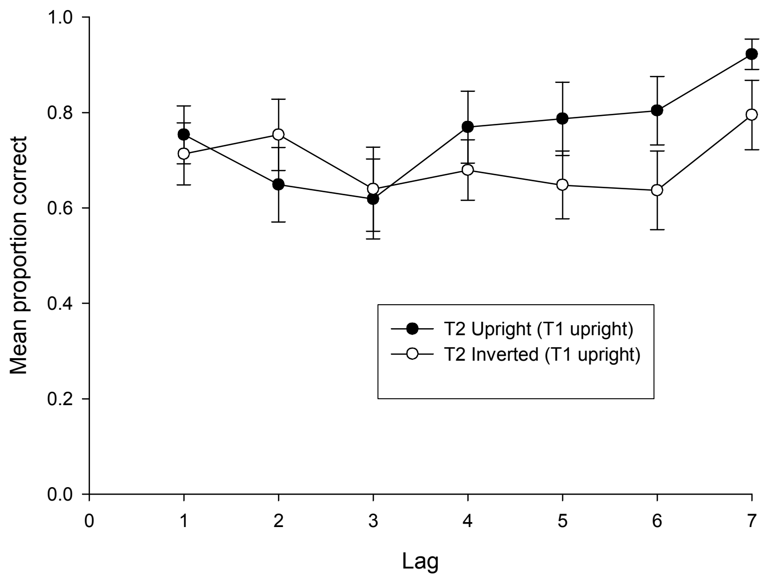


Figure 4.1. The mean proportion of correctly detected T2 upright and inverted face targets when T1 is upright (with SE).

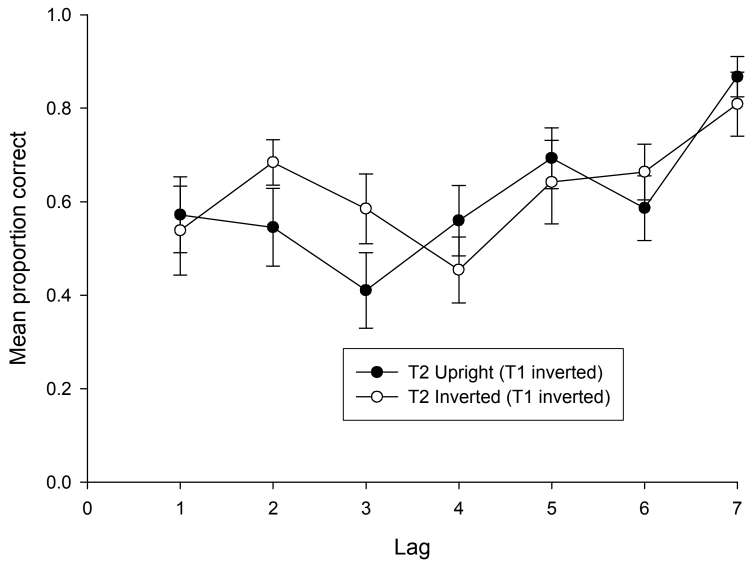


Figure 4.2. The mean proportion of correctly detected T2 upright and inverted face targets when T1 is inverted (with SE).

Overall, performance was worse when the second target was inverted, regardless of T1 orientation. Figures 4.1 - 4.2 suggest an AB effect only when T2 is upright, but this needs to be shown statistically.

A mixed ANOVA on proportion of correctly detected T2 faces used T2 orientation and lag as within-subject factors, and T1 orientation as the between-subject factor. This found a main effect of lag (F (6, 168) = 7.76, p < .001), which polynomial contrasts showed was a quadratic fit (F (1, 28) = 15.17, p < .001). There was no main effect of T2 orientation (F (1, 28) = .44, *ns*). There was, however, an effect of T1 orientation (F (1, 28) = 4.7, p < .05) indicating better T2 detection when T1 was upright than inverted. Lag by T1 orientation, and lag by T1 orientation by T2 orientation were not significant, (F (6, 168) = 1.2, *ns*; and F (1, 28) = .52, *ns,* respectively). A significant interaction of T2 orientation by lag however was evident (F (6, 168) = 2.16, p < .05) indicating a difference in the AB according to the orientation of the T2.

To explore this interaction further, performance was collapsed across T1 orientation and 2 one-way ANOVAs were conducted to examine the AB for upright T2 stimuli and inverted T2 stimuli separately.

AB for upright T2 stimuli. For upright T2 stimuli, the ANOVA revealed a significant effect of lag (F (6, 174) = 7.44, p < .001), which was explained by a quadratic fit to the data (*F* (1, 29) = 20.83, *p* <.001). Examination of Figure 4.3 confirms the presence of an attentional blink. Thus, the results support the pattern of results required to support the existence of an attentional blink.

AB for inverted T2 stimuli. For inverted T2 stimuli, there was also a significant effect of lag (*F* (6, 174) = 2.84, *p* < .025) which was explained by a cubic fit of the data (*F* (1, 29) = 4.77, *p* < .05). This cubic fit does not support the presence of an AB, and the pattern of results do not reflect the operational definition of an attentional blink as applied in this thesis (Figure 4.43). Rather, it most probably reflects noise in the data.

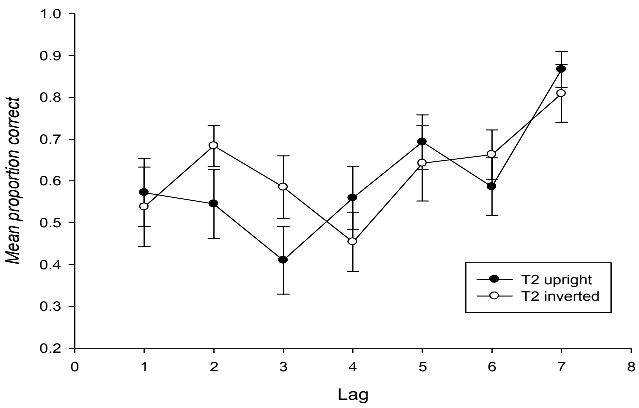


Figure 4.3. The mean proportion of correctly detected T2 upright and inverted face targets (with SE) collapsed across T1 orientation.

Control condition

The control condition presented both T1 and T2, but participants were required to detect only T2. A mixed ANOVA was conducted on the proportion of correctly detected T2 upright and inverted face targets using T1 orientation as the between-subjects variable, and T2 orientation and lag as the within-subjects factors. In line with the experimental results, this revealed a main effect of lag (*F* (6, 168) = 30.33, *p* <.001). A significant interaction was also revealed between lag and T1 orientation (*F* (6, 168) = 2.86, *p* <.025) and post hoc contrasts confirmed this as due to a linear lag effect when T1 was upright (*F* (1, 14) = 18.06, *p* <.001) but noise in the data when T1 was inverted with all bar one polynomial contrast reaching significance (*F* (1, 14) = 6.02), *p* > .028). However, more interestingly and in line with the experimental trials, a significant interaction was revealed between lag and T2 orientation (*F* (6, 168) = 4.21, *p* <.001) indicating a difference in the AB according to the orientation of the second target face. No other main effects or interactions reached significance (*Fs* (1, 28) < 3.92, *p* > .05).

AB for upright T2 faces: To explore the interaction of T2 orientation and lag, the post-hoc analysis conducted for experimental trials was repeated here. Again, data were collapsed across T1 orientation and a one-way ANOVA was conducted on T2 detection of upright faces. This showed a significant effect of lag (F (6, 174) = 25.79, $p < .001$) revealed as a quadratic fit of the data (F (1, 29) = 5.66, $p < .025$). Figure 4.4 confirms the presence of an attentional blink given the pattern of results reflects the operational definition of the AB as used in this thesis.

AB for inverted T2 faces: With the same analysis on the detection of T2 inverted faces, although a significant lag effect was revealed (F (6,174) = 10.14, $p < .001$). Figure 4.4 shows that this is not indicative of an AB effect as defined in this thesis and again indicates noise in the data.

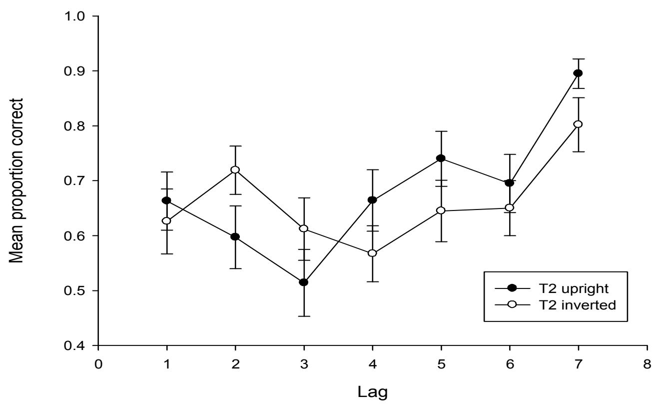


Figure 4.4. The mean proportion of correctly detected T2 upright and inverted face targets (with SE), collapsed across T1 orientation in control trials.

The results generally mirror the pattern found with T2 proportion correct in the experimental trials. An AB was found when the second target was upright but not when the second target was inverted. This indicates that we cannot ignore a face even when instructed to do so and participants were still influenced by the presence of the first target.

Discussion

The present study has yielded a clearer picture in an attempt to address the question of how faces are processed under temporal constraints. In the previous chapter, it was found that although analysis did not reveal significant attentional blink effects, there was an effect of orientation in terms of T2 detection. Within this study, it was shown that an AB was produced when the second target was an upright face, but not when the second target was an inverted face. These results suggest that orientation of a face is important in the allocation of attention to faces.

First, it was shown that identification of T1 was facilitated only when T2 was upright. Second, T2 detection was subject to an attentional blink only when T2 was upright. The results are consistent in terms of the accuracy of T1 identification: T1 identification was facilitated when T2 was upright but only at the point in time of the RSVP when the AB was apparent for T2. Theoretically, lag 1 performance of T2 upright was spared because it slipped into both processing and consolidation stages with the first target, as suggested by Chun and Potter (1995) in their two-stage model. However, by lags 2-3, when processing resources were occupied with the identification of T1, performance on T2 decreased, especially if one considers that there may have been confusion over the two faces, given they were both upright, in the 2AFC task.

Moreover, the orientation of the first target was not important in terms of the subsequent blink. What was important, however, was the orientation of the second target. Thus, an AB, as defined in this thesis, was apparent when the second target was upright but not when inverted. This first indicates the processing limitations of the second target (an upright face) when processing another complex second target, which becomes even more resource demanding when that second face is inverted. Then, performance is poor across all lags and so no AB can be established. Close inspection of the data shows that identification of the first target face was better when the second target was an upright face compared to an inverted face at the time of the attentional blink. During this time, processing resources were required to consolidate the first target, resulting in good T1 identification but poor T2 detection. However, this facilitation was not apparent when the second target was an inverted face because attentional resources were already under high load having to process a face of an unusual orientation.

Faceness is thus an important factor in the demonstration of an attentional blink. In this study, an AB was only evident when detecting a second target that was upright. Conversely, there was no traditional AB shown for detection of an inverted T2 face. Again, this is interpreted as the effect of processing demands on limited attentional capacity. When T2 was upright, attentional resources where sufficient enough to process both T1 and T2, but at lags 2 and 3, resources had to concentrate on the consolidation of the first target and so T2 detection became impaired. On the other hand, the lack of an AB when the second target was inverted is most likely due to the complexity of the task, especially on processing ability. In support, apart from lag 7, performance did not exceed past 65% across lags when T2 was inverted. A number of reasons may have created this processing complexity. First, processing a face that is at an unusual orientation is far harder than in its upright form (Leder & Bruce, 2000; Maurer, Le Grand & Mondloch, 2002; Rousselet, Macé & Fabre-Thorpe, 2003; Yin, 1969). Second, the fact that the inverted face was amongst scrambled distractor faces may have made the task especially difficult given that both face types still contained the same (limited) amount of faceness. In support Visser, Bischof and DiLollo (2004) commented that the greater the similarity between the targets and distractors, the harder the task becomes, yet they assert that this similarity is a necessary feature of any RSVP task.

This study therefore has three interesting findings. First, there was a clear demonstration of an attentional blink effect when T2 was upright. Second, orientation of the second target impacted upon T1 processing such that impairment arose when T2 was inverted. Finally this study showed that the issue of faceness in the RSVP is an important one. Faces are therefore not capacity free and indeed, require greater resources to process when their orientation is odd. Other studies have also shown that inverted faces take longer to process and receive worse identification rates than upright faces (Leder & Bruce, 2000; Maurer, Le Grand & Mondloch, 2002; Rousselet, Macé & Fabre-Thorpe, 2003; Yin, 1969). The cognitive demands of rotating a face are high, and this study has revealed a deficit of such processing when under time constraints.

The results here complement Awh *et al.'s* (2004) demonstration of an AB when presenting faces as both T1 and T2. Whilst they found this effect in a skeletal AB (Duncan, Ward & Shapiro, 1994), this study replicated this using a more traditional AB design. First, Awh *et al.* (2004) found the AB was diminished when T2 was a face and T1 was a digit indicating that in this task, faces could override the AB. Then, when T1 and T2 were both faces, they found that the AB was magnified because extensive processing resources were required to consolidate both items. Two notable limitations to this study do, however, exist. First, they used Duncan, Ward, and Shapiro's (1994) skeletal design, of 2 target items and 2 distractors only, and as such, the results require replication within a conventional RSVP methodology. Second, they used both male and female faces; the gender of the participants and stimulus may interact, so this needs to be controlled. Nonetheless, the present study has provided similar evidence of extensive resources needed for processing two faces in the RSVP, which is made worse by inverting a face.

Awh *et al.* (2004) suggested that with an RSVP, faces must undergo both featural and configural processing. This multi-route processing model of faces would imply that if both T1 and T2 faces were targets, T2 detection would be impaired, especially at the time when T1 requires consolidation, because both routes of processing are required for both targets. Taken further, a disruption in orientation would place further load on the processing resources from both routes. Perhaps participants were first mentally rotating the inverted face, which would then bring it to the normal upright position to allow for configural and featural processing. This cognitive procedure would certainly take time and resources. As an extension to this study, it would be interesting to take brain imaging scans whilst participants completed the task to determine the difference in time it took to process the upright and inverted faces under temporal constraints. Already, it has been shown that processing inverted faces takes longer than upright ones (Itier & Taylor, 2004; Rossion, *et al.,* 2000; Rossion & Gauthier, 2002).

Having established that faceness per se is an important factor in terms of attentional allocation and processing in the RSVP, the focus now is to consider the emotionality of faces. This is to address the issue of whether or not the emotional expression of a face impairs or facilitates attentional processing under temporal constraints. The next chapter will therefore examine this issue by focusing on happy and angry faces in an RSVP design.

Chapter 5

Experiment 3: The effect of angry and happy faces in the RSVP

Introduction

The main aim of this chapter is to move beyond the issue of faceness to the issue of emotional face processing under temporal constraints. More specifically, this chapter aims to determine the effect that emotional faces have on the attentional blink using the RSVP paradigm. Emotional and neutral faces will function as both first and second targets in the RSVP so as to fully examine their effect on attention.

Faces facilitate social communication through their emotional expression and are considered as socially significant stimuli (Bruce & Young, 1998). A large body of literature has converged to indicate that the face can display six basic emotions (Ekman, 1982; Ekman, Friesen & Ellsworth, 1982), although there may be many more subtle variations of expression caused by fleeting displays and blends of expression (Porter & Brinke, 2008). Further, there appears to be universal recognition of these emotions (Ekman, 1999; Ekman & Friesen, 1971; Ekman, Sorenson, & Friesen, 1969; Ekman *et al.,* 1987). Dimberg, Thunberg, and Elmehed (2000) argued that humans have a biological predisposition to attend to emotional faces. Specifically, angry and threatening faces are more likely to attract attention compared to happy and neutral faces (for reviews see Mogg, & Bradley, 1998; Williams, Watts, MacLeod & Mathews 1997). This may be evolutionarily advantageous as such faces provide information about present danger that the perceiver may be in, allowing for a rapid behavioural response. Eimer (2006) found that the brain is more responsive to fearful compared to non-fearful faces, indicated by enhanced positive event-related potentials to such faces. Moreover, Le Doux (1998) has argued that the amygdala can respond in two ways to the presence of threat. It can either allow for elaborate cognitive processing that takes time, or engage in a quick and 'dirty' pathway to rapidly assess for danger and prepare the individual.

Attention to emotional faces has been shown in a number of different paradigms. Both visual search studies (Eastwood, Smilek & Merikle, 2001; Fox, Lester, Russo, Bowles, Pichler & Dutton, 2000; Hansen & Hansen, 1988;

Ohman, Lundqvist & Esteves, 2001) and dot-probe cueing studies (Fox, Russo, Bowles & Dutton, 2001; Fox, Russo & Dutton, 2002; Green, Williams & Davidson, 2003) have produced results which converge on the conclusion that angry and threatening faces grab attention in the first stages of stimulus onset, and can also delay disengagement from such faces later on (Amir, Elias, Klumpp & Przeworski, 2003; Fox *et al.,* 2001; Georgiou *et al.,* 2005; Koster, Crombez, Verschuere & de Houwer, 2004; Yiend & Mathews, 2001). Having said this, the results are open to debate in terms of whether angry faces grab attention, or whether happy or neutral faces are easily suppressed (Hampton, Purcell, Bersine, Hansen & Hansen, 1989). Certainly, in traditional studies, it is not possible to say whether one is attending to the threatening stimuli, or simply attending away from the non-threatening ones.

Given this controversy, the RSVP paradigm is considered as a good indicator of attentional allocation. The previous attentional studies generally examined spatial effects of emotion on attention. On the other hand, the RSVP holds constant spatial location, whilst temporal presentation is carefully controlled. There is no stimulus competition in a spatial sense, and the temporal competition then informs about the competition for resources when processing expressions of different valence. As the RSVP design has been discussed extensively elsewhere in this thesis, to reduce repetition, this chapter will focus on the effects of the use of the RSVP with salient stimuli.

Recently, research has focused on the effect of stimulus significance in directing attention by using salient emotional stimuli within the RSVP. For example, Shapiro, Caldwell and Sorenson (1997) found that one's own name as T2 significantly reduced the AB compared to another name. Similarly, Arend and Botella (2002) found that the AB was reduced when T2 was a threatening word compared to neutral, which suggested that threat was processed rapidly and with fewer resources. Further, this effect was demonstrated even for non-anxious participants, suggesting that the RSVP method may be sensitive enough to investigate threat effects in the general population. A limitation of this study, however, is that only threat words were used as T2 stimuli, so there was no neutral or positive T2 stimulus to provide a baseline for comparison. As such, an emotionality hypothesis (response to negative and positive over neutral stimuli) cannot be ruled out. Nevertheless, it is worth noting that even if mildly threatening stimuli can influence the magnitude of the AB, more socially significant stimuli might be expected to affect the AB in a clearer and more robust manner.

More research recently examined the influence of facial emotion in the RSVP. Both Fox, Russo and Georgiou (2005), and Milders, Sahraie, Logan and Donnellon (2006) found that T2 fearful faces in the RSVP produced a reduced AB compared to T2 happy faces, which would seem to indicate that threatening faces are less attentionally demanding and thus show a smaller AB under temporal constraints. Further, de Jong and Martens (2007) found that T2 detection accuracy was higher when the face was angry compared to happy, and that the effect was stronger with low anxious participants. However, these studies are not without methodological and stimulus limitations. Neither Fox *et al.* (2005) nor Milders *et al.* (2006) used a neutral T2 condition, and so no baseline response was recorded. Similarly, de Jong and Martens (2007) did not have neutral T2 faces, although they did use neutral inverted distractors. Further, in de Jong and Martens' (2007) study, it is not known how similar the happy and angry faces were in terms of degree of expressed emotion. For example, it was not clear whether the emotional faces were matched on stimulus factors such as visibility of teeth, which can have a bearing on the extent of threat perceived in the face. Interestingly, Milders *et al*. (2007) presented their T1 face target with a green tint, which may have enabled the T1 face to stand out from other items and therefore made the task easier to complete relative to other studies. Moreover, their distractor faces contained scrambled internal features of both male and female faces, which may have affected the important factor of similarity between target and distractors.

Taking these limitations into consideration, the current experiment aims to improve upon the recent papers that have begun to examine emotional face targets in the RSVP. This will be achieved through using faces displaying happy, angry and neutral emotional expressions within a dual-task RSVP. Additionally, emotional expression will be explored in both the T1 and T2 positions. In explicit terms, the first aim of the following studies is to determine the effect that facial expression has on the AB. To reiterate, the thesis presents the operational definition of an AB as demonstrating lag 1 sparing, followed by a deficit in

performance, and then performance recovery, which follows existing definitions of the AB (Chun & Potter, 1995; Raymond, Shapiro and Arnell, 1992).
The second aim is to investigate whether any effect is driven by emotionality (occurring for both happy and angry faces compared to neutral ones), or is driven by threat (occurring for the angry faces only). Finally, the third aim is to determine whether there is a difference in effect when T1 is emotional and T2 is neutral, compared to when T1 is neutral and T2 is emotional. All images were colour photographs, rated for degree of expressed emotion to increase ecological realism. Again, distractors were scrambled faces to retain complexity. Given that chapter 3 exposed the negative consequences of presenting an experiment lasting for up to an hour, the following study again used a between-subjects design, showing half the participants T1 emotional faces (with neutral T2 faces) and half the participants T2 emotional faces (with neutral T1 faces). It is hoped that this would minimise fatigue effects.

Experiment 3a

The first experiment used emotional faces displaying happy, angry and neutral expressions as T1 faces, and neutral faces as T2 within a conventional dual-task RSVP design. Distractor items were scrambled faces so as to ensure target-distractor similarity in terms of matching for complexity and component parts.

Method

Participants

Fifteen students from Southampton University (one male, fourteen female) participated in the study on a voluntary basis. Their ages ranged from 18 to 37 years (mean = 20.6 years, SD = 4.8). All participants had normal or corrected-to-normal vision and were unfamiliar with the faces used in the current study. None of the participants had taken part in previous studies of this thesis.

Materials

Eighty-five Caucasian, male, full-frontal faces, representing 17 individuals displaying neutral, happy and angry facial expressions were obtained from the NimStim Face Set. The angry and happy faces displayed both open and closed mouth expressions. The happy and angry faces were presented to 25 participants (12 males, 13 females, mean age = 26.3 years, SD = 6.31) who did not participate in the study, and were asked to rate each face for level of expressed happiness/anger on a scale of 0 (*no expressed happiness/anger*) to 8 (*high expressed happiness/anger*). Faces were then selected which displayed equivalent levels of happiness and anger. The three angry faces had a mean score of 6.91 (SD = .36), and the three happy faces had a mean score of 6.77. (SD = .15), t (2) = 9.45, *ns*. Fifteen neutral faces were also selected. All of the faces had open-mouthed expressions, and all were of different identities. (See Appendix A and B for faces used in experiment 3a and 3b). The same seven scrambled faces were used as distractor faces as used in chapters 3 and 4. Also, the same three female faces were used from chapters 3 and 4 for the practice trials. The experiment was run on an IBM personal computer, using Presentation software.

Design

The experiment implemented a dual-task RSVP design; presenting 2 target faces among scrambled distractor faces (see Figure 5.1). The within-subjects independent variables were the emotional valence of the T1 face (happy, angry, neutral expressions), and the lag position of the neutral T2 face (1-7). The dependent variables were the accuracy of identification of T1 in a two-alternative forced choice (2AFC) task, and the accuracy of detection of T2 conditional on T1 identification in a present/absent task.

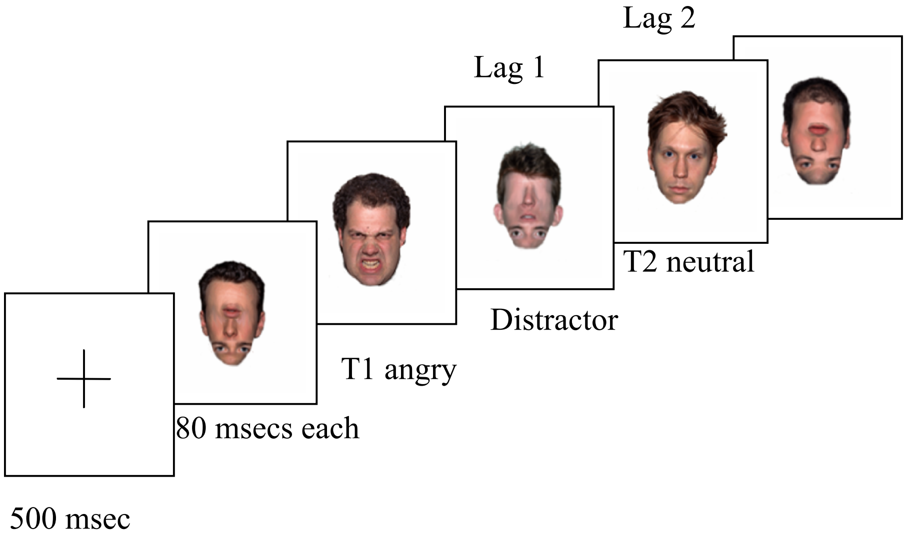


Figure 5.1. An example of the presentation display with T2 (here, a neutral face) in the lag 2 position (note, seven lags were actually presented).

Procedure

Participants were individually seated in a quiet cubicle approximately 60 cm from the computer screen, and were instructed to make responses using the appropriate response keys. To familiarise participants with the design, a practice block was presented first. This consisted of one block of 70 trials, using neutral female faces.

The main experiment then commenced. Participants were instructed to remember the identity of the first face they saw (T1) and to determine the presence (or absence) of a second face (T2). Participants were unaware that T2 appeared on every trial and speed of RSVP presentation ensured that this was not transparent.

On each trial, a 500 msecs fixation cross was followed by the RSVP. A distractor face always started the sequence, followed by T1. T1 was an emotional face (happy, angry, and neutral) and emotionality was blocked. Seven lag positions followed T1, and T2 could appear in any lag position. T2 was always neutral, and a different face was paired with each of the T1 emotion faces. The remaining lag positions contained distractor faces. Each stimulus in the RSVP was displayed for 80 msecs. Thus, each trial lasted 1220 msecs (500 msecs fixation and 720 msecs RSVP). After each trial, participants were prompted for two responses. The first response screen presented 2 faces in a 2AFC task showing the presented T1 and an alternative face of the same expression. Participants pressed one of two marked keys to indicate which face they had seen in that trial. The second response screen presented the T2 neutral face, and participants again pressed one of two marked keys, this time to indicate whether the face had been seen as T2 or not. There was no time limit for responses. After each response, there was an inter-stimulus blank screen for 1000 msecs, and then the next trial began. Participants initiated each block of trials, and could take short breaks between each block.

The main experiment consisted of 6 blocks. The first three blocks contained experimental trials requiring response to T1 and T2. The last three blocks contained control trials requiring a response to T2 only (to ensure that T2 was detected). Emotionality of the T1 target face was blocked in both experimental and control phases, and the three experimental blocks always came before the three control blocks. For each trial, T1 was in a fixed position in the

RSVP, appearing after one distractor. T2 appeared randomly in each of the seven lag positions a total of 10 times. This yielded the 70 trials within each block. Responses were made after each trial for T1 (where required) and then for T2. After completing the experiment, participants were thanked and debriefed. The experiment lasted approximately 35 minutes.

Results

As before, the results are presented in three parts. Part one examines the proportion of T1 emotional face targets that were correctly identified. Part two examines the proportion of T2 neutral face targets correctly detected conditional on T1 identification. Finally, part three examines the performance in the control condition.

First Target (T1) Analysis

The proportion of correctly identified T1 face targets is displayed in Table 5.1, as a function of emotionality.

Table 5.1
Mean proportion of correctly identified T1 faces in each T1 emotion condition (with SE)

Happy T1		Angry T1		Neutral T1	
Mean	SE	Mean	SE	Mean	SE
0.56	0.28	0.46	0.31	0.54	0.17

Examination of Table 5.1 indicates that performance overall was worse when the T1 target was an angry face compared to both happy and neutral faces. A repeated-measures ANOVA was applied to the proportion of correctly identified T1 faces using lag (7) by T1 emotion (happy, angry, neutral) as the within-subject factors. This showed a main effect of T1 emotion (F (2, 28) = 5.66, p = .009), but no main effect of lag (F (6, 84) = .87, *ns*). There was no significant interaction (F (12, 168) = .76, *ns*).

To explore this main effect of T1 emotion, three paired samples t-tests were conducted (with Bonferroni corrections, such that alpha = .01). This revealed no difference in performance in the happy T1 face condition compared to the angry T1 face condition (t (14) = 2.51, *ns*), and no significant difference between performance with happy T1 faces and neutral T1 faces (t (14) = .19, *ns*). However, there was a significant difference between angry faces and neutral faces, (t (14) = -3.6, p = .003), with worse performance on identification of angry T1 faces compared to neutral T1 faces.

Second Target (T2) analysis

The proportion of correctly detected T2 faces was analysed conditional on correctly identifying the T1 face. Overall, 72% (SE .04), 73% (SE .05) and 82% (SE .04) of T2 neutral faces were detected when T1 was happy, angry and neutral respectively. Figure 5.2 shows the results of correct response to T2 neutral faces conditional on T1 accuracy across the seven lag positions for each T1 condition.

A repeated-measures ANOVA was conducted, using lag (1-7) and T1 emotion (3) as the within-subject variables, with the proportion of correctly detected T2 faces conditional on T1 identification as the dependent variable. A significant interaction was required to justify post-hoc comparisons to examine for AB effects.

A main effect of lag was revealed (F (6, 84) = 5.46, $p < .001$). Polynomial contrasts showed that the best fit of the data was quadratic (F (1, 14) = 23.18, $p < .001$). There was no main effect of emotion (F (2, 28) = 2.89, *ns*), and no significant interaction of emotion and lag (F (12, 168) = .58, *ns*). Thus, there was no evidence to support the presence of an attentional blink for any particular group as the conditions could not be broken down and analysed separately.

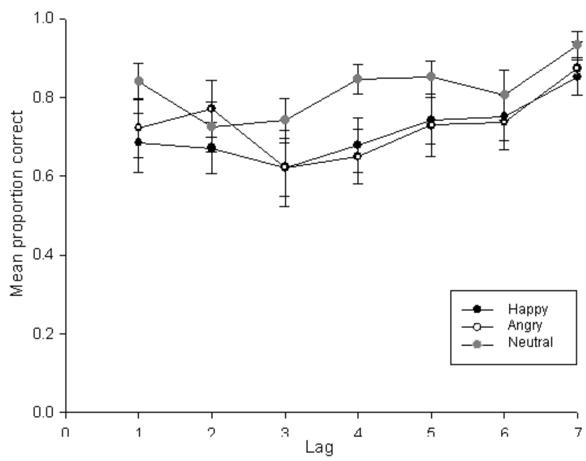


Figure 5.2. Mean proportion of correct decisions when detecting T2 neutral targets when T1 was happy, angry, and neutral.

Control Condition

The control condition consisted of presenting both T1 and T2 faces within the RSVP but instructing participants to detect the T2 face only. Overall, 74% (SE .49), 71% (SE .41) and 80 % (SE .44) of T2 faces were detected in the happy, angry and neutral T1 conditions respectively. Figure 5.3 shows the proportion of T2 faces correctly detected at each lag for each condition. Figure 5.3 indicates a similar pattern of responding to T2 neutral faces regardless of the T1 face. Again, a repeated-measures ANOVA on the proportion of correctly detected T2 targets, with lag (7) and T1 emotion (3) as factors, showed a main effect of lag (F (6, 84) = 6.71, $p <$ *.001*). Polynomial contrasts showed that the data had a quadratic fit (F (1, 14) = 12.87, p = .003). There was no main effect of emotion (F (2, 28) = 1.34, *ns*), and no significant interaction (F (12, 168) = 1.25, *ns*). These data thus confirmed the pattern shown in the experimental trials.

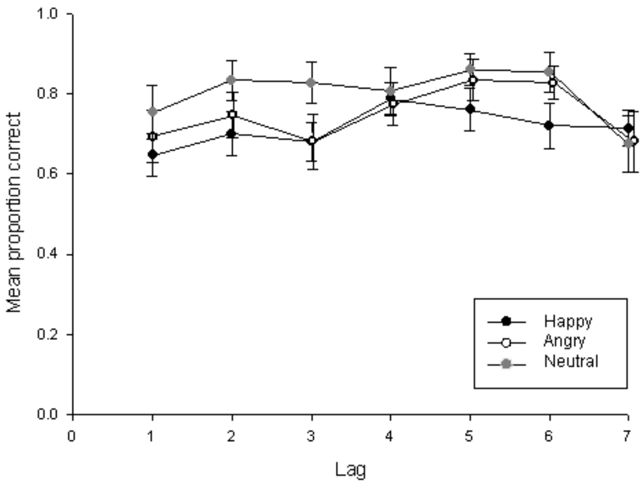


Figure 5.3. The mean proportion of correct decisions to T2 neutral face targets in the control blocks when T1 was happy, angry, and neutral (with SE).

Discussion

This study has two interesting findings. First, this study found no attentional blink effects, as operationally defined previously, when using emotional first targets and neutral second targets for any condition. Second, the expression of the T1 face had no direct effect on the processing of the subsequent T2 face. These results do not fit well with the previous chapter. Specifically, given the AB results with upright faces of the previous chapter, one may suggest that when presenting neutral (upright) faces as both T1 and T2 there would be some indication of an AB. Alternatively, it may be argued that the added influence of emotional faces in this particular study reduced the likelihood of exposing such an AB with neutral faces, especially if processing became more demanding with the inclusion of emotion.

These results also go against Awh *et al.*'s (2004) previous research that found a magnified AB when using neutral male and female faces as both T1 and T2 targets. Awh *et al.* (2004) advocated a multiple processing model of face perception, which would have beneficial effects when only one target was a face, but would impair detection when both targets were faces since both configural and featural processing would be required for both stimuli. Perhaps the added influence of emotional salience in the current study extinguished any attentional blink effects as processing was difficult *per se*, regardless of lag due to faces requiring maximal resources.

An important finding that arose from this experiment was that angry faces in the T1 position were significantly harder to identify than neutral faces, whilst there was no difference in performance between happy and neutral faces. This is counter to the notion that angry faces receive priority processing. However, poor identification results may have arise because, rather than assess identity first, participants may have initially assessed the degree of threat that the faces posed, which would concur with the notion of rapid threat detection (Le Doux, 1998). That is, upon presentation of threat faces, identification processing was put on hold. Indeed, detection is a cognitively easier task than identification (Palermo & Rhodes, 2003). Conversely, in the absence of threat, identity could be assessed, and thus happy, and especially neutral, faces received better identification processing. The explanation for poor accuracy of T1 when the face is angry may be because there is a processing advantage only for detection of threat, not identification. It is noted that although there was a difference in T1 identification between angry and neutral faces, no difference existed between T1 angry and happy faces, so this interpretation of the results is tentative given a pure ‘threat’ effect was not found here.

In partial support of the idea that socially significant stimuli do not always have a processing advantage, Arend and Botella’s (2002) found that even one’s own name as T1 (i.e. a significant stimulus) was unable to weaken the subsequent attentional blink. That is, even significant stimuli required attentional resources and were not capacity free. In this light, the inability for angry faces to attract more resources is less surprising. Indeed, any advantage may only appear in a detection task.

A further explanation may be that participants developed a top-down attentional strategy to examine face identity, which may have been impaired upon presentation of threat. This is because default, bottom-up, attentional control settings are particularly attuned to threat stimuli (Folk, Remington & Johnston, 1992). Thus the two opposing goals (top-down identity search and bottom-up threat detection) may have clashed and impaired performance, especially for T1 angry identification.

In the control conditions, it was evident that even though participants were instructed to respond to T2 only, they were still affected by the presence of T1. This supports previous data showing that it is very difficult to ignore a face (Dimberg, Thunberg & Elmehed, 2000). A main effect of lag was found, which was also found in the experimental trials where T2 report was conditional on T1 report. This indicates that the T1 faces were most likely being attended to subconsciously, and indeed previous studies have found subconscious awareness of faces (e.g. Batty & Taylor, 2003; Sato, Kochiyama, Voshikawa & Matsumura, 2001; Whalen, Rauch, Etcoff, McInerney, Lee & Jenike, 1998). Overall however, there was no evidence to suggest that emotion of the T1 had an effect on T2 processing in the experimental or control conditions.

Experiment 3b

To provide a coherent picture, it is now necessary to determine the effects of emotionality when T2 is the emotional face, and T1 is the neutral face in the dual-task RSVP. The methodology and stimuli were the same as the previous study, except that this time the T1 faces were neutral, and the T2 faces displayed an emotional expression. As stated before, an observed attentional blink is defined as demonstrating lag 1 sparing, followed by a deficit in performance, and then performance recovery, which follows existing definitions of the AB (Chun & Potter, 1995; Raymond, Shapiro and Arnell, 1992).

Method

Participants

Fifteen female students from Southampton University participated in the study on a voluntary basis who had not taken part in Experiment 3a. Their ages ranged from 18 to 21 years (mean = 19.3 years, SD = .09). All participants had normal or corrected- to-normal vision and were unfamiliar with the faces used. None of the participants had taken part in previous studies of this thesis.

Materials

Stimuli, apparatus and programming environment were identical to Experiment 3a. (Again, the stimuli used can be seen in Appendix A).

Design

As in Experiment 3a, the current experiment implemented the dual-task RSVP design, presenting two face targets among scrambled face distractors. This time however, the T2 face was happy, angry, or neutral, and T1 was always neutral. Again, the dependent variables were the accuracy of identification of T1 in a 2AFC task, and the accuracy of detection of T2 in a present/absent task.

Procedure

All aspects of the procedure were identical to Experiment 3a with the exception that emotional expression (happy, angry, neutral) was now varied for T2, while the T1 faces were always neutral. In this way, Experiment 3b represents the complement of Experiment 3a.

Results

As before, the results are presented in three parts. Part one examines the proportion of T1 targets that were correctly identified. Part two examines the proportion of T2 correctly detected conditional on T1 accuracy. Finally, part three examines the performance in the control condition.

First Target (T1) analysis

The proportion of correctly identified T1 neutral faces as a function of the T2 face emotion is displayed in Table 5.2.

Table 5.2

Mean proportion of correct response to T1 faces in each T2 emotion condition (with SE)

Happy T2		Angry T2		Neutral T2	
Mean	SE	Mean	SE	Mean	SE
0.5	0.35	0.52	0.31	0.54	0.17

Table 5.2 indicates that identification of T1 was similar across groups. This would be expected since all such faces were neutral. As before, a repeated-measures ANOVA was conducted using the proportion of correctly identified T1 stimuli as the dependent variable, and using lag (1-7) and T2 emotionality as the within-subjects factors. This found no main effect of lag (F (6, 84) = .75, *ns*), nor of T2 emotionality (F (2, 28) = 5.27, *ns*). There was no significant interaction (F (12, 168) = 2.1, *ns*). Thus, the type of T2 face and its position in relation to T1 did not have any effect on the prior identification of the neutral T1 face.

Second Target (T2) analysis

The proportion of correctly detected T2 faces was calculated conditional on correctly identifying the T1 face. Overall, 59% (SE .05) of happy T2 faces, 82% (SE .04) of angry T2 faces, and 67% (SE .06) of neutral T2 faces were correctly detected on T1 correct trials. Figure 5.4 shows the results across the different lag positions for each condition.

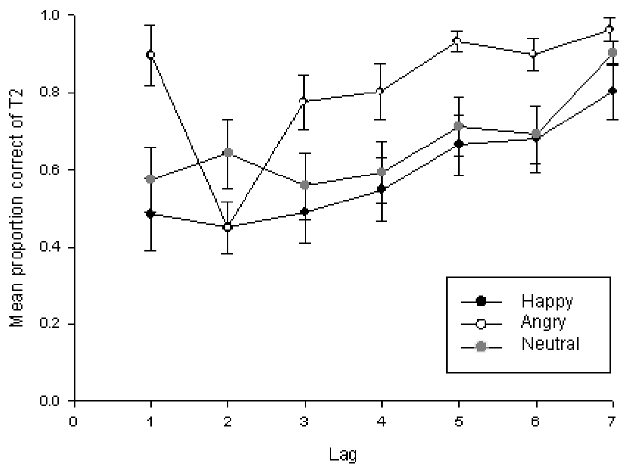


Figure 5.4. The mean proportion of correct decisions to T2 face targets when T2 was happy, angry, and neutral (with SE).

The most noticeable result from Figure 5.4 is that the AB curve for T2 angry faces indicates an AB at lag 2, with good performance at lag 1 and recovery of performance by lag 3. This indicates that the angry faces as second targets have a better chance of being processed at lag 1 due to their threat potential, but are still subject to an attentional blink at lag 2, with subsequent performance recovery. This pattern of results conforms to the operational definition of an attentional blink as used in this thesis.

To explore this statistically, as before a repeated-measures ANOVA with lag and T2 emotion as within-subject factors with T2 detection accuracy as the dependent variable was conducted. This found a main effect of lag (F (6, 84) = 12.8, $p < .001$), best explained as a linear fit (F (1, 14) = 33.18, $p < .001$), and a main effect of emotion (F (2, 28) = 9.6, $p < .001$) with detection highest for angry faces. These main effects, however, were qualified by a significant interaction of lag by emotion (F (12, 168) = 3.11, $p < .001$) facilitating further tests to examine for AB effects.

To explore this significant interaction, lags 1 to 3 were examined further. Lags 1-3 were chosen on the basis of the shape of the data as shown in Figures 5.4, where there appears to be differences between groups and lags. Further, limiting the number of tests preserved statistical power. A 3 x 3 ANOVA was conducted (with factors being lags 1-3; face type – angry, happy neutral), which found a main effect of lag (F (2, 28) = 5.95, p < .05), a main effect of face type (F (2, 28) = 5.69, p < .05), and a significant interaction (F (4, 56) = 5.81, p <.05). This further justified focusing on these three lags per face type. Thus, a series of paired samples t-tests were conducted comparing performance on lags 1 to 3 for each T2 face emotion. All results were Bonferroni corrected so that alpha was .005.

Angry T2. The analysis showed a significant difference on T2 detection in the angry face condition between lags 1 and lag 2 (t (14) = 4.21, p < .001), and between lags 2 and 3 (t (14) = -4.45, p < .001). No significant difference between lags 1 and 3 in the angry condition indicates that performance at these two points was comparable (t (14) = 1.68, *ns*). This would indicate that at lag 1, the angry face is quickly attended to and processed, followed by a deficit in processing at lag 2, with a rapid recovery of performance by lag 3.

Happy T2. In the T2 happy face condition, no AB was found. There was no significant difference between lags 1 and 2 (t (14) = .48, *ns*), nor between lags 2 and 3 (t (14) = -.49, *ns*), or between lags 1 and 3 (t (14) = -.04, *ns*).

Neutral T2. Similarly, no AB was found in the T2 neutral face condition. There was no significant difference between lags 1 and 2 (t (14) = -1.2, p = ns), between lags 2 and 3 (t (14) = 1.4, p = ns) or between lags 1 and 3 (t (14) = .28, *ns*). Taken together, these results demonstrate an AB effect driven by threat rather than emotion.

All lags

It is also possible to examine the effect of emotion across all 7 lags. The following presents these comparisons for each face type.

Angry faces. Alpha was adjusted to .002 to take account of the 21 paired t-tests (i.e., comparing each lag to every other lag). This found significant differences between lags 1 and 2 (t (14) = 4.21, p < .001), lags 2 and 3 (t (14) = -4.45, p < .001), lags 2 and 5 (t (14) = -6.96, p < .001), lags 2 and 6 (t (14) = -6, p < .001), and lags 2 and 7 (t (14) = -7.29, p < .001). In each case, detection was significant worse at lag 2, which indicates the detrimental effect of detection performance of the second target face during lag 2, with this deficit in processing being exposed when compared with most other lags. No other comparisons were significant (largest t (14) = 1.68, p = ns).

Happy faces: Alpha was adjusted to .002 to take account of the 21 paired t-tests. This found only one significant result, with better detection performance on lag 7 compared to lag 3 (t (14) = -5, p <.001). All other comparisons were non significant (largest t (14) = .49, all p = *ns*).

Neutral faces. Again, alpha was adjusted to .002 to take account of the 21 paired t-tests. This found significant differences between lags 1 and 7 (t (14) = -3.96, p < .001), lags 3 and 7 (t (14) = -4.44, p <.001), and between lags 4 and 7 (t (14) = -4.23, p <.001). Detection performance was significantly better at lag 7 in each case. No there comparisons were significant (largest t (14) = .28, p = *ns*). This indicates that by lag 7, detection performance on T2 significantly better than early lags.

Taken together, this further demonstrates an attentional blink as defined in this thesis for angry faces, but it is less clear for happy and neutral faces, and this will be explored in the discussion.

Further analyses

The above analyses looked at the effect of performance within each face type. Alternatively, one can examine across emotions. Hence, paired t-tests were also conducted to explore detection performance at lags 1-3 *across* the three face types. To take account of 9 paired t-tests, alpha was Bonferroni corrected to .005. Due to correcting for multiple tests, no effects were significant. However, some tests suggested a trend effect of better detection performance for angry faces compared to happy faces at lag 1 (t (14) = -3.15, p = .007, and better detection performance for angry face compared to happy face at lag 3 (t (14) = -3.07, p = .008) .This indicates that when not in the AB, detection performance for angry faces tended to be better detected that happy faces. All other comparisons were non significant: lag 1: happy faces and neutral faces (t (14) = -.83, p = *ns*), angry faces and neutral faces (t (14) = 2.64, p = *ns*); lag 2: happy faces and angry faces (t (14) = -1, p = ns), happy faces and neutral faces (t (14) = -2.19, p = *ns*), angry faces and neutral faces (t (14) = -2.19, p = *ns*), lag 3: happy faces and neutral faces (t (14) = -.79, p = *ns*), angry faces and neutral faces (t (14) = 2.19, p = *ns*).

Control Condition

The control condition consisted of presenting both T1 and T2 but instructing participants to respond to the T2 face only. Figure 5.5 shows the proportion of correctly detected T2 targets as a function of lag and condition.

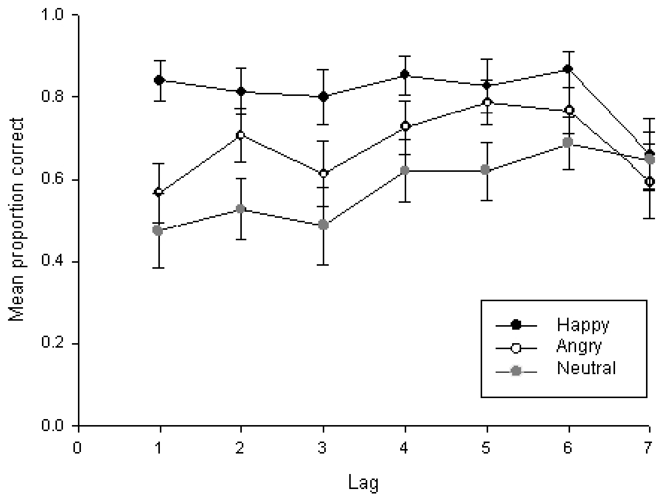


Figure 5.5. The mean proportion of correct decisions to T2 face targets in the control trials when T2 was (i) happy, (ii) angry, (iii) neutral (with SE).

As before, a repeated-measures ANOVA on the mean proportion of correctly detected T2 faces was conducted using lag (7) and T2 emotionality as the within-subjects factors. This showed a main effect of lag (F (6, 84) = 4.04, p < .001), explained best by a quartic fit (F (1, 14) = 10.44, p < .006), a main effect of condition (F (2, 28) = 11.31, p < .000), and a significant interaction (F (12, 168) = 2.25, p = .012). To explore this interaction, the same method of paired t-tests was conducted as conducted before. With corrected alpha of .005, these found no significant differences between lags 1 to 2, lags 2 to 3, or between lags 1 and 3 for any face expression. Statistically, therefore, there was no presence of an AB. Indeed, the absence of lag one sparing does not conform to the operational definition of an attentional blink used within this thesis.

Discussion

Unlike in Experiment 3a, this study demonstrated a significant effect of emotionality on the AB when T1 was neutral and T2 was emotional. Specifically, this was a threat effect as it was only evident with angry T2 faces, but not with happy or neutral T2 faces. This AB for angry faces conforms to the applied definition used in this thesis of lag one sparing, then a deficit in performance, followed by performance recovery (Chun & Potter, 1995; Raymond, Shapiro & Arnell, 1992). In terms of T1 identification, there were no significant differences in T1 identification as a function of the T2 condition. This was unsurprising since all T1 faces were neutral and T2 was presented after the fact. The clearest effects were evident in the T2 detection data. Initially, the graphical data suggested an AB for T2 angry faces, with lag 1 sparing and performance recovery by lag 3. Statistical analysis supported this, showing that an AB was present in the angry face condition only.

The AB could be understood in three phases. First, lag one sparing occurred, in the sense that the angry face at lag one was spared from the attentional blink. Second, there was a subsequent drop in performance by lag 2, and finally significant recovery of detection by lag three. This pattern of results constitutes an attentional blink of target two at approximately 180 msecs after target one. This pattern of results was not found for happy or neutral faces and therefore reflects a threat effect, rather than an emotion effect.

This study has shown that angry faces had a significant influence on processing resources, specifically when they appeared as second targets. The effect, however, goes against previous literature which has indicated that angry faces actually require fewer resources and thus reduced the AB (e.g. Fox *et al.,* 2005). In the present experiment, at lag one angry faces were able to quickly enter the attentional gate with the first target. This is endorsed by the drop in performance at lag 2 when processing resources were occupied with T1, leading to an AB. However, by lag three, detection was not significantly different from lag one performance, indicating that the processing resources dealing with target 1 were rapidly released, in order for the attentional gate to re-open. This final release of resources to give good lag 3 performance does fit with the literature on quick threat processing (Le Doux, 1998) and that threat has special social significance in terms of attracting attentional processing resources (Ohman, Flykt & Esteves, 2001; Ohman & Mineka, 2001). However here, quick threat processing is indicated by a quick recovery rather than by a reduced AB to begin with.

Given that seven lags were presented in this RSVP study, a second analysis was also conducted for each face type to compare each lag against every other lag. For angry faces, this again showed the deficit in detection performance at lag 2, and revealed that this was still significantly worse than performance at both lag 1 and at later lags. First, this supports the notion of good performance during the first lag, and thus lag one sparing as performance was not significantly worse at lag 1 compared to other lags. Second, it demonstrates the detrimental effect of having the second target presented 160 msecs after the first target. For happy faces, the only significant comparison was better detection at lag 7 compared to lag 3. For neutral faces, there was also better detection performance for T2 faces at lag 7 compared to most other lags. This may be interpreted as an AB effect at lag 3 for both happy and neutral faces, which would mean a later AB effect for non-threatening faces compared to the angry face. However, in line with the proposed definition of an AB needing lag 1 sparing, one may argue that good performance at lag 7 may have occurred due to the uniqueness of the lag 7 position: no other face followed this final lag, and therefore there was no subsequent face to interfere with the processing of the target when in this position. Hence, the design may have given rise to these findings of good performance at lag 7 compared to early lags for happy and neutral faces. One way to explore this further would be to always present a face after the final lag, but not have a target face as the final item. Arising from this discussion is the idea that within the RSVP, masking may be an issue. That is, each face may provide a strong mask for the preceding face, making it harder to distinguish between faces, and thus making the task more difficult than if distractors had been non-face items. (This idea of masking is discussed further in the final discussion chapter). Hence, at lag 7, the issue of masking is no longer apparent given that no distractor face will follow the T2 face in this position, and so performance is good as processing becomes easier. It is therefore acknowledged that this is a weakness of the design in this present task, and thus is certainly an area that could be explored with future research.

To note, a further analysis was conducted to examine detection performance of the second face target across face types at lags one to three. Unfortunately, due to the alpha correction to take account of multiple tests, the comparisons were not significant. However, there was a trend for detection performance to be better during lags 1 and 3 for angry faces compared to happy faces. This might be expected given the theoretical argument that angry faces are detected quicker than positive ones due to their threat potential (Le Doux, 1998, Ohman, 1997), which is often borne out in the empirical literature (e.g. Ohman, Lundqvist, & Esteves, 2001). Hence, in this present study, this analysis indicates that when not in the AB (i.e. during lag 2), detection performance for angry faces tended to be better detected than for happy faces. Although this could be taken as a threat effect, because there was no difference between angry and neutral faces at lags 1 and 3, such conclusions should be drawn tentatively and with caution until further studies are conducted to replicate such an effect under the same parameters.

The main results found in Experiment 3b differ from that of Fox *et al.'s* (2005) study, where they found an AB for both happy and fearful expressions. The present study found no evidence of an AB for happy, nor for neutral faces. This may be attributed to task differences. For example, Fox *et al.* (2005) did not present a face as their T1, presenting instead mushroom or flower pictures for a classification task. Further, it is not clear whether their emotional stimuli were matched, and this is essential when comparing emotional effects. Fox *et al.* (2005) used fearful faces from the Ekman set, whilst the present study used angry faces from the NimStim set thus the stimuli are not directly comparable. Finally, their reduced AB for T2 fearful faces was evident with anxious participants only. Nonetheless, they did show quicker recovery of detection performance when the stimuli were threatening, which was indicated in the present study here. Unfortunately, anxiety effects were not explored here, but personality characteristic could be examined in future studies.

A subsequent study by Milders, Sahraie, Logan and Donnellon (2006) found a weaker AB for T2 fearful faces compared to T2 happy faces, and this held for non-anxious participants. Again discrepancies between their results and the present results may rest with methodological differences. For example, they did not use neutral T2 faces, and used highly distorted distractor faces composed of scrambled male and female. This would essentially change the amount of visual information the distractors had compared to the targets, and may have therefore made the T1 and T2 task too easy. The present study, however, retained faceness by only scrambling internal features of a male neutral face

Nevertheless, Experiment 3b and recent papers are compatible in terms of finding rapid recovery of detection performance when T2 was threatening, compared to happy, and neutral in this case. This would suggest that the attentional gate is affected by the saliency of the stimulus, and will rapidly re-open if threat is detected. Indeed, if threatening faces are so socially relevant to human safety, one would expect results to hold not only for anxious individuals, but also for the general population. This is what was observed here. Finally, overall detection of T2 angry faces was highest, which de Jong and Martens (2007) also found with T2 angry compared to happy faces.

The methodological differences between this and previous studies may account for some of the differences in the results. These include the lack of a neutral face control, and scrambled faces as distractors. The present study is, however, indicative of a threat, rather than an emotionality effect. Only angry faces had a significant influence on processing resources. It is argued that in the T2 angry condition only, the attentional gate was rapidly re-opened by lag three by virtue of the appearance of a threatening stimulus. In support of this proposition, Akyurek and Hommel (2005) argued that the size of the attentional window within which targets are processed may be variable, and thus sensitive to the social significance of the stimuli. This experiment may further inform our understanding of our flexible attentional system that is responsive to significant stimuli.

General Discussion

Previous studies have shown that emotion, especially threat, does have an effect on attention. In the two experiments presented here, angry expressions in the T2 position showed evidence of being susceptible to processing limitations, but with the ability to recover quickly. Conversely, neutral and happy faces were unable to affect resources in a similar way. Furthermore, emotionality of T1 had no influence on T2 processing, indicating that within this study, emotion is only a factor when it is presented as a second target.

Akyurek and Hommel (2005) argued that the size of the attentional window within which targets are processed may be variable, and thus sensitive to the social significance of the stimuli. Indeed, both this study, and previous AB studies with faces (Fox *et al.,* 2005; Milders *et al.,* 2006) have found better detection rates with angry faces, compared to happy and neutral faces. This indicates that, as shown by numerous behavioural studies, threatening faces grab attention. Further, Experiment 3b suggests rapid recovery from the attentional blink with angry faces, which was not evident with T2 happy or neutral faces.

This is consistent with the literature by Fox *et al.* (2005), Milders *et al.* (2006) and de Jong and Martens (2007). This compatibility of results does indicate the effect of threat having the power to attract attention, even when resources may be limited. However, when identity of the angry faces is also required, any processing advantage is extinguished.

These results with angry faces also conform to the initial attention blink studies that demonstrated an AB through lag one sparing, followed by a performance deficit, and then subsequent performance increase (e.g. Chun & Potter, 1995; Raymond, Shapiro & Arnell, 1992). Here, this pattern of results was most apparent with angry faces. Although there were significant improvements in performance from early lags to lag 7 for happy and neutral T2 faces, (and T1 was neutral) as shown by the full lag analysis, it is difficult to argue for a true attentional blink effect given the problem of masking issues as previously discussed. (This will also be discussed in more detail in the final chapter of the thesis). Further, neither the happy faces nor the neutral faces as second targets showed signs of lag one sparing, where as the angry T2 faces did.

The results found here are in contrast to those found in other RSVP studies presenting emotional faces. Rather than finding a reduced AB effect for angry faces, the opposite results was found, showing an AB only for angry faces in the second target position. Differences in methodologies may account for this discrepancy, although replication would be required, especially because of the infancy of the use of the RSVP with emotional faces. As far as the author is aware, this was one of the first studies to look at the effect of expression on attention using the RSVP presenting colour emotional faces for a T1 identification task and a T2 detection task, and presenting a neutral condition, whilst using distractors that retained the same amount of visual information as the targets.

It is now an aim of this thesis to determine what effect disfigured faces will have when used in the RSVP, compared to non-disfigured faces. If it can be found that the results with T2 disfigured faces mirror what has been found with T2 angry faces, it may indicate that disfigured faces are appraised as threatening much like the angry faces.

Chapter 6

Experiment 4: The effect of disfigured faces in the RSVP

Introduction

In this present chapter, the focus will turn to investigating the processing of facial disfigurement under restricted time constraints. The previous chapter found that there was an apparent attentional blink when T2 was angry and T1 was neutral, with lag 1 sparing, and recovery of processing resources by lag 3. No AB was found for T2 happy and neutral faces, so it was argued that the attentional gate was affected by the social significance of threat and not emotionality. Curiously, the data were counter to published data showing a reduced AB for angry faces. The present chapter will now determine whether disfigured faces will act in the same way as angry faces within the RSVP.

Schimmack (2005) indicated that we need to broaden our understanding of the effect of threat intensity on attentional biases to determine what stimulus changes affect attention. Along with expression changes, manipulating the appearance of a face can also alter the salience of the face for the perceiver. As yet, little research has examined the effect of different facial appearances. This study will therefore be one of the first to use facial disfigurement within an RSVP paradigm. Such a study is important to both extend our current theoretical understanding of threat, and to understand what drives initial reaction to facial disfigurement.

Disfigurement affects approximately 500,000 people in the United Kingdom (Changing Faces). Social psychological research indicates that individuals with disfigurement receive negative reactions, from avoidance in public places to poor recruitment chances (Bull & Rumsey, 1988; Clarke, 1997; Partridge, 1990; Rumsey, Bull & Gahagan, 1982; Stevenage & McKay, 1999). The negative social consequences have been well documented, yet the immediate cognitive reaction to disfigurement has received little attention (Grandfield, Thompson & Turpin, 2005). This is therefore an important research area.

Disfigurement, by definition, disrupts symmetry, and Park, Faulkner and Schaller (2003) suggested that asymmetrical stimuli in the environment receive negative appraisal, which increases as the visibility of the difference increases

(Pryor, Reeder, Yeadon & Hesson-McInnis, 2004; Schaller, Park & Faulkner, 2003). Theoretically therefore, the initial reaction may be one of threat, since facial disfigurement can differ substantially from the norm face, and which may eventually lead to the negative social consequences that have been reported. Since initial threat detection, via the amygdala, is rapid and dirty (Le Doux, 1998) it does not allow for full cognitive appraisal and therefore the threat response to disfigurement may be uncontrollable and automatic. Thus, if disfigurement is perceived as threatening, then it should affect the attention system much like other threat stimuli, such as angry faces (Le Doux, 1998; Ohman & Mineka, 2001).

The use of the RSVP design here will address the issue of how disfigurement is attended to and perceived. First, this will allow for a comparison between disfigured faces and non-disfigured faces in the dual-task RSVP. Second, this will allow for a comparison between the results obtained here, and the results obtained with the emotional faces in chapter 5.

In terms of the present study, if disfigurement is perceived as a potential threat in the initial stages of perception, it is expected that the results of this study will be comparable to the emotional RSVP such that a disfigured face will yield the same results as an angry face. To allow for comparisons to be made across studies, and to retain experimental consistency, the same dual-task RSVP methodology as used in chapter 3 was applied to the present experiment using disfigured and non-disfigured faces. To control for type of disfigurement, disfigured faces all have the same disfigurement, that is, a port wine stain (PWS). The incidence of port wine stains occurs in approximately 3 in 1,000 people, and so is a prevalent type of facial disfigurement. This has been artificially applied to the faces and always on the right side of the face. This is in the hope of controlling for extent and location of the PWS. Again, to control for fatigue effects, half of the participants saw non-disfigured faces as T1, and half saw disfigured faces as T1 (with both types as second targets). This time however, a mixed experiment was used to enable better comparisons between conditions.

Method

Participants

Thirty students from Southampton University (mean age = 28.53, SD = 8.6, 10 males) participated in the study on a voluntary basis. Fifteen participants (mean age = 30 years, SD = 10.4, 5 male) were in the non-disfigured T1 face condition, and 15 participants (mean age = 27.1, SD = 6.3, 5 males) were in the disfigured T1 face condition. All participants had normal or corrected-to-normal vision and were unfamiliar with the faces used in the study.

Materials

The experimental stimuli consisted of 12 Caucasian, male, full-frontal faces (six neutral, six disfigured) and seven male distractor faces. The six male neutral faces were from the NimStim Face Set. The six male faces that were artificially disfigured were obtained from the Stirling PICS Database. The disfigurement was a port wine stain (PWS) created artificially using Photoshop after extensive research on the shape and colour of the PWS. Each face had the same red PWS on the right side of the face. This controlled for extent and location of the PWS. (See Appendix C for faces used). The seven male distractor faces, and the three female faces used for practice trials, were the same as those used in the previous emotional AB experiment (chapter 5). The experiment was run on an IBM personal computer, using Presentation software.

Design

The experiment implemented an RSVP design, presenting 2 target faces among distractor faces. The between-subjects variable was the T1 face type (non-disfigured, disfigured). The within-subjects variables were the T2 face type (non-disfigured, disfigured) and T2 lag position (1-7). The dependent variables were the accuracy of identification of T1 in a 2AFC task, and the accuracy of detection of T2 in a present/absent task. Apart from the change to the stimuli, all aspects of the design were the same as chapter 5.

Procedure

Again, all aspects of the procedure were the same as the experimental procedure used in chapter 5.

Results

As before, the results are presented in three parts. Part one examines the proportion of T1 targets that were correctly identified. Part two examines the proportion of T2 faces correctly detected conditional on T1 accuracy. Finally, part three examines the performance in the control condition. In line with the other AB studies in this thesis, the AB is defined as showing lag 1 sparing, followed by a deficit in performance, and then performance recovery, which follows existing definitions of the AB (Chun & Potter, 1995; Raymond, Shapiro and Arnell, 1992).

First target (T1) analysis

The proportion of correctly identified T1 non-disfigured and disfigured faces as a function of T2 face collapsed across lags is displayed in Table 6.1.

Table 6.1

Overall mean proportion of correctly identified T1 normal faces and T1 disfigured faces as a function of T2 face type (with SE)

	T1 Non-disfigured		T1 Disfigured	
	T2 Non-disfigured	T2 Disfigured	T2 Non-disfigured	T2 Disfigured
Mean	0.54	0.50	0.36	0.44
SE	0.03	0.06	0.03	0.03

A mixed ANOVA was conducted with lag and T2 face type as within-subject factors, and T1 face type as a between-subjects factor, using the proportion of correctly identified T1 face targets as the dependent variable. This revealed an effect of T1 face type (*F* (1, 28) = 10.03, *p = .004*). As can be seen from Table 6.1, this indicates that identification of T1 was significantly better when T1 was normal rather than disfigured. All other tests were non significant (lag: *F* (6, 168) = 1.23; lag x T1 face type: *F* (6, 168) = .46; T1 face type x T2 face type: *F* (1, 28) = 2.61, lag x T2 face: *F* (6, 168) = 1.04; three way interaction: *F* (6, 168) = .81, all *ns*).

Second Target (T2) analysis

The proportion of correctly detected T2 faces was examined conditional on correctly identifying the T1 target face. Figure 6.1 illustrates the results for each condition across the 7 lags positions.

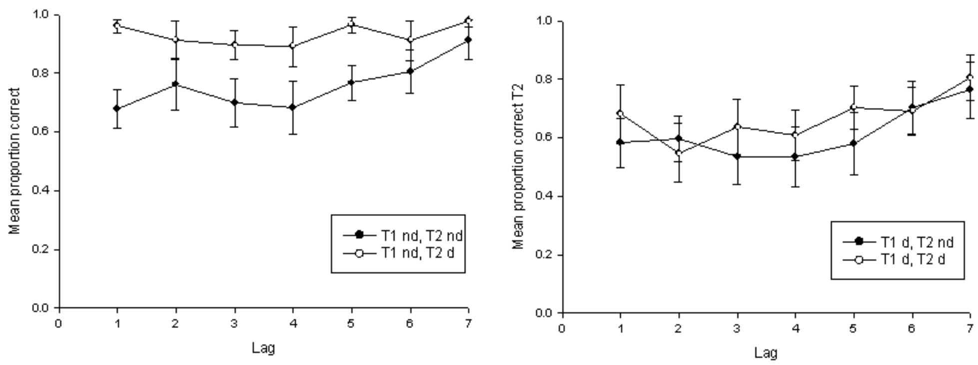


Figure 6.1. Mean proportion (with SE) of correctly detected T2 faces, (a) T1 non-disfigured (nd), T2 non-disfigured (nd), T1 non-disfigured (nd), T2 disfigured (d); and (b) T1 disfigured (d), T2 non-disfigured (nd); T1 disfigured (d), T2 disfigured (d).

A mixed ANOVA was applied to the proportion of correctly detected T2 targets using T1 face type (non-disfigured, disfigured) as the between-subjects factor, and lag (1-7) and T2 face type (non-disfigured, disfigured) as the within-subjects factors. A significant interaction with lag was sought to enable further examination for AB effects.

A main effect of T2 face type was revealed (*F* (1, 28) = 6.12, *p = .02*). Detection of T2 disfigured faces (mean = .8, SE = .04) was significantly better than detection of T2 non-disfigured faces (mean = .7, SE = .046). There was also a main effect of lag (F (6, 168) = 5.71, $p < .001$), explained best by a linear fit of the data (F (1, 28) = 25.8, $p < .001$). A main effect of T1 face type was also found (F (1, 28) = 7.94, $p = .009$), showing that performance on T2 detection was significantly better when T1 was non-disfigured than when T1 was disfigured. These effects were not moderated, either by 2-way or 3-way interactions (all Fs < 1.67, $p = ns$). Therefore, there was no evidence of an attentional blink for any of the conditions, as null interactions meant that the lag effect could not be explored further within particular conditions.

Control condition

As before, the control condition presented both T1 and T2 face stimuli, but participants were required to detect only the second target. This was to determine the ability to detect T2 without the need to process another target. Figures 6.2 to 6.3 shows the mean proportion of correctly detected T2 faces within each T1 face type condition in the control trials.

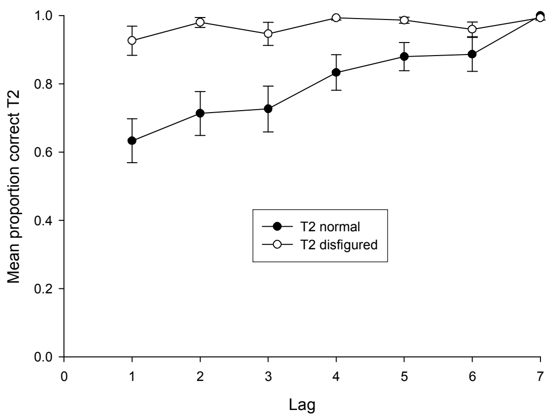


Figure 6.2. Mean proportion correct of T2 non-disfigured and disfigured faces in the control condition when T1 is a non-disfigured face (with SE).

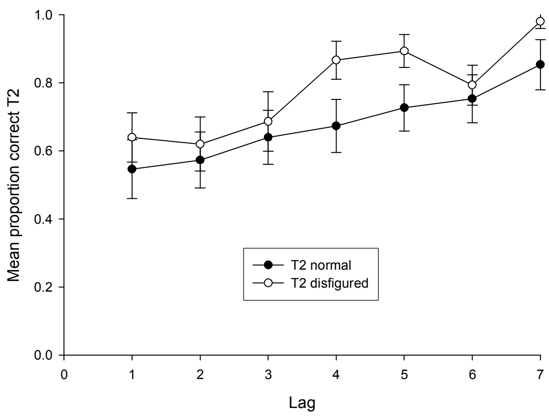


Figure 6.3. Mean proportion correct of T2 non-disfigured and disfigured faces in the control condition when T1 is a disfigured face (with SE).

The same analysis was conducted here as with the experimental T2 trials. A mixed ANOVA was applied to the proportion of correctly detected T2 face targets with T1 face type as the between-subjects variable, and T2 face type and lag as the within-subjects variables. This found a main effect of lag (F (6, 168) = 25.76, p < .001), best explained as a linear fit as shown by polynomial contrasts (F (1, 28) = 48.32, p < .001), and a main effect of T2 face type (F (1, 28) = 8.58, p = .007). Performance was significantly better with disfigured T2 faces (mean .88, SE .026) compared to non-disfigured T2 faces (mean = .75, SE = .04). The main effect of T1 face type was also significant (F (1, 28) = 10, p = .004). Performance was significantly better on control trials when the ignored T1 was non-disfigured rather than disfigured. There was a significant T2 face type by lag interaction (F (6, 168) = 2.48, p = .025). There was also no interaction of T1 face type by T2 face type (F (1, 28) = .41, *ns*), nor of lag by T1 face type (F (6, 168) = 2.02, *ns*). These were however qualified by a significant three-way interaction (F (6, 168) = 4.29, p < .001).

To explore the significant interactions in more detail, each T1 face type group was taken separately. A repeated-measures ANOVA was run for each group, using the same within-subjects variables as before.

Non-disfigured T1. For the non-disfigured T1 face condition, this revealed a main effect of T2 face type (F (1, 14) = 10.94, p = .005). Performance was significantly better with disfigured T2 faces compared to normal T2 faces. There was also a main effect of lag (F (6, 84) = 13.95, p <

.001). Polynomial contrasts showed this to be a linear pattern (F (1, 14) = 34, p < .001. There was also a significant T2 face type x lag interaction (F (6, 84) = 6.6, p = < .001). This indicated a steady improvement as lag increased when T2 was a normal face type but performance with T2 disfigured faces was the same across lags, and thus no true AB effect. Hence, because detection performance just showed a steady increase across lags when T2 was non-disfigured and steady performance across lags when T2 was disfigured, there is no evidence to confirm the presence of an AB as defined by this thesis.

Disfigured T1. For the T1 disfigured face condition, there was only a main effect of lag (F (6, 84) = 13.87, p < .001). Polynomial contrasts showed this was a linear pattern (F (1, 14) = 23.38, p <.001). This again indicated a steady improvement as lag increased.

Discussion

This study has revealed several interesting findings. First, in terms of T1 identification, disfigured faces were harder to identify. Identification of the face may have been disrupted by the appearance of the port wine stain. Therefore more time may have been necessary to process a disfigured face. This could be attributed to the disfigurement creating a visible deviation from the norm, and this needs further analysis before identity can then be processed. Indeed, just like inverted faces, disfigured face most likely placed greater processing demands on cognition. Identification performance in both cases therefore suffered compared to a non-disfigured, upright face.

Secondly, interesting results were apparent with the T2 data. Detection of the T2 face was significantly better when it was a disfigured face relative to non-disfigured face. This was evident in both experimental and control conditions. When disfigurement appears as the second target, it may receive better detection as detection is a cognitively easier and less demanding task than identification. Further, regarding good detection of disfigured faces, angry faces also received good T2 detection (chapter 5). Thus, this detection advantage may arise because both disfigured and angry faces are perceived as significant to the perceiver as so require further analysis. Perhaps this is an indication that, like angry faces, disfigured faces contain some sort of threat, although at this stage there is not enough evidence to claim this.

Finally, this study failed to find any effect of disfigurement on the attentional blink, as defined by this thesis. First, a linear pattern with non-disfigured faces when functioning as both T1 and T2 faces indicates that perhaps there was a processing disadvantage in the first few lags until resources were free to consolidate T2. This is in contrast to the previous findings in chapters 3 and 4, which found that upright faces show evidence of an AB, and facilitation effects in processing compared to other face types. As was the case when emotional faces were presented and no AB was found with the neutral faces, perhaps the presence of disfigured faces weakened any effect with non-disfigured, upright, neutral faces and so no AB could be established. Second, there was no evidence in the present study to indicate that disfigurement, either in the T1 or T2 position, produced an attentional blink. In fact, performance across lags remained relatively constant. Whilst angry and disfigured faces shares some similarity regarding a detection advantage, there were no further similarities. This weakens the argument that disfigured faces may be appraised as threatening, as the results here are not compatible with the results found with angry T2 faces in chapter 5. The results do, however, indicate that disfigurement was cognitively demanding to process, much like inverted faces.

These results may indicate that a dual-task RSVP is not suitable to reveal very subtle attentional effects. That is, if it is difficult to process a particular face, then the requirements of an RSVP to process two items is lost (Chun & Potter, 1995). Both the presence of emotional and disfigured faces may have weakened any effect that was previously presented with upright, neutral faces as second targets (chapter 4). In light of the present empirical chapters, it is suggested that the RSVP design may be too resource demanding to reveal sensitive similarities (or indeed differences) between angry and disfigured faces. Thus, the RSVP may not allow us to examine whether or not disfigurement elicits a threat reaction like angry faces because of task demands. In light of this, it is at this point a change of methodology is required and this will be discussed further in the next interim chapter.

It is expected that there will be at least some degree of threat in the response elicited by a disfigured face. Indeed, Blascovich *et al.* (2001) found a physiological threat reaction, as revealed by increased cardiovascular activity, by participants when interacting with an actor made up with a port wine stain. Park, Faulkner and Schaller (2003) have commented that throughout history, individuals with visible physical differences are often stigmatised. They argued that this has evolved from an adaptive system of our ancestors to avoid organisms that could be infected with diseases. In an age before modern disease knowledge, this would have been beneficial for survival. However, this can be maladaptive if such cognition persists upon sight of something not aesthetically pleasing, such as facial disfigurement, but is not harmful. Theoretically therefore, based on Park *et al.*'s (2003) parasite-avoidance model, disfigurement may elicit a threat response and thus there is continued effort to reveal this within this thesis.

In summary, this study did not reveal any AB effects with neutral faces. Specifically, no AB effects were found with disfigured faces. This weakens the idea that disfigured faces are perceived as threatening because T2 disfigured faces did not act in the same way as T2 angry faces. However, there was some similarity between angry and disfigured faces in terms of a detection advantage, which could indicate that the reaction to disfigured faces contains an element of threat. The RSVP task may not be able to expose this further, and so a change of methodology is required, and this will be discussed in the next chapter.

Chapter 7
Interim Summary

7.1 Summary of previous experiments

So far, the studies reported have used an established RSVP design to examine whether reaction to facial disfigurement mimics reactions to facial anger. Chapters 3-4 showed that face processing is affected by rapid presentation, especially when the face is inverted. Inversion increases the amount of resources needed to process such a face, and so performance is impaired across all lags. Only when both targets are upright faces is there evidence of an attentional blink, because when faces were inverted processing was just too demanding.

Regarding emotional faces, results were less clear, showing that only angry faces exhibited a rapid attentional blink at lag 2. Interestingly, however, the results of chapter 5 did not mimic the established literature even when a standard threat face was examined. Indeed, chapter 5 found that an attentional blink was evident when first targets were neutral faces and second targets were angry faces, but no AB effects were present with neutral or happy T2 faces. In other words, an AB was present when the second target was threatening rather than being reduced in this condition (Fox *et al.,* 2005; de Jong & Martens, 2007; Milders *et al.,* 2006). Conflicting results, as discussed, may have arisen due to differences in methodology between the present and previous experiments. Specifically, the present study used neutral faces as distractors, thus embedding the two targets within a highly similar RSVP stream. In contrast, previous studies have used neutral pictures of non-faces such as flowers or mushrooms, or scrambled male and female faces together as a distractor images. Indeed, Visser, Bischof and DiLollo (2004) commented that the RSVP task may become harder the more similar the targets and distractors are, yet they said that this is a necessary aspect of the RSVP. To account for the results found in chapter 5, it was argued that the attentional gate rapidly opened after an AB to angry faces as shown by rapid recovery of T2 performance, indicating that threat caused an initial attentional blink. Researchers have argued that angry faces quickly recover from the AB (Fox *et al.,* 2005; Milders *et al.*, 2006), although given the interpretation problems that will be discussed, it is difficult to argue for this here as well.

Chapter 6 was designed to examine whether the attentional blink to angry faces would generalise to disfigured faces. The results, however, found no statistical evidence of an AB to disfigured faces. From the outset, it was hypothesised that if disfigured faces were appraised as threatening, the response to them should be similar to the response found with angry faces. In terms of a detection advantage for T2, angry and disfigured faces both shared this property, and so there was some evidence of similarity between them. However, this was not borne out through the demonstration of an AB itself. It was argued that perhaps the method was not sensitive enough to reveal this further. It is also important to recall that in both the RSVP studies using emotional and disfigured faces, there was no indication of an AB with the neutral and non-disfigured faces. This further suggests that the added presence of emotion and facial disfigurement in the RSVP placed great processing demands on cognition so as to impair task performance. The issue of masking as a problem in the attentional blink, due to presenting faces as both targets and distracts, as well as presentation timing, was also discussed.

In an attempt to address some of these issues, a change of methodology will now be adopted to enable not just the temporal allocation of attention to be examined, but the spatial allocation of attention to be examined as well. Whilst this thesis set out to use two prominent attentional paradigms to provide convergent evidence, it is now theoretically appropriate to change paradigm at this stage as driven by the empirical results. Specifically, the dot-probe cueing task will enable scrutiny of the allocation of attention not just under time pressure (as the RSVP) but also in a way in which separates out attentional focus toward or away from a single target.

There are several reasons to prompt a change in methodology at this stage. The RSVP paradigm involves a dual response. That is, participants must attend to both T1 and T2. This places a large cognitive demand on processing resources. Therefore, if processing facial disfigurement is cognitively demanding, any effect on T2 processing may be lost under the weight of task demands for T1 processing. Thus, we cannot differentiate between the influence of faces in both first and second positions.

Importantly, there is an issue of interpretation difficulty associated with the RSVP. That is, one could interpret the presence of an attentional blink in one of two ways. The first and most conventional interpretation would be that T1 processing takes up significant resources and so resources are limited during the consolidation phase, resulting in poor T2 detection (Chun & Potter 1995). Alternatively, the AB may actually be a consequence of an avoidance of the T2 at a particular point in time. This issue of interpretation becomes more problematic when examining salient stimuli, especially when considering the debate over whether a particular face captures or averts attention. Thus, this dual-task methodology does not allow us to specifically expose whether there are processing limitations when consolidating the first face, or whether the second face itself is causing aversion of attention. Given that the RSVP design requires dual processing, this is a significant problem. A change in methodology is adopted here in response to this.

Furthermore, the initial reaction to facial disfigurement may be more complex than first thought. Although the reaction may contain an element of threat, this may be exhibited as both an avoidant and capture response with different behavioural responses exhibited at different points in time. In the social psychological literature, it is evident that individuals stare at those with facial disfigurement (Grealy, 2004; Partridge, 1990), but also avoid such individuals (Bull & Stevens, 1981; Crystal, Watanabe & Chen, 2000; Johnston, 2002; Rumsey, Bull & Gahagan, 1982). This indicates that perhaps there are two motivating forces driving the perceiver response, which may be exposed at different times. Importantly, this could be exposed when using a different methodology with different stimulus onset asynchronies. The cueing task enables this, and provides a spatial measure as well as a temporal measure of allocation of attention. In this sense, direction as well as time course of attentional allocation can be examined.

Thus, it now appears that the cueing paradigm seems more appropriate than the RSVP paradigm to examine the initial reaction to facial disfigurement if it is hypothesised that the reaction is more complex than first assumed. Furthermore, within each study, both angry and disfigured faces can be presented so that results can be directly compared within-subjects, producing more robust analysis.

7.2 Proposed methodology

The dot-probe, or exogenous cueing, paradigm examines the effect that a stimulus item has on the capture and engagement of attention (Posner, 1980). As already discussed in the introductory chapters (chapters 1 and 2) this paradigm has been used with emotional faces showing that angry faces initially capture attention and then delay the disengagement of attention, especially in anxious individuals (e.g. Fox *et al.,* 2001). Recent evidence also suggests an avoidance of angry faces by some individuals (Cooper & Langton, 2006) and so the threat effect with angry faces may also depend on the methodology used. The paradigm will therefore allow for an assessment of both where attention is allocated and at what stage it is allocated there. Angry and disfigured faces will be used, alongside happy and neutral faces. Based on the literature, it is hypothesised that if disfigured faces are appraised as threatening, they will mimic the response found with angry faces.

Again, these studies will explicitly address the main aims of this thesis. First, the studies will provide a demonstration of the threat effect with angry faces. Second, they will be used to establish whether the same effects exist with disfigured faces to enable an extension of our theoretical understanding. Finally, the studies will provide controlled and systematic experiments to an under-researched area.

Therefore, the next set of experiments will use both emotional faces and disfigured faces but this time the methodology makes use of the exogenous cueing paradigm. Stimulus onset asynchrony (SOA, the time interval between the onset of the cue and the onset of the probe) will be manipulated to examine attentional capture and delayed disengagement effects. A measure of anxiety will be taken in all experiments in an attempt to clarify the effect of anxiety as a mediating variable (see Mogg & Bradley, 1998). This is because the threat effects in typical cueing studies generally hold with high anxious individuals only (e.g. Fox, Russo & Dutton, 2002). Given the parameters of the cueing task, the next set of studies will allow for an examination of attention to disfigurement not just at a temporal level, but at a spatial level as well, in order to see whether attention is oriented towards, or averted away from, angry and disfigured faces.

Chapter 8
Experiment 5: Presenting emotional and disfigured faces in a rapid cueing task

Introduction

This chapter aims to examine the effect of emotional and disfigured faces when such faces are presented very quickly at different spatial locations. Attention orients rapidly to threatening stimuli such as angry faces, which provides an adaptive response to allow for safety-seeking behaviour (Le Doux, 1998). Empirical evidence for this has been shown using attentional paradigms such as visual search and dot-probe tasks. This chapter is concerned with the dot-probe cueing method, which assesses orientation of attention at different spatial locations. It aims to further demonstrate this attentional effect with angry faces, and to determine whether the same response can be found with disfigured faces. This would facilitate a clearer theoretical understanding of the initial reaction to facial disfigurement.

The dot-probe task involves the presentation of two boxes either side of a central fixation cross. A cue then appears in one of the two boxes, followed by a probe. When the probe appears in the same location as the cue, the trial is known as ‘valid’. When the probe appears in the opposite location to the cue, the trial is known as ‘invalid’. The time between cue onset and probe onset is called the stimulus onset asynchrony (SOA). The SOA can be manipulated to reveal initial capture to, and delayed disengagement of attention from a specific stimulus as well as later inhibition of return when attention has finally been disengaged (Posner, 1980). With a short SOA of less than 300 msecs, initial capture can be assessed (Cooper & Langton, 2006). This is when response is quick on a valid trial, indicating that the cue was significant as it rapidly drew attention to the location of the subsequently probe. At SOAs of up to 600 msecs, engagement of attention may be shown through slowing of response on invalid trials. This occurs when a particular cue holds attention and response is slow to the probe at the other location (Fox, Russo & Dutton, 2002). Finally at long SOAs, i.e. over 900 msecs, attention is said to inhibit the previously cued location (Theeuwes & van der Stigchel, 2006). This chapter will focus specifically on capture effects of threat stimuli. That is, the ability of angry faces, and perhaps also disfigured faces, to draw attention. Accordingly, the SOA is short to address attentional capture within the initial fixation.

Using the dot-probe (exogenous cueing) task, evidence indicates that threatening stimuli capture attention more than non-threatening stimuli. That is, on valid trials, response to the probe is quicker when it replaces a threatening cue than when it replaces a positive or neutral cue. This is because attention has already been drawn to the location of the probe by the presence of the threat. This is true of threat words (e.g. MacLeod, Mathews & Tata, 1986; Mathews & MacLeod, 1994), threatening pictures (e.g. Yiend & Mathews, 2001), and threatening faces (e.g. Fox, Russo, Bowles & Dutton, 2001).

Typically within the attentional literature, and especially within the dot-probe studies, threat effects are found with high state or trait anxious individuals (Mathews & MacLeod, 1985, 1994; Mogg & Bradley, 1998; Williams, Watts, MacLeod & Mathews, 1997). It is generally argued that anxiety lowers the threshold of threat perception due to hypervigilant monitoring of the environment for potentially dangerous stimuli (Beck, 1976; Bradley, Mogg, Falla & Hamilton, 1998; Mogg & Bradley, 1998; Mogg, Philipport & Bradley, 2000; Williams *et al.,* 1997). Therefore attention is more likely to be captured by threatening faces when anxious as the threat-perception threshold is lower. Early attentional capture by angry faces was shown, for example, in socially anxious individuals. Mogg and Bradley (2002) found that when faces were presented for only 17 msecs and then masked, reaction time to probes following the angry faces were quicker compared to happy faces in a dot-probe task. Further studies have also shown a threat effect even with non-anxious individuals (e.g. Cooper & Langton, 2006; Ohman, Lundqvist & Esteves, 2001).

Cooper and Langton (2006) have argued that several of the previous dot-probe studies claiming to assess capture have used SOAs/presentation times of faces that are too long. They suggested that the use of an SOA of approximately 500 msecs allowed enough time for covert eye movements, and hence does not assess initial orienting of attention (Posner & Petersen, 1990). This can be seen in Fox *et al.'s* (2002) dot-probe task, where they presented happy, angry and neutral faces with an SOA of 300 msecs. They were unable to find any capture effects with angry faces on valid trials, even when 75% of trials were valid. This is likely to be a consequence of using an SOA that allows for a shift of attention.

To rectify this, Cooper and Langton (2006) presented a dot-probe task with happy-neutral and angry-neutral face pairs at presentation rates of 100 msecs and 500 msecs per pair followed by the probe. Thus, for each trial, two faces appeared one at each location, for either 100 msecs or 500 msecs and then one of the faces was replaced by the probe. They found that there was a tendency to orient toward the angry faces at 100 msecs, exhibited as a non-significant vigilance bias of 7 msecs toward the threat face. Whilst this indicates a threat effect, the authors did comment that, because of the design, it was also possible to interpret this as participants inhibiting or avoiding the neutral face, rather than attending to the threat face. This highlights the potential interpretive difficulties of using face pairs as cues rather than a single face presentation design. They also found that by 500 msecs there was a significant 11 msecs bias *away* from the angry face. Hence, they demonstrated an aversion away from angry faces. Again however, because of their design, this could also be interpreted as attention toward the non-threatening face. Nonetheless, they concluded that attentional capture could be found in non-anxious individuals at a very early stage of perception followed by attentional avoidance, although the effect is tenuous.

As their study demonstrated, one flaw of the dot-probe design is that presenting face pairs on screen makes it more difficult to determine whether one face type is capturing attention, or whether one is inhibiting or suppressing attention. Therefore, a more sensitive method would be to present only one face cue in either of the boxes, and assess reaction to the probe across valid and invalid trials as in exogenous cueing (Posner, 1980). Thus, there is only one cue that can draw, avert, or engage attention.

Although Cooper and Langton (2006) found only weak effects, their work indicates a need to be more stringent in presentation timing in order to find a capture effect of threatening faces in non-clinical samples. That being said, it is also important to note that the literature is not entirely supportive of a capture effect by angry faces. For example, using eye movement data, Rohner (2004) found an aversion away from angry faces compared to happy faces. Further, Lau and Viding (2007) used a conditioning procedure, and recorded children's willingness to choose cards that had been subliminally paired with happy and angry faces. They found that the children were significantly less likely to choose cards that had been paired with angry faces. They argued that this avoidance of cards associated with angry faces may have facilitated a reduction in anxiety caused by their threatening nature.

This paper attempts to remedy the previous problems in order to assess whether or not angry faces capture attention in a non-clinical sample of individuals. An exogenous cueing task is used to assess spatial allocation of attention. A short SOA between face cue and probe of 100 msecs is in place to prevent multiple eye movements and allow for assessment of initial capture of threat. This timing allows for emotional face processing, as this can take place as early as 80 msecs of face onset (Eger, Jedynak, Iwaki & Skrandies, 2003). Participants were not explicitly told to look for faces, and therefore the task provides an indirect measure of allocation of spatial attention. Given the debate over the influence of anxiety on attentional biases, a measure of anxiety is also taken.

Emotional faces (angry and happy), neutral faces, and a non-face stimulus are presented. Disfigured faces also function as cues as this is central to the aims of the thesis. This will assess whether disfigured faces affect attention in the same was as angry faces. If the reaction is comparable, based on what is known about the response to angry faces, it may be surmised that the reaction to disfigurement is similar to a threat response. Although social psychological literature indicates a negative reaction to individuals with facial disfigurement (e.g. Bull & Rumsey, 1986; Partridge, 1990), the current literature on immediate reaction to disfigurement is minimal, and as yet there is limited understanding as to the initial cognitive reaction. Given the previous experiments in this thesis, no direct hypothesis can be made concerning the reaction to facial disfigurement. This present study, and the subsequent cueing studies in this thesis, will therefore allow for an assessment of whether or not disfigured faces affect attention in the same was as angry faces using a controlled methodology. This is an exploratory set of studies that aims to shed light on initial reactions to disfigurement. If the reaction to disfigurement is not comparable to the reaction to angry faces, however, an alternative explanation must be sought.

This study therefore has three aims. First, it aims to determine the effect of angry faces on attention when SOA is at 100 msecs. Second, it aims to determine the reaction elicited by disfigured faces and whether or not this is comparable to that elicited by angry faces. Finally, it aims to determine whether these effects are moderated by anxiety.

Method

Participants

Thirty students from Southampton University (3 males, 27 females), aged 18 to 23 years, (mean = 19.6 years, SD = 2.1) took part on a voluntary basis for course credit. They were unfamiliar with the faces used and had not taken part in previous studies of this thesis. All participants had normal or corrected-to-normal vision.

Materials

Faces were obtained from the NimStim Database as before. Two full-frontal, Caucasian, male faces were chosen which displayed equivalent levels of expressed emotion based on the emotional ratings (see methodology from chapter 5; happy means = 6.64 (SD = 1.5), 6.96 (SD = 1.1), angry means = 6.88 (SD = 1.1), 6.80 (SD = 1.2), $t(1) = .20$, *ns*). The neutral versions of the same individuals were also chosen. Using Adobe Photoshop, an artificial port wine stain was placed on the left side of the face on a version of each neutral face. Finally, an inverted version of each neutral face was generated. This yielded 5 images for 2 identities, displaying (i) a happy expression, (ii) an angry expression, (iii) a neutral expression, (iv) a neutral-disfigured image, and (v) a neutral-inverted image. Thus, identity was kept consistent across manipulation of facial appearance. Faces measured 4.5cm by 6.5cm. (See Appendix D for faces used). The experiment was programmed in Presentation and run on an IBM computer. Participants also completed the State-Trait Anxiety Inventory (STAI: Spielberger, Gorusch, Luchene, Vagg & Jacobs, 1983) to measure anxiety.

Design

A 5 x 2 x 2 mixed design was used. The within-subjects variables were face type (happy, angry, neutral, disfigured, and neutral inverted) and trial type (valid, invalid). Anxiety (high, low) was a between-subjects factor. The dependent variable was reaction time (RT) to a probe-classification task.

Procedure

After providing written informed consent, participants were tested individually in small cubicles. Participants were seated approximately 60 cm from the computer screen. They were provided with onscreen instructions. After completing a practice trial consisting of six trials as described below, the main experiment began. Participants were instructed to maintain focus on the fixation cross at the centre of the screen, to ignore a subsequent face cue, and to classify the direction of a black arrow (probe) using a 2 button response box[3] (see Figure 8.1).

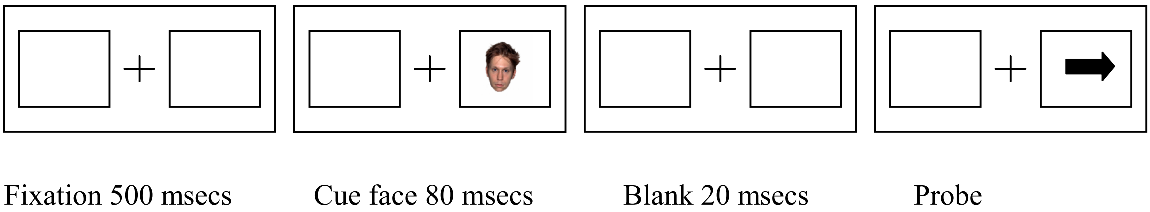


Figure 8.1. Sequence of events on a valid trial.

Each trial consisted of a fixation cross for 500 msecs. This was replaced by the cue screen, and the cue face could appear to the left or right side of fixation for 80 msecs. This was followed by a blank screen for 20 msecs to act as a mask. SOA was therefore 100 msecs. The probe then appeared to the left or right side of the cross. If the face was replaced by the probe on the same side it was a valid trial; if the face was replaced by the probe on the opposite side of fixation, it was an invalid trial. The probe remained visible until the participant responded. Response was made via a 2-button response box, to indicate the direction of the arrow probe. No feedback was given.

[3] A detection task is not optimal in this design due to the capacity to complete the task by simply focusing on one side of the screen only. Arrow direction classification has been used in other studies (e.g. Mogg, Philippot, & Bradley, 2004). As Fox, *et al.* (2002) argued, a probe categorisation task ensures that the validity effects cannot be attributed to response preparation effects as the cue location and response location are not associated with the cue type.

There were 800 trials, divided into 5 blocks of 160 trials. Across the experiment, 50 per cent of trials were valid. Each face and each left and right arrow probe was presented an equal amount of times on the left and right side. Each block contained an equal number of valid/invalid trials, an equal number of presentations of each face, and an equal number of left/right arrow probes presented on the left and right side equally. Thus, there was full counterbalancing and randomisation. Participants could initiate each block to allow for short breaks.

Participants were also asked to fill out the STAI to take a measure of anxiety. At the end of the experiment, participants were thanked and debriefed. The experiment took approximately 20 minutes to complete.

Results

Self reported anxiety scores

Participants completed the STAI measure of anxiety. The mean state anxiety score was 39.7 (SD = 13.4) out of 80. The mean trait anxiety score was 42.8 (SD = 8.9) out of 80. Since the sample is non-clinical, state anxiety was chosen to be a more accurate reflection of current individual anxiety level[4]. To divide participants into high and low state anxiety groups, the median state score was found (38). Individuals above the median were grouped as high state (N = 15, mean state score = 44.9, SD = 5.1) and individuals below the median were grouped as low state (N = 15, mean state score = 30.1, SD = 6.56). Accordingly, these two groups were statistically different on their state anxiety (t (28) = -6.91, p < .001).

Data preparation

Reaction times (RT) on incorrect trials were removed (M = .06% incorrect responses). Accuracy was not analysed for the purpose of this study as it does not reflect the speed of attentional allocation. As the reaction time data was skewed, based on a significant Shapiro-Wilks test, the mean RTs were log transformed to minimise skew. All results discussed will therefore be based upon

[4] In further defence of the use of state anxiety. Mathews, Fox, Yiend, & Calder, (2003) found threat effects when using both state and trait anxiety, however Mogg and Bradley (2002) found no angry face effects when using trait anxiety in a dot-probe task.

this transformation. Figures 8.2 and 8.3 show the log transformed mean RT for high and low anxious participants across face types, split by validity.

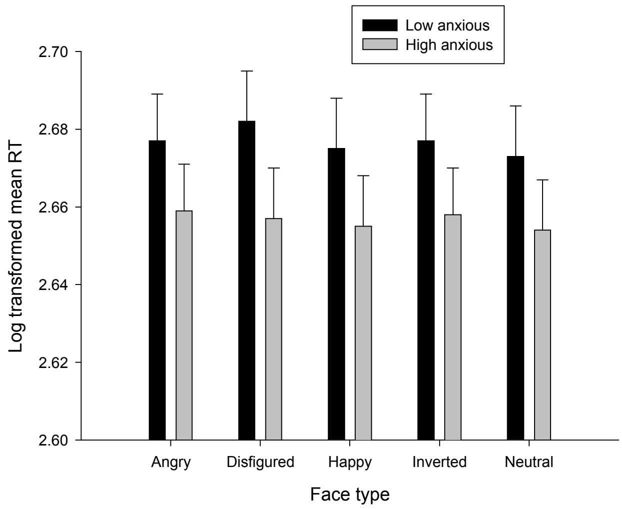


Figure 8.2. Log transformed mean RT (with SE) on valid trials as a function of face type and state anxiety.

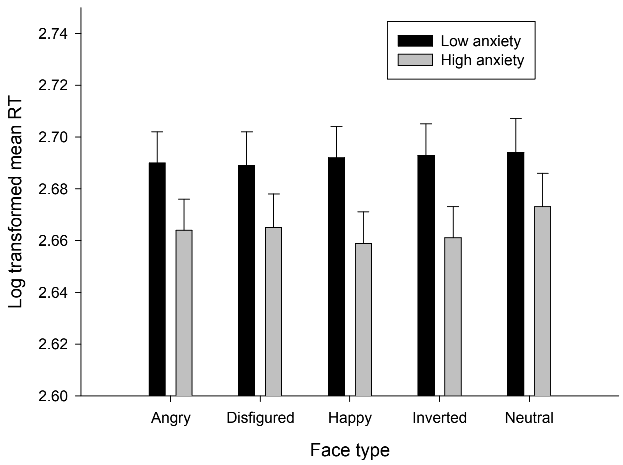


Figure 8.3. Log transformed mean RT (with SE) on invalid trials as a function of face type and state anxiety.

A mixed ANOVA was applied to the log transformed mean RTs on correct trials, using face type (angry, disfigured, happy, inverted, neutral) and validity (valid, invalid) as within-subject variables, and state anxiety (high, low) as a between-subject variable. To examine for cue validity effects in relation to the type of expression, it was particularly important to find an interaction effect between face type and cue validity. An effect of anxiety would indicate that the two anxiety groups were acting differently.

The ANOVA found a main effect of validity (F (1, 28) = 25.69, p < .001). As would be expected with a cueing study, reaction time on valid trials (M = 2.67, SE = .008) was quicker compared to invalid trials (M = 2.68, SE = .008).

There was no main effect of face type (F (4, 112) = .38, *ns*). Contrary to expectations, there were no significant two way interactions: face x validity (F (4, 112) = .46, *ns*); face x anxiety (F (4, 112) = .51, *ns*); validity x anxiety (F (1, 28) = 2.38, *ns*). Finally, the three-way interaction was also not significant (F (4, 112) = .61, *ns*). There was no between-subject effect of anxiety (F (1, 28) = 1.97, *ns*).[5]

Correlation analysis

To supplement the above analysis, correlation analyses were also carried out to examine the relationship between anxiety and bias scores (log transformed bias scores in each case to remain consistent) for each face. A bias score is calculated by: Invalid trials – Valid trials per face type so that positive values indicate attending to the face, and negative values indicate avoiding the face. This follows the general method in the published literature for calculating bias scores (e.g. Cooper *et al.,* 2006).

Thus, a bias score was calculated for each face type (angry, disfigured, happy, neutral) and correlated against anxiety scores (both trait and state anxiety, note scores for scale each range from 20 to 80). These results are presented below for each face type.

Angry faces

[5] It is also noted that an analysis with 'block' as a factor was carried out. This can be seen in Appendix F, and is also discussed in the Discussion section.

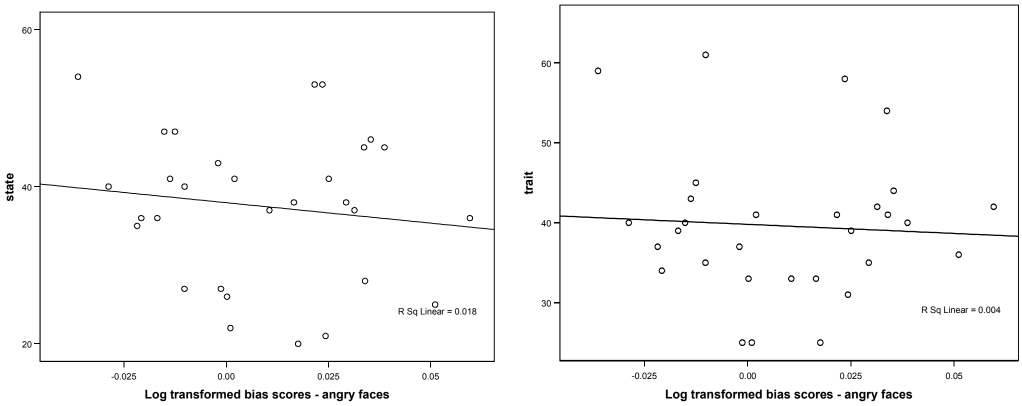


Figure 8.4. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for angry faces.

A Pearson's correlation addressed the relationship between state anxiety scores and angry faces bias scores. This found no significant relationship *r* (N=30) = -.14, *p = ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and angry faces bias scores. This also found no significant relationship *r* (N=30) = -.06, *p = ns*.

Disfigured faces

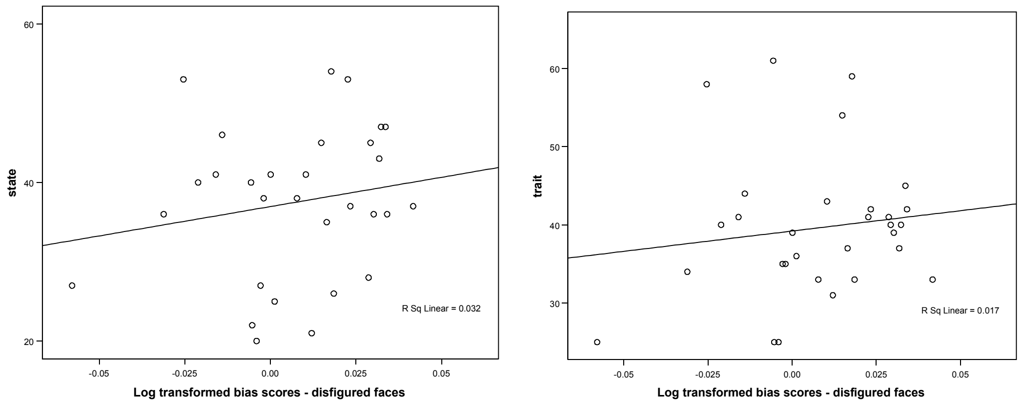


Figure 8.5. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for disfigured faces.

A Pearson's correlation addressed the relationship between state anxiety scores and disfigured faces bias scores. This found no significant relationship *r* (N=30) = .18, *p = ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This also found no significant relationship *r* (N=30) = .13, *p* = *ns*.

Happy faces

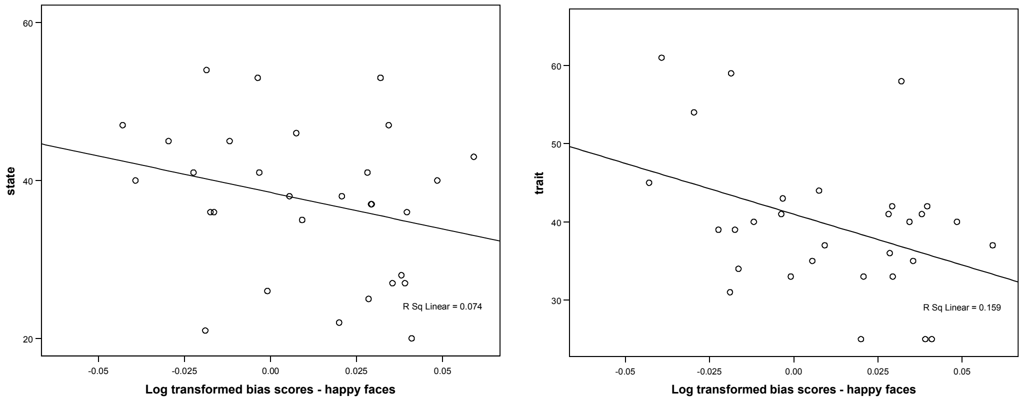


Figure 8.6. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for happy faces.

A Pearson's correlation addressed the relationship between state anxiety scores and happy faces bias scores. This found no significant relationship *r* (N=30) = -.27, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This found significant relationship *r* (N=30) = -.39, *p* = .03, indicating that as trait anxiety score increases, the tendency to avert attention away from happy faces increases.

Neutral faces

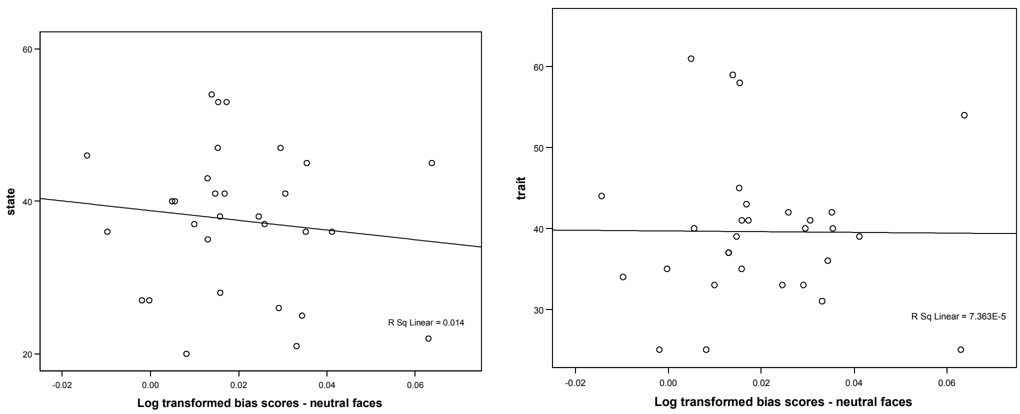


Figure 8.7. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for neutral faces.

A Pearson's correlation addressed the relationship between state anxiety scores and neutral faces bias scores. This found no significant relationship *r* (N=30) = -.12, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and neutral faces bias scores. This also found no significant relationship *r* (N=30) = .01, *p* = *ns*.

Discussion

As would be expected in a typical cueing task, response time was significantly faster to probe categorisation on valid trials, when face and probe appeared in the same location, compared to invalid trials. However, there was no effect of face type, and no moderation effects of state anxiety. This study therefore did not show any effect of emotionality or threat in terms of speed of attentional allocation in a spatial paradigm.

One explanation for the lack of any face effect may be that participants responded so fast to the cue, any advantage caused by a particular face would not be evident. If participants were performing in such a way for all trials regardless of the face type, this would indeed be the case. This is supported by the finding of a main effect of validity: participants were just too good at ignoring a face and instead concentrated effort on the explicit probe detection task. An alternative explanation may be that participants failed to see the face at all given the quick SOA. However, this seems less likely given that facial expression judgments are accurately made when the face is presented for only 20 msecs (Milders, Sahraie & Logan, 2008).

The present study therefore does not support a capture effect of attention by angry faces. Instead, the results indicate that no particular facial expression affected attention. With reference to the aims of this chapter, no effects of angry or disfigured faces were found at this rapid presentation rate. Importantly, the inability to find an angry face effect indicates that perhaps the SOA here was too fast. Alternatively, a fast SOA may have enabled good top-down attentional control to focus only on the probe classification task and ignore the face. Whilst Cooper & Langton (2006) presented happy-neutral and angry-neutral face pairs at a presentation of 100 msecs per pair, their reported finding of capture by angry faces was tentative given only a trend in their data. Further, in their study, they presented face pairs, and therefore there were two face cues on screen. Thus, capture to, or avoidance from a particular face type was difficult to assess in this case. Perhaps when there is only one face cue, as in the present study, no face effects can be found with such a short SOA. In support, even at SOAs of 350-500 msecs, Fox and colleagues failed to find clear capture effects to angry faces (Fox *et al.,* 2001, 2002).

Researchers such as Ohman (1997) and Le Doux (1998) have argued that threat detection is rapid and serves an adaptive purpose in that it allows the perceiver to prepare to take action if needed. Le Doux (1998) proposed that the amygdala rapidly and crudely assesses threatening stimuli for this purpose. Based on this evolutionarily argument, one would expect that even at 100 msecs, there would be evidence of a threat (capture) effect by angry faces. However, the nature of the present task may not expose this. Participants may have simply performed at an optimal level for all faces as their ability to locate the cue and direct attention to that location was high for all faces. This therefore resulted in significantly quicker responding on valid trials compared to invalid trials without any face effects. Rather than a certain face capturing attention, attention was captured by the onset of the cue, whatever it was, and so participants were significantly quicker to respond when the probe appeared at the same location.

Furthermore, as participants were from a non-clinical sample, even high state anxious participants here may have also developed good attentional control to focus on the probe alone. For example, capture effects to angry faces were only evident in *clinically* anxious participants in Mogg and Bradley's (2002) study, compared to non-anxious participants. This indicates that the level of hyper-vigilance can be important in the effect that threatening stimuli has on attention.

One must be cautious in assigning a special status to angry faces as sometimes the lack of an effect may simply represent the angry face being unable to draw attention. Several studies have failed to find any angry face effect compared to other expressions (e.g. Stone & Valentine, 2007). For example, under backward masking conditions, Maxwell and Davidson (2004) showed that participants were more aware of happy faces masked by neutral faces than angry faces masked by neutral faces at an SOA of 16.67 msecs. In a similar study, Milders, Sahraie and Logan (2008) found that the greatest awareness sensitivity was to happy not angry faces. One would expect that angry faces under such time presentation would rapidly draw attention, given the adaptive advantage of orienting to a potential threat. Whilst the participants were drawn from student populations in all the studies, there was no measure of anxiety so unfortunately they are not fully conclusive.

A correlation analysis was also carried out on bias scores to determine if there was any relationship between state or trait anxiety with attention to or aversion away from each face type. The only significant relationship found was between trait anxiety and happy faces. This relationship indicated that as trait anxiety score increased, the tendency to avert attention away from happy faces increased. This tendency to avoid a positive face by those higher in trait anxiety may be due to the need to avoid social interaction, which a happy face typically expresses. Indeed, published research suggest that that socially anxious participants tend to avoid happy (as well as negative) faces , which is explained as being a result of the need to escape from social interactions by those with anxious characteristics (Chen *et al.,* 2002; Heuer *et al.,* 2007; Mansell *et al.,* 1999).

Given the type of samples used, some researchers suggest that exposing this threat effect within a student population may actually be quite difficult. Koster, Leyman, Raedt and Crombez (2006) suggested that university students especially have a high degree of attentional control as a consequence of their working environment. Therefore they are more able to successfully control their attention to focus solely on a task rather then be distracted by external events. Empirical support comes from their cueing study: Koster *et al.* (2006) also failed to find any capture effects with emotional faces using a similar design as the present study. Moreover, in a cueing task participants are almost always told to ignore the face and focus on the probe, so perhaps good top-down attentional control can override even default control settings (Folk, Remington & Johnston, 1992; Folk & Remington, 2006). This in itself is an area in need of further study but it is not within the scope of this thesis to fully examine the attentional control abilities of different populations.

It is also noted that a supplementary analysis was run using block as a factor (Appendix E). This found that participants were quicker on valid trials in each block compared to the first block, indicating that they were be coming better at the task of responding to the probe on valid trials. This concurs with Koster et al.'s (2006) idea that students have good attentional control, and it indicates that they were good at maintaining focus on the probe, and were not affected by the face type.

Given the lack of face effects from this study, but taking into account Cooper and Langton's (2006) suggestion that an SOA of 500 msecs is too long to examine initial orientation of attention, the next chapter will use an SOA of 250 msecs. This is hoped to reduce null face effects, but to allow for initial reaction to faces before multiple eye movements can be made.

Chapter 9
Experiment 6: The effect of emotional and disfigured faces in a cueing task

Introduction

This chapter aims to re-examine capture effects for emotional faces using the spatial cueing paradigm. The previous study, using an SOA of 100 msecs, found no effect of expression or disfigurement on attention, and no influence of anxiety. The present study aims to resolve the problem of ceiling effects on performance by extending the SOA to 250 msecs. This retains Cooper and Langton's (2006) suggestion to use quick SOAs as a way of examining initial orienting of attention.

Based on the hypothesis that quick threat detection is advantageous (Le Doux, 1998; Ohman, 1997) it would be expected that at rapid presentations, angry faces would capture attention. In partial support, this thesis indicated that angry faces rapidly recovered from the attentional blink when presented at a rate of 80 msecs (chapter 4). Further, Cooper and Langton (2006) found a trend of an attentional bias toward angry faces at 100 msecs followed by avoidance by 500 msecs.

Nevertheless, the literature is somewhat contentious over whether attention is actually captured by angry faces, or engaged by angry faces compared to other expressions. For example, when presenting happy, angry and neutral faces in an exogenous cueing task with an SOA of 300 msecs, Fox, Russo and Dutton (2002) found no face effects on valid trials, i.e., no capture effect by angry faces. Notably, however, they had 75% of trials as valid, and therefore response may have been quicker on such trials per se as participants learnt this contingency. Hence any face effect would be meaningless. Instead, for invalid trials, participants showed delayed disengagement from angry faces compared to happy and neutral faces. Georgiou *et al.* (2005) modified this paradigm by showing a central face for 600 msecs and then a peripheral letter (at one of four locations around the face) and instructed participants to ignore the faces and categorise the letter. They found that high anxious participants took longer to categorise the peripheral letter when the central face was fearful compared to neutral or happy. Georgiou *et al.* (2005) argued that this slowing in response indicated delayed disengagement from the fearful faces. They suggested that this was indicative of the ability of negative facial expressions (angry and fearful) to engage attention in comparison to other facial emotions.

To add to this complex literature, there is now evidence to suggest that participants may even avert attention away from angry faces in order to reduce anxiety (Mansell, Clark, Ehlers & Chen, 1999). Isaacowitz (2006) suggested that gaze of attention toward a face may be dependent upon mood and age. In support, he and his colleagues found that contrary to prediction, no age group showed vigilance *toward* angry faces. Instead, older participants (57-84 years old) actually averted their attention *away* from angry faces (Isaacowitz, Wadlinger, Goren & Wilson, 2006). One possible reason for this, they suggested, was that averting attention can maintain positive affect. Thus, in review, Isaacowitz (2006) argued that motivation to maintain positive affect would result in an aversion away from negative stimuli. Rohner (2004) also found aversion of eye movements away from angry faces compared to happy faces. Using a conditioning paradigm, Lau and Viding (2007) found that anxious children significantly avoided cards that had been associated with angry, compared to neutral faces. Similarly, Lau and Viding (2007) argued that this helped the children to maintain positive affect. One limitation of their study, however, was the lack of a happy face to conclude a threat, rather than emotion, effect.

Given this literature, this present study aims to determine what effect angry faces have on attention when the SOA is at 250 msecs. Examination will indicate whether there is a capture or aversion effect. A second aim is to determine the effect of disfigurement on attention. The previous chapter failed to find any face effects and so any similarities or differences between angry and disfigured faces were not obvious. For the present study, if disfigured faces are responded to in the same way as angry faces, it may be argued that, like angry faces, disfigurement is being appraised as threatening. If, however, the response is not comparable, there must be another explanation for the negative reaction reported by individuals with facial disfigurement (e.g. Partridge, 1990). The present study also aims to determine the influence of anxiety as a moderating variable on task performance.

Method

Participants

Thirty students from Southampton University (3 males, 27 females), aged 18 to 35 years, (mean = 20.5 years, SD = 4.07) took part on a voluntary basis for course credit. They were unfamiliar with the faces used and had not taken part in previous studies in this thesis. All participants had normal, or corrected-to-normal, vision.

Materials

The same materials were used as used in the previous study (chapter 8).

Design

A 5 x 2 x 2 mixed design was used. The within-subjects variables were face type (happy, angry, neutral, disfigured, and neutral inverted) and trial type (valid, invalid). Anxiety (high, low) was a between-subjects factor. The dependent variable was reaction time (RT) to the probe in an exogenous cueing task.

Procedure

The procedure remained the same as in chapter 8 except for one crucial change. The SOA was extended to 250 msecs, (the face cue was presented for 200 msecs, followed by a blank for 50 msecs, and then the probe). All other aspects of the procedure remained the same. The experiment took approximately 25-30 minutes to complete.

Results

Self-reported anxiety scores

Participants completed the STAI measure of anxiety. The mean state anxiety score was 39.7 (SD = 13.4) out of 80. The mean trait anxiety score was 42.8 (SD = 8.9) out of 80. Again, given the use of a non-clinical sample, state anxiety was used as the grouping variable. To divide participants into high and low state anxiety groups, the median state score was found (36). Individuals above the median were grouped as high state (N= 15, mean state score = 49.7, SD = 11.4) and individuals below the median were grouped as low state (N= 15, mean state score = 29.6, SD = 5.14). Accordingly, these two groups were statistically different on their state anxiety (t (28) = -6.22 , p <.001).

Data preparation

Response times (RT) on incorrect trials were removed (M = .06% incorrect responses). As the RT data was skewed, based on a significant Shapiro-Wilks test, the mean RTs were log transformed to minimise skew. All results discussed will therefore be based upon this transformation for ease of presentation and interpretation. Figures 9.1 and 9.2 show the log transformed mean RT for each type of trial, as a function of face type and anxiety.

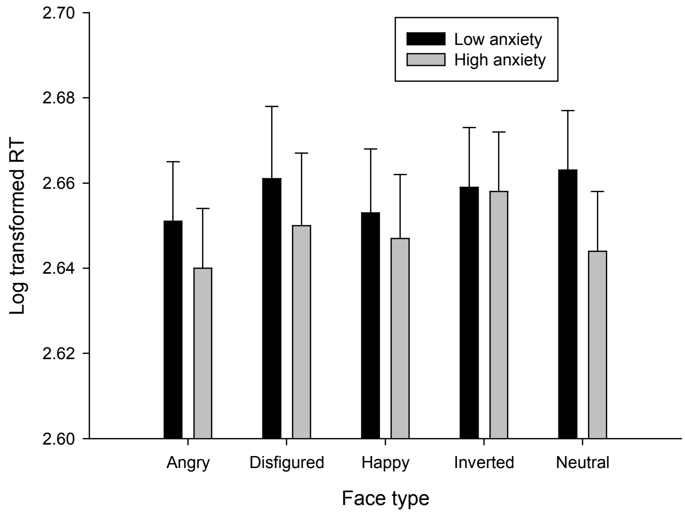


Figure 9.1. Log transformed mean RT (with SE) as a function of face type and anxiety on valid trials.

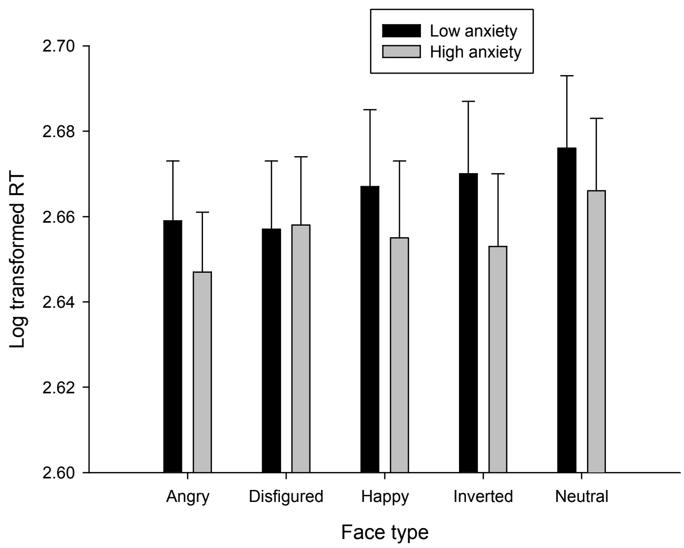


Figure 9.2. Log transformed mean RT (with SE) as a function of face type and anxiety on invalid trials.

As before, a mixed ANOVA was applied to the log transformed mean RTs on correct trials, using face type (angry, disfigured, happy, inverted, neutral) and validity (valid, invalid) as within-subject variables, and state anxiety (high, low) as a between-subject variable. At a basic level, one would expect a face type by validity interaction to allow for an examination of whether capture, aversion or engagement existed. If such an effect was moderated by anxiety, one would expect a three-way interaction. This would allow for an examination of each anxiety group so as to look at validity and face effects. Hence, if such effects are found, paired t-tests comparing each face type to the neutral face will allow for an examination of whether attention is oriented toward or away from a baseline face type. This can be carried out on valid and invalid trials separately. Further, to assess whether angry and disfigured faces elicit comparable responses, it is necessary to compare these two face types.

The 5 x 2 x 2 mixed ANOVA found a main effect of face type (F (4, 112) = 5.4, $p < .001$) and a main effect of validity (F (1, 28) = 8.6 $p = .007$) with faster RTs on valid trials. As predicted, the interaction between face and validity was significant (F (4, 112) = 3.28, $p < .05$), but the remaining two way interactions were not (face by anxiety: F (4, 112) = .64, *ns*; validity by anxiety: F (1, 28) = .01, *ns*). There was no between-subjects effect (F (1, 28) = .22, *ns*).

Modifying all these effects however, was the expected significant three-way interaction of face type by validity by anxiety (F (4, 112) = 2.7, $p < .05$). Each anxiety group was then analysed separately with ANOVAs using face type and validity as factors. For each analysis, a significant interaction was sought to examine for attentional biases.

Low state anxiety

For low anxious participants, there was a significant main effect of face (F (4, 56) = 2.7, $p < .05$) and a trend for a main effect of validity (F (1, 14) = 4.4 $p = .054$) with faster RTs on valid trials. However, there was no significant interaction (F (4, 56) = 1.9, *ns*).

High state anxiety

For high anxious participants, there was a main effect of face (*F* (4, 56) = 3.6, $p < .01$) and a trend for a validity effect (*F* (1, 14) = 4.1, $p = .06$). Importantly, there was a significant face by validity interaction (*F* (4, 56) = 4.4, *p* = .004). As motivated by predictions, each validity type was examined using paired t-tests to compare each face type to the neutral face. Disfigured and angry faces were also compared.

Valid trials. For valid trials, there were no significant effects (angry and neutral: *t* (14) = -.91; happy and neutral: t(14) = .69; inverted and neutral: *t*(14) = 2.38; disfigured and neutral: *t*(14) = .74; disfigured and angry: *t*(14) = -1.82, all *ns;* Bonferroni corrected alpha = .01). This suggests that there was no attentional capture by any of the faces.

Invalid trials. For invalid trials, there was a significant difference between angry and neutral face trials (*t* (14) = -5.2, $p <.001$). Response was quicker on angry trials compared to neutral trials. This indicates an aversion away from angry faces and toward the other probe location compared to neutral faces for high anxious participants. There were no significant difference between happy and neutral (*t* (14) = -2.92, *ns*), inverted and neutral (*t* (14) = -2.92, *p* = *ns*), disfigured and neutral (*t* (14) = -1.52, *ns*), nor between angry and disfigured (*t*(14) = -2.02, *ns*, using Bonferroni corrected alpha .01).

Correlation analysis

To supplement the above analysis, correlation analyses were also carried out to examine the relationship between anxiety and bias scores (log transformed bias scores in each case to remain consistent) for each face. A bias score is calculated by: Invalid trials – Valid trials per face type so that positive values indicate attending to the face, and negative values indicate avoiding the face. This follows the general method in the published literature for calculating bias scores (e.g. Cooper *et al.,* 2006).

Thus, a bias score was calculated for each face type (angry, disfigured, happy, and neutral) and correlated against anxiety scores (both trait and state anxiety). These results are presented below for each face type.

Angry Faces

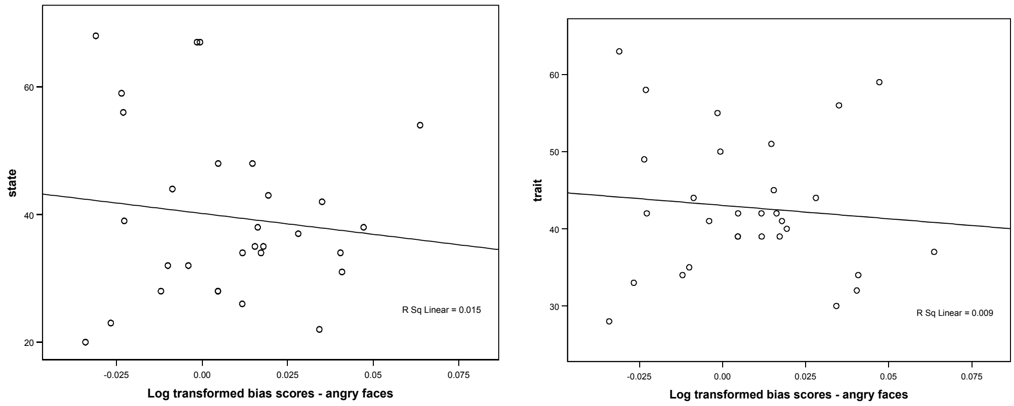


Figure 9.3. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for angry faces.

A Pearson's correlation addressed the relationship between state anxiety scores and angry faces bias scores. This found no significant relationship *r* (N=30) = -.12, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and angry faces bias scores. This also found no significant relationship *r* (N=30) = -.1, *p* = *ns*.

Disfigured faces

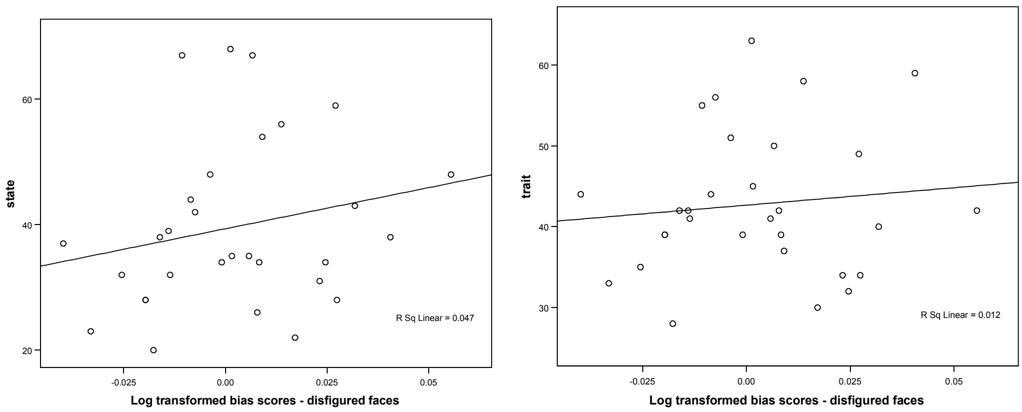


Figure 9.4. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for disfigured faces.

A Pearson's correlation addressed the relationship between state anxiety scores and disfigured faces bias scores. This found no significant relationship *r* (N=30) = .22, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This also found no significant relationship *r* (N=30) = .11, *p* = *ns*.

Happy faces

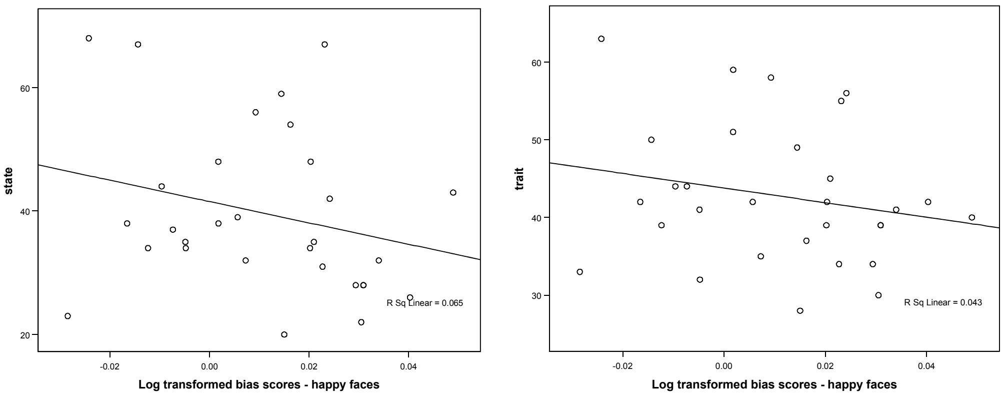


Figure 9.5. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for happy faces.

A Pearson's correlation addressed the relationship between state anxiety scores and happy faces bias scores. This found no significant relationship *r* (N=30) = -.25, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and happy faces bias scores. This also found no significant relationship *r* (N=30) = -.21, *p* = *ns*.

Neutral faces

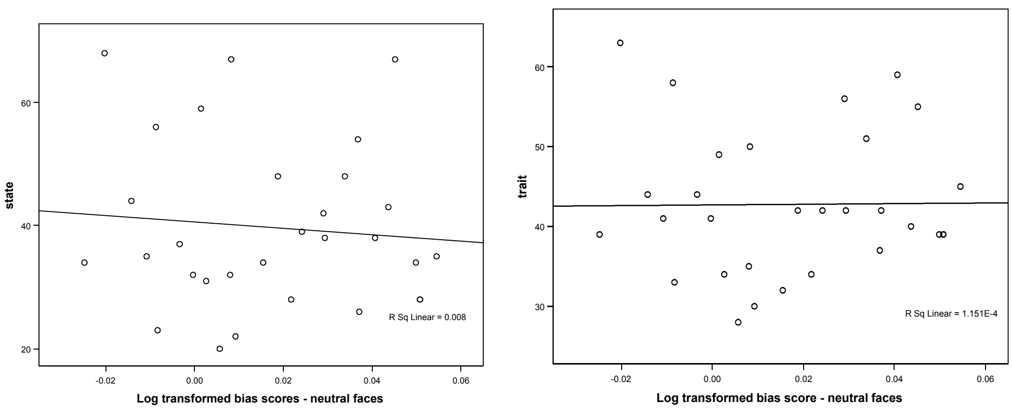


Figure 9.6. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for neutral faces.

A Pearson's correlation addressed the relationship between state anxiety scores and neutral faces bias scores. This found no significant relationship *r* (N=30) = -.1, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and neutral faces bias scores. This also found no significant relationship *r* (N=30) = .01, *p* = *ns*.

Also to note, a supplementary analysis was conducted to explore the effect of block (see Appendix F). Overall, this found that participants were slowest to respond on block 1: performance was significantly quicker on the other blocks compared to block one, and was significantly quickly on block 5 compared to block 2, indicative of block 1 being the slowest performing block. This suggested that in the first block, participants were significantly slower to respond to the dot probe compared to the other blocks, indicating that over the experiment they were quicker on the task overall compared to block one. However, there were no interaction effects with block, indicating that it did not play a major part in this particular experiment.

Discussion

This study has found that for high state anxious individuals, responses were significantly quicker to probes following angry faces compared to neutral faces when performance depended on orienting away from the (angry) cue and toward the other (probe) location. These effects were not observed on valid trials, or with low anxious participants.

When examining the effect on invalid trials, this effect can be interpreted as an avoidance response away from threatening stimuli. An emotionality effect can be ruled out as there was no effect with happy faces. Thus, on an invalid trial, when an angry face appears, attention is rapidly averted, or disengaged away from, the angry face. This moves attention to the un-cued box, and then facilitates rapid probe categorisation when the probe appears there. This can be seen as an active motivation away from the angry face.

In support, Lau and Viding (2007) have argued that attention may be averted away from threatening stimuli such as an angry face, so as to reduce the anxiety caused by such stimuli. Moreover, Rohner (2004) also found aversion away from angry faces compared to happy faces as revealed by eye movements. The results in the present study were found only with high state anxious individuals, who may more quickly avert their attention because they are more sensitive to the anxiety caused by the threatening stimuli (Beck, 1976; Beck & Clarke, 1988).

The present findings also converge with the recent literature that has found aversion to angry faces. (Lau & Viding, 2007; Isaacowitz, 2006; Isaacowitz *et al.,* 2006). In a review of over 170 attentional studies, Bar-Haim, Lamy, Pergamin, Bakermans-Kraneburg and van Ijzendoorn (2007) remarked that there was an emerging literature documenting avoidance away from threatening faces, especially with high anxious participants. Again, such findings are explained in terms of the need for participants to minimise negative affect and maintain positive affect, especially for those experiencing anxiety.

Interestingly, there was no significant demonstration of attentional capture effects for angry faces (or any other faces) on valid trials. This was surprising given the literature suggesting that humans are attuned to rapidly respond to threat (e.g. Le Doux, 1998; Ohman, 1997). However, perhaps in the modern world more modern stimuli, such as guns, pose a comparatively greater threat than do angry faces, and therefore capture effects to angry faces is weak. Failure to find a capture effect was also reported by Fox, Russo and Dutton (2002) who used an exogenous cueing task with an SOA of 300 msecs. As with this study, they did not find any effects on valid trials. An alternative explanation may be an issue of measurement. If the participants are performing at ceiling level on valid trials, i.e. are fast to respond when the probe appears in the same location as the cue, then the effects of different cue faces will be lost. This is a reasonable explanation given the consistent pattern of results showing no capture effects on valid trials, at 100 msecs (previous chapter), 250 msecs (this chapter) and 300 msecs (Fox, *et al.,* 2002).

As in the previous cueing study, correlation analyses were carried out on the bias scores for each face with both state and trait anxiety. This found no significant relationships. Thus, in this study when SOA was set at 250 msecs, there was no negative relationship between trait anxiety and attention to happy faces, so the avoidance of happy faces as trait anxiety increases may only be evident at very quick presentation speeds (i.e. 100 msecs as in the previous chapter), suggesting that the elicitation of social anxiety threat is short-lived in such non-clinical individuals. This can be explored further when the SOA is increased to 500 msecs; one would expect not to find a relationship between trait anxiety and bias scores for happy faces when the presentation rate is even longer given that no relationship was found here.

This study also has important implications for the response elicited by disfigurement. The results here indicated that the reaction to angry faces and the reaction to disfigured faces were not comparable. There was no significant difference between angry and disfigured faces on invalid trials. Yet, whilst there was a significant difference between angry and neutral faces, there was no such significant difference between disfigured and neutral faces. Therefore, this indicates that high anxious participants were not rapidly averting their attention away from the disfigured faces. This general dissimilarity between angry and disfigured faces converges with results found in the attentional blink studies (chapters 5-6) with the exception of the second target detection advantage similarity. In both the RSVP study and the study here, angry faces have elicited a threat response. Here, angry faces caused aversion of attention in high anxious participants in a study of an implicit measure of attention orientation. No such effects were evident with disfigured faces. This apparent difference in response clearly requires further investigation. If the reaction to facial disfigurement is not driven by a pure threat response, then an alternative account needs to be considered. Failure for facial disfigurement to elicit either a capture or aversion effect again points toward speculation that the initial behavioural reaction is a complex mix of responses.

With limited data, it is indeed only possible to speculate what the response may be, but our understanding is developing. It is therefore necessary to obtain further data concerning reactions under spatial constraint through extending the SOA. This is because literature on emotional faces has shown that at longer SOAs there is significant dwell of attention on angry compared to happy and neutral faces. If reactions between angry and disfigured faces converge post 250 msecs onset, it may be assumed that a threat response does not occur until after half a second of viewing disfigurement. Indeed, the response to angry and disfigured faces does not appear to be directly comparable up to this point as shown by the RSVP studies (chapters 5-6) and the present cueing study. However, if there is still no convergence, there is even more reason to suggest that disfigured faces are not appraised as threatening in the same way as angry faces.

It is therefore the aim of the next study to increase the SOA to 500 msecs. This will determine whether angry faces continue to avert attention, or whether there is then a dwell of attention on angry faces. It further allows for an examination of whether the response to disfigurement remains dissimilar to angry faces at a longer presentation duration. Again, anxiety will be measured as it appears to have a moderating effect.

Chapter 10

Experiment 7: Examining delayed disengagement effects with emotional and disfigured faces

Introduction

This chapter aims to determine whether emotional and disfigured faces affect attention as revealed by delayed disengagement of attention using a spatial paradigm. The present chapter will also assess whether the effects with disfigured faces mirror those with angry faces to allow for our theoretical understanding of attention to threat to be applied to initial reaction to facial disfigurement.

The previous study found that, for high state anxious participants, angry faces caused quick disengagement of attention away from the face on invalid trials. This was specific to angry faces, so it was argued to be a threat effect, rather than an expression effect. In line with previous research (e.g. Fox, Russo & Dutton, 2002) this effect held only for high anxious participants. It was therefore suggested that disengagement from threat was a motivated response to reduce anxiety (Isaacowitz, *et al.,* 2006; Lau & Viding, 2007; Rohner, 2004). It was further evident that the reaction to angry faces and to disfigured faces was not comparable, as there was no aversion away from disfigured faces compared to neutral faces. Consequently, it was speculated that disfigurement was not perceived as threatening in the same way as angry faces were. This begs the question as to what motivates the reaction to facial disfigurement. When reviewing the current attentional literature, it is evident that at longer SOAs, angry faces engage attention for longer compared to other faces and this is explained as a threat effect (Fox *et al.,* 2002). Thus, this chapter has two aims. First, it aims to reveal a dwell effect with angry faces. Second, it aims to determine whether a similar effect is elicited by facial disfigurement or whether the difference in reaction still persists at a longer SOA.

The literature indicates a delayed disengagement of attention or dwell on threatening faces by anxious participants when the SOA is 300 msecs and over (Fox, Russo, Bowles & Dutton, 2001; Fox, Russo & Dutton, 2002; Georgiou, Bleakley, Hayward, Russo, Dutton, Eltiti & Fox, 2005). That is, highly anxious participants tend to maintain their attention on threatening stimuli rather than being able to shift their attention away from the threat at this level of exposure duration. This clearly seems at odds with the previous demonstration that highly anxious participants tend to avert their attention away from threatening stimuli at a slightly briefer duration. With this in mind, to produce a clearer picture of how threat affects attention, it is important to extend the SOA. This is for several reasons. First, it will allow for a re-examination of the previous literature with angry faces that have examined delayed disengagement of attention. Second, it will allow for an examination of the reaction toward disfigurement, and whether it continues to be different to angry faces. Third, the study again aims to follow the influence of anxiety relating to both threat and disfigurement.

Fox *et al.* (2001) used schematic happy, angry and neutral faces in a dot-probe task with an SOA of 300 msecs. It was found that for high state anxious participants, reaction times on invalid trials was slower following angry faces (388 msecs) than following neutral (368 msecs) or happy faces (374 msecs, Experiment 3). No such effect was evident with non-anxious participants. Fox *et al.* (2001) therefore argued that for high anxious individuals only, there was evidence of delayed-disengagement from angry faces, indicating that threatening facial expressions could hold attention. In a subsequent study, Fox *et al.* (2002) replicated these results. Again, there was evidence of delayed-disengagement from schematic angry faces, relative to schematic happy and neutral faces, and this was displayed by high trait anxious participants only.

Georgiou *et al.* (2005) used a slightly different methodology but came to the same conclusion. They presented black and white photographs of happy, fearful, and neutral Ekman faces at the centre of the screen and asked participants to detect certain letters that could appear in one of four locations around the face. The SOA between face onset and letter onset was 600 msecs. They found that it took longer for high trait anxious participants to categorise a target letter when the central face was fearful, compared to happy or neutral. There was no such effect for non-anxious participants. They therefore argued that their results supported the argument that attention dwells on fearful faces due to their threatening nature for high anxious participants.

Although the above studies have demonstrated delayed-disengagement of attention from threat faces, they are not without criticism. First, there are stimulus issues, and second, there are methodological issues. Two of the studies presented participants with schematic faces (Fox *et al.,* 2001, 2002) which may not capture the uniqueness of a specific emotion, and may therefore reduce ecological validity. Further, the faces were in monochrome, which again weakens stimulus realism. It is also important to note that they conceptualised threat in different ways. One study used angry faces and the other used fearful faces. This is an issue as some research shows similarities in response to these faces, whilst some document discrepancies. For example, Whalen, Shin, McInerney, Fischer, Wright, and Rauch (2001) measured brain activation using fMRI and found that the amygdala was more responsive to fearful faces compared to both angry and neutral faces. On the other hand, Mogg, Garner and Bradley (2007) presented fearful-neutral and angry-neutral face pairs in a dot-probe task and measured both response times and eye movement information. They found that high anxious participants displayed an attentional bias to orient attention towards both fearful and angry faces relative to neutral faces. To explain the discrepancies between their study and the differential amygdala responses, the authors concluded that whilst angry and fearful faces both grab attention, the maintenance of this attention on them differs. Hence, angry faces clearly display threat, whilst fearful ones are more ambiguous and require greater amygdala processing (Mogg *et al.,* 2007). Thus, the stage of processing under investigation must be taken account of when comparing fearful and angry faces as they may not be directly comparable. Second, methodological details, such as precise SOA, differ quite markedly across the studies examining delayed disengagement of attention. Consequently, it is not clear under what constraints delayed disengagement occurs. Finally, the studies by Fox and colleagues selected for extreme high and low anxiety scores by excluding participants with mid-range scores. This may artificially inflate the differences between the two groups.

It is also important to note that some studies have reported *avoidance* of threat – quite the opposite of a delayed disengagement effect. Rohner (2004) found that anxious participants actually avoided angry faces compared to happy faces. Isaacowitz *et al.* (2006) also found that older adults tended to avoid angry compared to happy faces. So, like the capture effect, the delayed disengagement effect appears tenuous.

With this in mind, the present experiment examines the effect of emotional faces in the exogenous cueing paradigm using an SOA of 500 msecs. This SOA was selected to maintain SOA increment consistency with the previous exogenous studies in this thesis and to be consistent with previous literature. Further, the present study aims to rectify the limitations of previous studies in order to determine whether angry faces do indeed delay disengagement of attention. The present study uses colour photographic stimuli in a single cue paradigm. The purpose of the study is to investigate whether angry faces engage or avert attention in non-clinical samples. This further provides a comparison to which the reaction to disfigurement can be understood. All materials and the procedure, with the exception of the extended SOA, are the same as in the previous experiments (chapters 8 and 9) and will therefore provide a complement to them.

As before, disfigured faces will again function as face targets in the present experiment. This will provide an opportunity to compare a threat verses non-threat model of reaction to disfigurement. If disfigured faces are appraised as threatening, then the response should be the same as the response to angry faces. Alternatively, if the reaction to disfigurement is not comparable to that elicited by angry faces, it must be assumed that disfigurement does not elicit a similar threat response. Investigating this is important since it has now been found that initially disfigured faces do not avert attention, however, it is not known what happens at a longer presentation duration.

Method

Participants

Thirty students from Southampton University (9 males, 21 females), aged 18 to 41 years, (mean = 21.73 years, SD = 5.24) took part on a voluntary basis for course credit. They were unfamiliar with the faces used, and had not taken part in any studies of this thesis. All participants had normal, or corrected-to-normal, vision.

Materials

The same materials were used as used in Chapters 8-9.

Design

The design was the same as used in Chapters 8-9.

Procedure

All aspects of the procedure were the same as used in chapters 8-9. The crucial difference was that the face cue was presented for 300 msecs, and the blank screen presentation was extended to 200 msecs. This produced an SOA of 500 msecs.[6] Delayed disengagement of attention, rather than initial capture of attention, could thus be examined. The study took approximately 45 minutes to complete.

Results

Self reported anxiety scores

Participants completed the STAI measure of anxiety. The mean state anxiety score was 34.4 (SD = 8.55) out of 80. The mean trait anxiety score was 38.5 (SD = 7.69) out of 80. To divide participants into high and low state anxiety groups, the median state score was found (34.5). Individuals above the median were grouped as high state (N = 15, mean state score = 42, SD = 3.82) and individuals below the median were grouped as low state (N = 15, mean state score = 27.3, SD = 4.43). Accordingly these two groups were statistically different on their state anxiety (t (28) = -9.76, p < .001).

Data preparation

RTs on incorrect trials were removed (M = .04% incorrect responses). As the reaction time data were skewed, based on a significant Shapiro-Wilks test, the mean RTs were log transformed to minimise this. All results discussed will therefore be based upon this transformation. Figures 10.1 and 10.2 show the log transformed mean RT for each trial type, as a function of face type and anxiety level.

[6]This split was chosen to create an SOA of 500 msecs, and to keep timings consistent across experiments and previous literature.

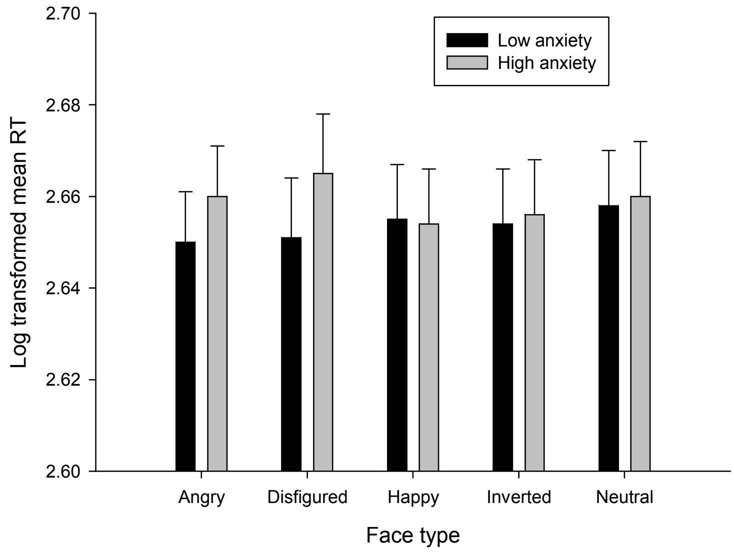


Figure 10.1. Log transformed mean RT (and SE) on valid trials as a function of anxiety and face type.

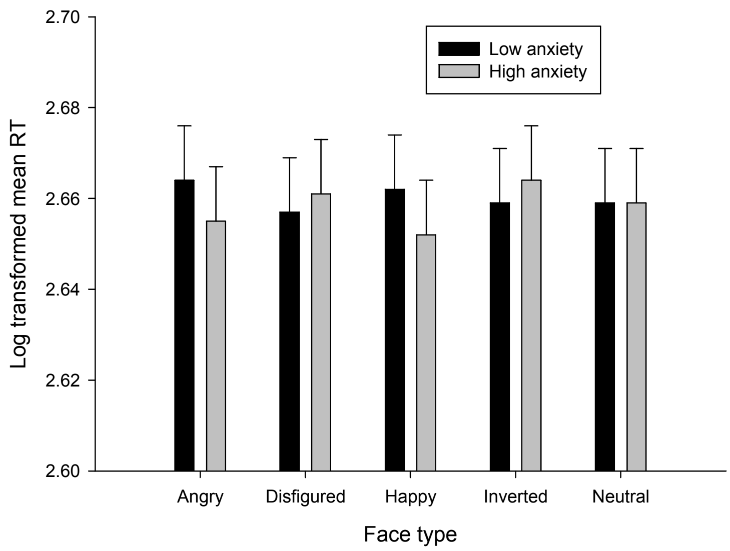


Figure 10.2. Log transformed mean RT (and SE) on invalid trials as a function of anxiety and face type.

Again, for a basic effect, a face by validity interaction was expected. Furthermore, to examine each anxiety group separately, a three-way interaction was required.

A mixed ANOVA was applied to the log transformed mean RT on correct trials, using face (angry, disfigured, happy, neutral, and inverted) and validity (valid, invalid) as within-subject variables, and state anxiety (low, high) as a between-subjects variable. There was no main effect of face (*F* (4, 112) = .12, *ns*), and no main effect of validity (*F* (1, 28) = .83, *ns*). There was no effect of anxiety (*F* (1, 28) = .03, *ns*). The expected face by validity interaction was not significant (*F* (4, 112) = .68; *ns*). There were no other significant two-way interactions (face by state: *F* (4, 12) = 1.73; validity by state: *F* (1, 28) = .97; all *ns*). Finally, the expected three-way interaction was not significant (*F* (4, 112) = 1.65, *ns*).[7]

Correlation analysis

As carried out in the previous two cueing studies, correlation analyses were also conducted to examine the relationship between anxiety and bias scores (log transformed bias scores in each case to remain consistent) for each face. A bias score is calculated by: Invalid trials – Valid trials per face type so that positive values indicate attending to the face, and negative values indicate avoiding the face. This follows the general method in the published literature for calculating bias scores (e.g. Cooper *et al.,* 2006).

Thus, a bias score was calculated for each face type (angry, disfigured, happy, and neutral) and correlated against anxiety scores (both trait and state anxiety, note scores for each range from 20 to 80). These results are presented below for each face type.

Angry faces

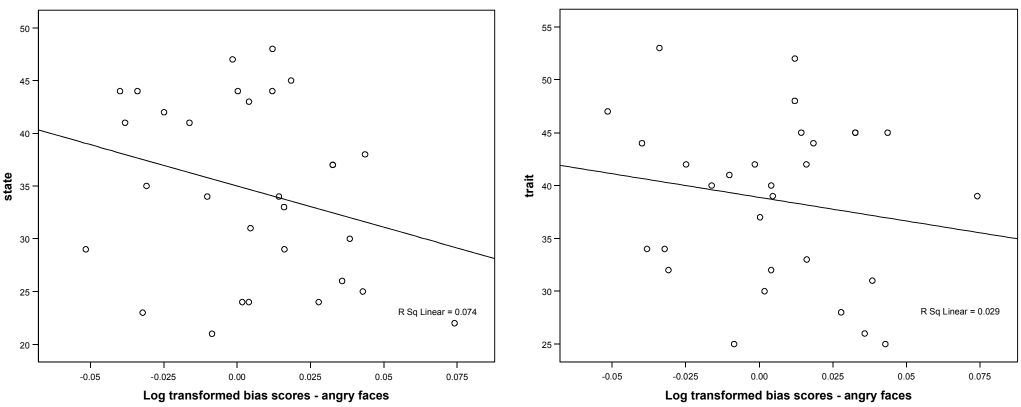


Figure 10.3. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for angry faces.

[7] Also note, a block analysis was carried out for this chapter as well, and the results can be found in Appendix F, and are reviewed in the discussion.

A Pearson's correlation addressed the relationship between state anxiety scores and angry faces bias scores. This found no significant relationship *r* (N=30) = -.27, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and angry faces bias scores. This also found no significant relationship *r* (N=30) = -.17, *p* = *ns*.

Disfigured faces

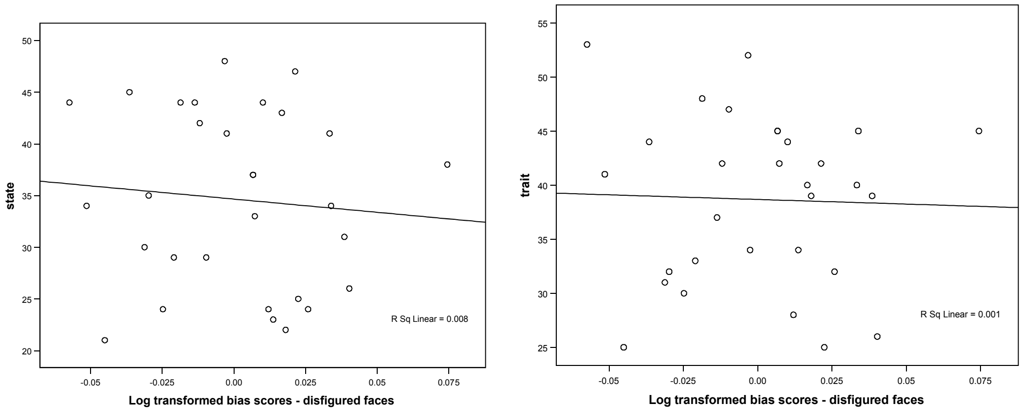


Figure 10.4. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for disfigured faces.

A Pearson's correlation addressed the relationship between state anxiety scores and disfigured faces bias scores. This found no significant relationship *r* (N=30) = -.09, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This also found no significant relationship *r* (N=30) = -.03, *p* = *ns*.

Happy faces

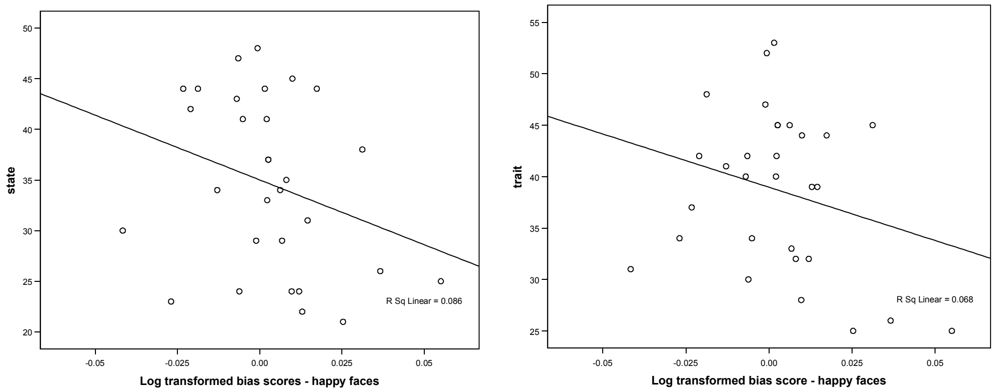


Figure 10.5. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for happy faces.

A Pearson's correlation addressed the relationship between state anxiety scores and happy faces bias scores. This found no significant relationship *r* (N=30) = -.29, *p = ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and happy faces bias scores. This also found no significant relationship *r* (N=30) = -.26, *p = ns*.

Neutral faces

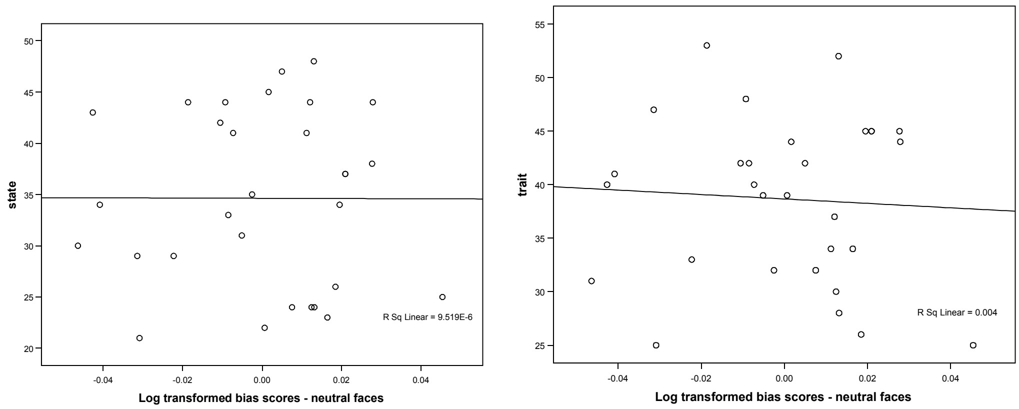


Figure 10.6. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for neutral faces.

A Pearson's correlation addressed the relationship between state anxiety scores and neutral faces bias scores. This found no significant relationship *r* (N=30) = -.003, *p = ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and neutral faces bias scores. This also found no significant relationship *r* (N=30) = -.06, *p = ns*.

Discussion

Contrary to expectations, this study was unable to find delayed-disengagement for any faces for either low anxious or high anxious participants. Additionally, there was no significant effect of disfigurement on attention.

The lack of any effect for angry faces is a most surprising result given that the previous literature has found a delayed disengagement of attention, or dwell, on threatening faces (e.g. Fox, Russo, Bowles & Dutton, 2001; Fox, Russo & Dutton, 2002; Georgiou, Bleakley, Hayward, Russo, Dutton, Eltiti & Fox, 2005). The null results in this study may be attributable to variations in methodology, with two particularly pertinent issues for discussion.

First, this study presented five different face types (happy, angry, disfigured, neutral and neutral-inverted). Previous published studies have presented up to three types only (happy, angry and neutral) and some only two face types. It was speculated that using high quality images, in colour, would increase ecological realism, and therefore enhance differences between face types in terms of attentional responding. It is possible, however, that the number of different face types caused any differences between them to be small, or at least to remain non-significant. This may largely have been due to the high attentional load within the task, caused by so many faces. Indeed, the experiment lasted approximately 20-30 minutes longer than the previous exogenous experiments in this thesis. High attentional load can indeed restrict the amount of stimulus processing (Lavie, 2005). For example, Pessoa, McKenna, Gutierrez and Ungerleider (2002) found that there was no emotion effect on response when participants viewed negative and positive faces when the task was designed to produce high attentional load. To rectify this issue, the study will be repeated excluding the neutral-inverted condition, and using only 4 face types (happy, angry, disfigured, neutral). The remaining types are required to explore whether any attentional effects for angry or disfigured faces are based on emotion or threat.

Second, the inability to find an anxiety effect may be attributed to differences in conceptualising the high and low anxiety groups. For example, in Fox *et al's* (2001) study, they defined the groups by way of high and low cut off scores, which resulted in the exclusion of participants falling between these points. In the present experiment, however, the median score was used to determine high and low groups, and no participants were excluded. This retained a representative range of anxiety scores in a non-clinical student population.

To remain consistent across cueing studies, correlation analyses were conducted on the relationship between bias scores to faces and state and trait anxiety. This revealed no significant relationships. As speculated, the relationship that was found between happy faces bias scores and trait anxiety when SOA was at 100 msecs was not evident at 500 msecs. Given that it was not evident either at 250 msecs SOA does suggest that the threat of social interaction, as would be expressed by happy faces, lasts for a very short time for those who are high in non-clinical trait anxiety. This is most likely because the sample is of a non-clinical nature.

A supplementary analysis was also conducted using block as a factor (see Appendix F). This found a main effect of block, but block did not interact with any other factor. Further comparisons indicated that participants were significantly slower on the first block compared to the other blocks, suggesting that response speed increased after block 1. Given that this did not interact with any other effect, one may assume that this reflects general boredom with the stud, as participants may have merely been responding to the probe as quick as possible to finish the experiment quickly, rather than examining other events on screen. This would also concur with the idea of fatigue effects, given that participants, upon leaving the experimental cubicle, reported that the study felt too long and they had ‘got bored’.

The effects of disfigurement on attention remain unclear from this study. At an SOA of 100 msecs, participants were responding by apparently ignoring the faces, so no threat or disfigurement effect was found. At an SOA of 250 msecs, results indicated rapid aversion away from angry faces for high anxious participants, with no similarity in response between angry and disfigured face trials. However, the present study found no attentional effects. Furthermore, the effect of disfigurement remains unanswered as a robust delayed disengagement from angry faces was not replicated. It was considered that a slight reduction in the number of stimuli may address this. Thus, the next experiment uses only four face types (angry, happy, disfigured and neutral) in an attempt to examine this issue.

Chapter 11
Experiment 8: Examining delayed disengagement effects with emotional and disfigured faces II

Introduction

This chapter aims to re-examine delayed disengagement effects with emotional and disfigured faces using the spatial cueing paradigm. Slight changes in methodology aim to rectify the problems associated with the null effects found in the previous study.

The previous chapter failed to find a delayed disengagement of attention with angry faces. A null result with the angry faces is contrary to previous studies, which have found delayed disengagement from angry faces with high anxious participants. However, in chapter 9 of this thesis when the SOA was 250 msecs, it was found that high state anxious participants actually averted their attention *away* from angry faces. Moreover, across all studies in this thesis so far, the reaction to disfigured faces has not been comparable to that with angry faces. Null results from the previous experiment (chapter 10) may, however, be the fault of a high number of presented stimuli, which may have weakened any differences between trials through overload or fatigue effects. Therefore, in the present experiment, the inverted-neutral face trials were removed. Thus, the design retained the neutral, happy, angry, and disfigured face trials so as to examine the effects of emotion, threat and disfigurement. First, the study aims to establish whether attention is averted or engaged by angry faces. Second, it aims to establish what effect disfigurement has on attention. Finally, it aims to examine the moderating role of anxiety.

Method

Participants

Thirty students from Southampton University (8 males, 22 females), aged 18 to 41 years, (mean = 22.3, SD = 5.4) took part on a voluntary basis for course credit. They were unfamiliar with the faces used and had never taken part in previous studies of this thesis. All participants had normal, or corrected-to-normal, vision.

Materials

The same materials were used in this study as in chapters 8-10, with the exception that the inverted faces were not used. There were therefore four images for each of the two identities (angry, happy, neutral and disfigured).

Design

The within-subjects independent variables were face type (happy, angry, neutral, and disfigured) and trial type (valid, invalid). The between-subject variable was state anxiety. The dependent variable was reaction time to dot-probe classification.

Procedure

The procedure was the same as in chapter 10 with an SOA of 500 msecs. The only change was that the inverted face trials were removed, reducing the total number of trials to 640, divided into 5 blocks of 128 trials. All other aspects of the procedure were the same as in chapter 10. The study took approximately 35 minutes to complete.

Results

Self-reported anxiety scores

Participants completed the STAI measure of anxiety. The mean state anxiety score was 32.9 (SD = 9.2) out of 80. The mean trait anxiety score was 36.5 (SD = 6.1) out of 80. As before, to divide participants into high and low state anxiety groups, the median state score was found (34). Individuals above the median were grouped as high state (N = 15, mean state score = 40.7, SD = 4.48) and individuals below the median were grouped as low state (N = 15, mean state score = 24.2, SD = 4.46). Accordingly, these two groups were statistically different on their state anxiety (t (28) = -10.1, $p < .001$).

Data preparation

RTs on incorrect trials were removed (M = .03% incorrect responses). As the reaction time data was skewed based on a significant Shapiro-Wilks test, the mean RTs were log transformed to minimise this. All results discussed will therefore be based upon this transformation. Figures 11.1 and 11.2 show the log transformed mean RT for each trial type, as a function of face type and anxiety.

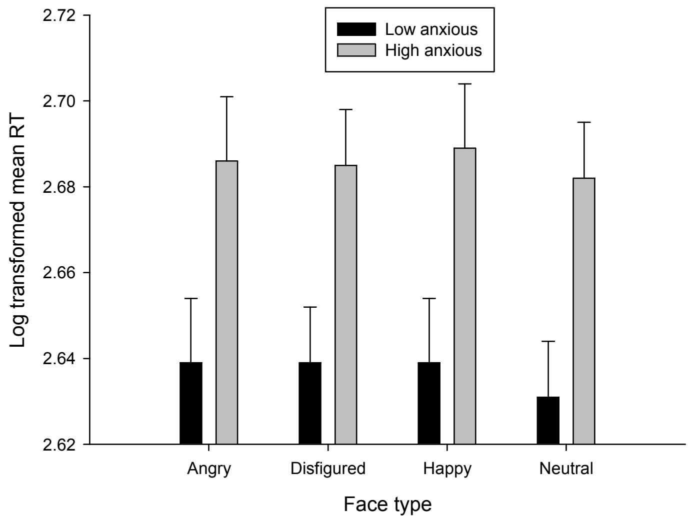


Figure 11.1. Log transformed mean RT (and SE) on valid trials as a function of anxiety and face type.

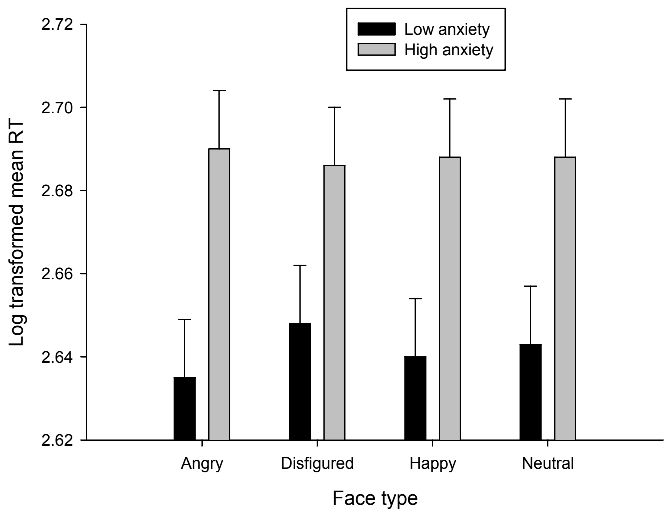


Figure 11.2. Log transformed mean RT (and SE) on invalid trials as a function of anxiety and face type.

As conducted previously, a mixed ANOVA was applied to the log transformed mean RT on correct trials, using face (angry, disfigured, happy, neutral) and validity (valid, invalid) as within-subject variables, and state anxiety (low, high) as a between-subjects variable. Again, a basic two-way interaction of face by validity was expected.

There was no main effect of face (F (3, 84) = .96, *ns*), and no main effect of validity (F (1, 28) = 1.89, *ns*). An effect of anxiety group was evident (F (1, 28) = 6.16, p = .019), indicating that the high state group (M= 2.69, SE = .01) were taking longer to respond than the low state group (M = 2.64, SE = .01) in the experiment overall. However, there were no significant interactions (face by state: F (3, 84) = 1.45; validity by state: F (1, 28) = .19; face by validity: F (3, 84) = 1.82; face by validity by state: F (3, 84) = 1.42, all *ns*). Thus, given that the expected two-way interaction effect of face by validity was not observed, and there were no interaction effects with anxiety, no further analyses were justifiable.[8]

Correlation analysis

Correlation analyses were again carried out to examine the relationship between anxiety and bias scores (log transformed bias scores in each case to remain consistent) for each face. A bias score is calculated by: Invalid trials – Valid trials per face type so that positive values indicate attending to the face, and negative values indicate avoiding the face. This follows the general method in the published literature for calculating bias scores (e.g. Cooper *et al.,* 2006).

Thus, a bias score was calculated for each face type (angry, disfigured, happy, and neutral) and correlated against anxiety scores (both trait and state anxiety, note scores for each range from 20 to 80). These results are presented below for each face type.

[8] As before, an analysis using block as factor was carried out, the results of which can be seen in Appendix F, and are reviewed in the discussion in this chapter.

Angry faces

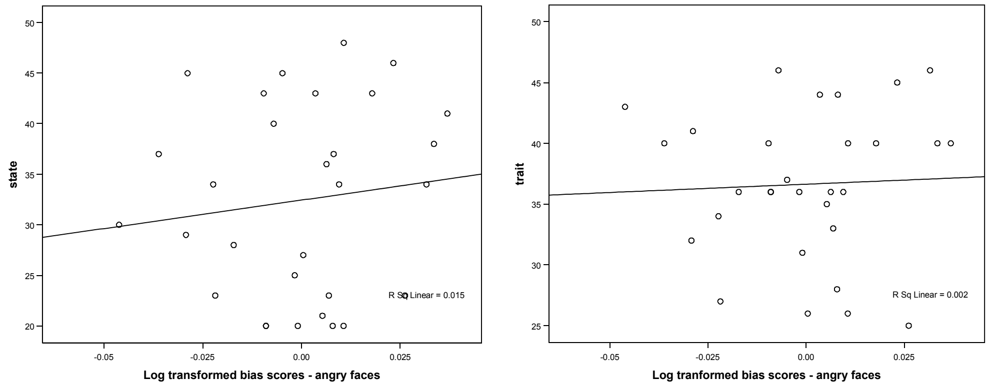


Figure 11.3. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for angry faces.

A Pearson's correlation addressed the relationship between state anxiety scores and angry faces bias scores. This found no significant relationship *r* (N=30) = .12, p = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and angry faces bias scores. This also found no significant relationship *r* (N=30) = .05, p = *ns*.

Disfigured faces

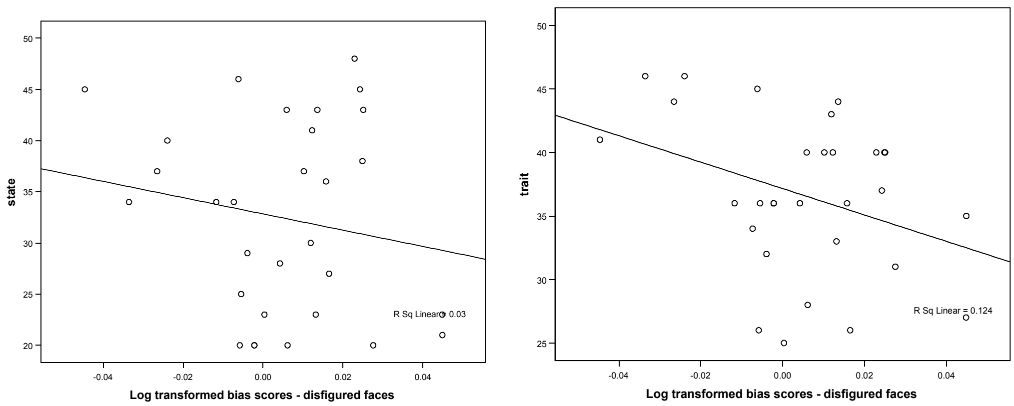


Figure 11.4. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for disfigured faces.

A Pearson's correlation addressed the relationship between state anxiety scores and disfigured faces bias scores. This found no significant relationship *r* (N=30) = -.17, p = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This also found no significant relationship *r* (N=30) = -.35, *p* = *ns*.

Happy faces

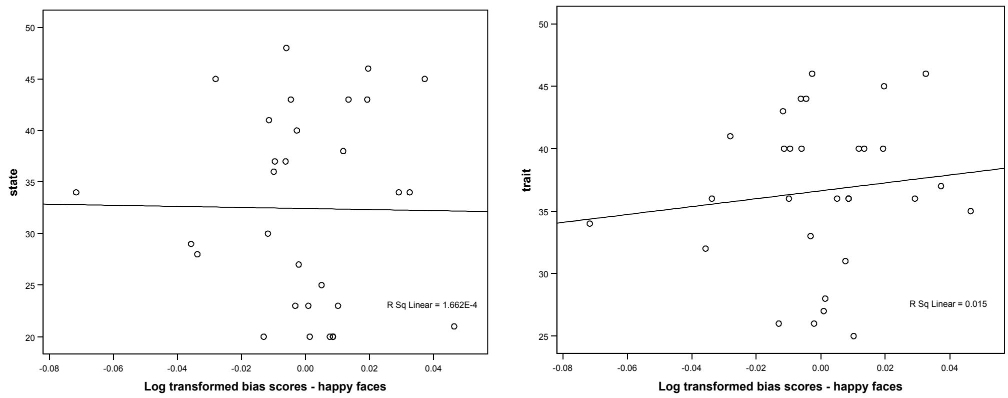


Figure 11.5. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for happy faces.

A Pearson's correlation addressed the relationship between state anxiety scores and disfigured faces bias scores. This found no significant relationship *r* (N=30) = -.01, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This also found no significant relationship *r* (N=30) = .12, *p* = *ns*.

Neutral faces

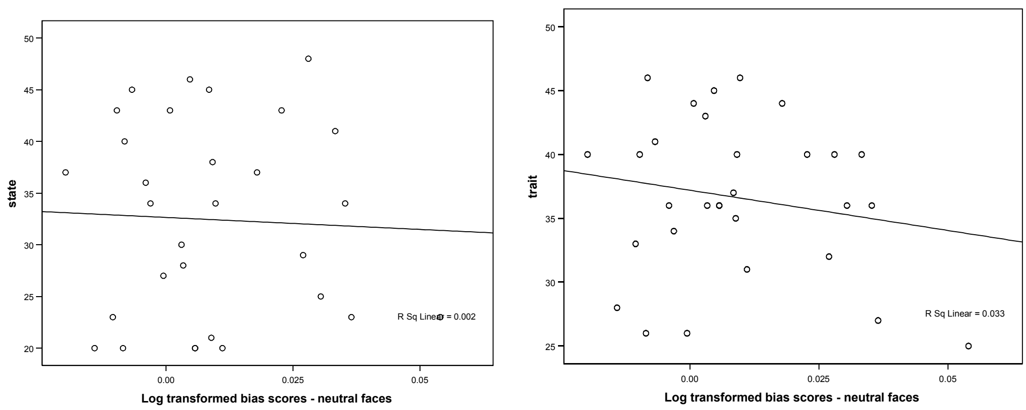


Figure 11.6. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for neutral faces.

A Pearson's correlation addressed the relationship between state anxiety scores and disfigured faces bias scores. This found no significant relationship *r* (N=30) = -.04, *p = ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This also found no significant relationship *r* (N=30) = -.18, *p = ns*.

Discussion

This study has been unable to find any attentional biases to emotional faces. The study was designed to reduce the number of trials compared to the previous study, but still examine the issue of attention to emotion by having happy, angry and neutral faces, as well as attention to disfigured faces, at a presentation rate of 500 msecs. However, even when the inverted face type was removed, the present study was unable to reveal any significant results. This concurs with the null effects found in the previous study which also had stimulus onset asynchrony set at 500 msecs, but the results are contrary to the published literature.

Several studies have reported delayed-disengagement effects with angry faces with high anxious individuals, arguing that attention dwells on such faces in order to determine potential threat (e.g. Fox *et al.,* 2002; Ioannou, Mogg & Bradley, 2004). This effect has been found with SOAs of 300 – 500 msecs, and therefore the present results provide a contradictory picture. However, the delayed-disengagement effect may actually be questioned. Although some studies have reported delayed disengagement of attention to threat stimuli, some studies have not found this. For example, Fox *et al.* (2002) actually found delayed disengagement from *both* happy and angry faces, indicative of an emotional, not a threat, effect. Therefore the literature on the delayed disengagement effect is far from clear. Thus, null results found here may be less surprising than first thought; perhaps using 500 msecs SOA is too long to reveal attentional biases in a non-clinical sample. Indeed, participants in this study were not selected on the basis of extreme anxiety scores, but instead all participants were used and grouped into high and low anxiety groups based on a median split. One possible way of investigating this further would either be to use a clinically anxious sample compared to a non-clinical one or to pre-select individuals on anxiety score so that chosen participants are extreme scorers. This may reveal differences that can be hard to detect, especially given that some researchers argue that attentional biases can be hard to reveal (Bar- Haim *et al.,* 2007).

It is also important to note that again, we cannot be sure whether disfigured faces and angry faces are affecting attention in the same way as each other given the lack of effects found here. Thus, it is important to examine this further.

A possible explanation for the lack of clear disfigurement effects is that the image depicting the facial disfigurement used in this study and others in this thesis may not realistic enough to generate a true emotional response from the perceiver. The disfigurement, a port wine stain (PWS) was artificially created after extensive examination of faces with real PWS. Colour was also used to mimic the colouring of a true PWS. That being said, it is necessary to address the issue of ecological validity so the next study (chapter 12) will make use of real faces with PWS in the exogenous cueing paradigm. This will determine if effects become clearer when the stimuli are true.

As before, the correlation analyses were also run with the bias scores and trait and state anxiety. This revealed no significant relationships, and therefore no further evidence of attention to, or aversion away from, a particular face depending on level of state or trait anxiety. It is also worth mentioning that again, the relationship between bias scores for happy faces and trait anxiety that was apparent at 100 msecs SOA was not apparent at this presentation display of 500 msecs SOA, which concurs with the previous study.

A supplementary analysis was also run with block as a factor (see Appendix F for further details). This found a main effect of block, but block did not interact with any other factors. Thus participants generally became faster at the dot probe task as the experiment progressed. As suggested before, this indicates that participants had good attentional control, and were able to focus much of their attention on providing a rapid response to the probe, and were not affected by the presence of different face types. This may hide any effects that faces had on attentional biases.

To conclude, this study failed to reveal any attentional biases. Whilst this does not concur with the published literature that has found delayed disengagement of attention from angry faces, it does mirror the previous study that also used 500 msecs SOA, which included inverted faces, but did not find any effects. Thus, the next step is to examine whether null effects may be due to poor ecological validity of the disfigured face, and so the next chapter will present real disfigured faces in the dot-probe paradigm, alongside the angry, happy and neutral faces. Given that the strongest attentional effects so far have been found when the SOA is set at 250 msecs, this presentation rate will be used in the next study.

Chapter 12

Experiment 9: The influence of real images of facial disfigurement in the cueing task

Introduction

This chapter aims to address the issue of whether the inability to find a clear threat effect with the disfigured stimuli arises because the previous disfigured stimuli lacked realism. This chapter will again use the cueing paradigm, presenting emotional faces, and photographs of individuals with real facial disfigurements. To remain consistent with the other studies, the images show individuals who exhibit port wine stains, and are males of a similar age to the NimStim faces used.

So far in this thesis, it has been established that the behavioural reaction to angry faces and the reaction to disfigured faces may not be equated. This has been the case using both an RSVP task and an exogenous cueing task. However, the realism of the disfigured images may be under question, and thus it is important to address this through the use of presenting real images. This will enable us to determine whether a lack of threat effect to facial disfigurement so far was due to the realism of the stimuli.

Given that the strongest effects in this thesis so far have been found using an SOA of 250 ms in the exogenous cueing task (chapter 9), this experiment will retain this SOA duration. If the response to real disfigured faces is comparable to the response to artificial disfigured faces, then it is reasonable to argue that the use of artificial disfigured faces in the previous studies was not the reason for the lack of a clear threat reaction.

Method

Participants

Thirty students (3 males, 27 females), aged 18 to 48 years, (mean = 20.73 years, SD = 5.54) took part on a voluntary basis for course credit. They were unfamiliar with the faces used and had not taken part in previous studies of this thesis. All participants had normal, or corrected-to-normal, vision.

Materials

The same materials were used in this study as in chapter 8-11. The two angry, happy and neutral faces were retained. The main difference was that the artificially disfigured faces were replaced by photographs of 2 individuals with real port wine stains obtained from the internet. (Appendix D presents the images used). Both were full frontal, white, male faces cropped to the same size as all other faces, to retain consistency with the stimulus set.

Design

The within-subjects independent variables were face type (happy, angry, neutral, and disfigured) and trial type (valid, invalid). The between-subject variable was state anxiety. The dependent variable was reaction time to dot-probe classification.

Procedure

The procedure replicated the previous design from Chapter 11, but with an SOA of 250 msecs. As in chapter 11, there were a total of trials 640 trials, divided into 5 blocks of 128 trials. As with chapter 11, the neutral-inverted face was again excluded to minimise the fatigue effects and so the experiment lasted approximately 25 minutes. All other aspects of the procedure were the same as in chapter 11 with the only differences being the use of real disfigured faces rather than artificial disfigured faces and an SOA of 250 msecs.

Results

Self reported anxiety scores

The mean state anxiety score was 39.5 out of 80 (SD = 10.57). The mean trait anxiety score was 41 out of 80 (SD = 12.29). As before, to divide participants into high and low state anxiety groups, the median state score was found (39). Individuals above the median were grouped as high state (N = 15, mean state score = 47.27, SD = 8.92) and individuals below the median were grouped as low state (N = 15, mean state score = 31.73, SD = 4.74). Accordingly, these two groups were statistically different on their state anxiety (t (28) = -5.95, p < .001).

Data preparation

Reaction time on incorrect trials was removed (M = .06% incorrect responses). Following a significant Shapiro-Wilks test to test for skew, mean RT data was log-transformed to minimise this skew. All results discussed will therefore be based upon this transformation for ease of reading and interpretation. Figures 12.1 and 12.2 show the log transformed mean RT for valid and invalid trials, as a function of face type and anxiety.

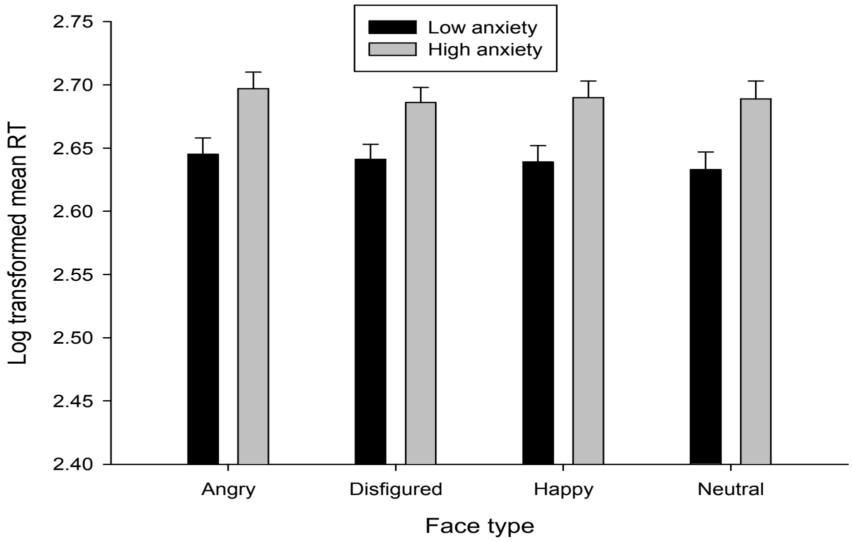


Figure 12.1. Log-transformed mean RT (with SE) as a function of face type and anxiety on valid trials.

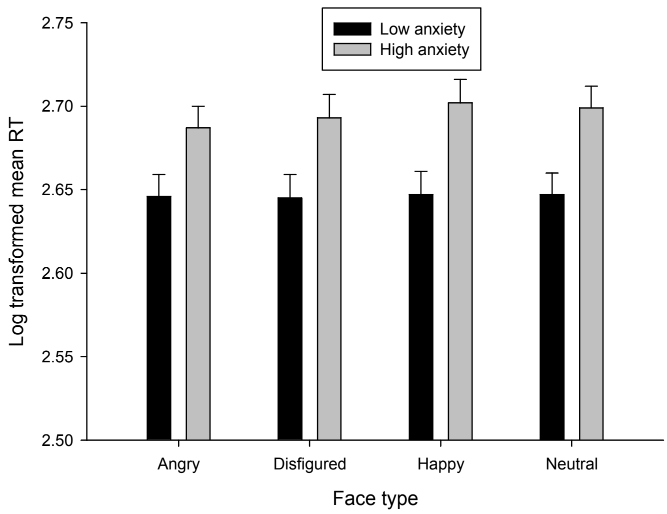


Figure 12.2. Log-transformed mean RT (with SE) as a function of face type and anxiety on invalid trials.

As before, a mixed ANOVA was applied to the log-transformed mean RT on correct trials, using face type (angry, real disfigured, happy, neutral) and trial validity (valid, invalid) as within-subject variables, and state anxiety (low, high) as a between-subjects variable. A significant face by validity interaction was hoped for.

The main effect of face type was not significant (*F* (3, 84) = .6, *ns*). There was a trend for an effect of validity (*F* (1, 28) = 3.91, *p = .058*). As expected with a cueing study, RT on valid trials tended to be quicker than on invalid trials.

The two-way interactions of face type and state anxiety, and validity by state anxiety were both non-significant (*F* (3, 84) = .95, *ns*; *F* (1, 28) = .14, *ns*, respectively). Although not robust, as expected there was a trend for an interaction of face type by validity (*F* (3, 84) = 2.32, *p* = .08).

The three-way interaction of all factors was not significant (*F* (3, 84) = .6, *ns*). However, the between-subjects effect of state anxiety was significant (*F* (1, 28) = 7.79, *p = .009*). This revealed that high state anxious participants were responding slower (mean = 2.69, SE = .01) than low state anxious participants (mean = 2.64, SE = .01).

Given the previous results in this thesis, even though the face by validity interaction only approached significance, it needs to be explored to determine if there is a trend for the same pattern of results as found in the other cueing studies. This is based on the expectation that there is avoidance of the angry faces, and that angry and disfigured faces are not comparable. Thus, with the same predictive motivations as before, a series of paired t-tests was conducted across all participants as an examination of the weak two-way interaction (comparing angry and disfigured faces to neutral faces and to each other).

Valid trials

Three paired t-tests were conducted (alpha corrected to .017). There was no significant difference between angry and disfigured face trials (*t* (29) = 1.57, *ns*), nor between disfigured and neutral face trials (*t* (29) = .59, *ns*). There was a trend, however, for participants to be slower on angry face trials (mean = 2.67, SE = .01) compared to neutral face trials (mean = 2.66, SE = .01), indicating a tendency to avert attention away from angry faces, resulting in a slowed reaction time even when the cue and face were in the same place (*t* (29) = 2.18, *p = .037*).

Invalid trials

Three paired t-tests were conducted (alpha = .017). There was no significant difference between angry and disfigured face trials (*t* (29) = -.52, *ns*) , nor between disfigured and neutral face trials (*t* (29) = -1.12, *ns*). There was a tentative indication that participants were quicker on angry face invalid trials (mean = 2.66, SE = .01) compared to neutral face invalid trials (mean = 2.67, SE .01), which is again indicative of avoidance of angry faces (*t* (29) = 1.72, *p* = .097) as attention had oriented away from the angry face cue to the opposite location quickly.

It is duly acknowledged that within these tests, as alpha was adjusted to .017, a trend effect would require the p value to be 1 – 2 times of that range; consequently the significance of the trend effects becomes extremely tenuous. However, the results were reported here to demonstrate to the reader the pattern of results in the data, especially because they follow the same pattern within cueing studies of this thesis. It is noted that conclusions drawn from such results are done so with caution and from an exploratory standpoint.[9]

Correlation analyses

As with the other cueing studies, to supplement the above analysis, correlation analyses were also carried out to examine the relationship between anxiety and bias scores (log transformed bias scores in each case to remain consistent) for each face. A bias score is calculated by: Invalid trials – Valid trials per face type so that positive values indicate attending to the face, and negative values indicate avoiding the face. This follows the general method in the published literature for calculating bias scores (e.g. Cooper *et al.,* 2006).

Thus, a bias score was calculated for each face type (angry, disfigured, happy, and neutral) and correlated against anxiety scores (both trait and state anxiety, note scores for each range from 20 to 80). These results are presented below for each face type.

[9] An addition analyses was also carried out with block as a factor. The results can be found in Appendix F, and are discussed within the discussion chapter of this thesis.

Angry faces

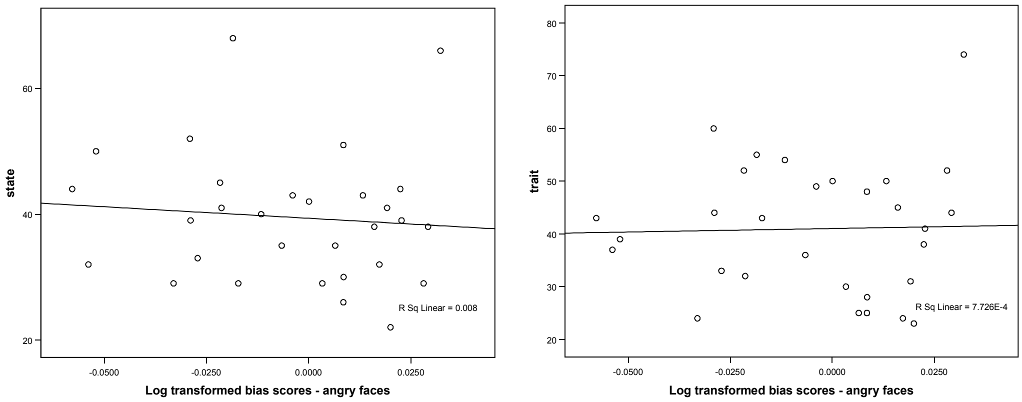


Figure 12.3. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for angry faces.

A Pearson's correlation addressed the relationship between state anxiety scores and angry faces bias scores. This found no significant relationship *r* (N=30) = -.00, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and angry faces bias scores. This also found no significant relationship *r* (N=30) = .03, *p* = *ns*.

Disfigured faces

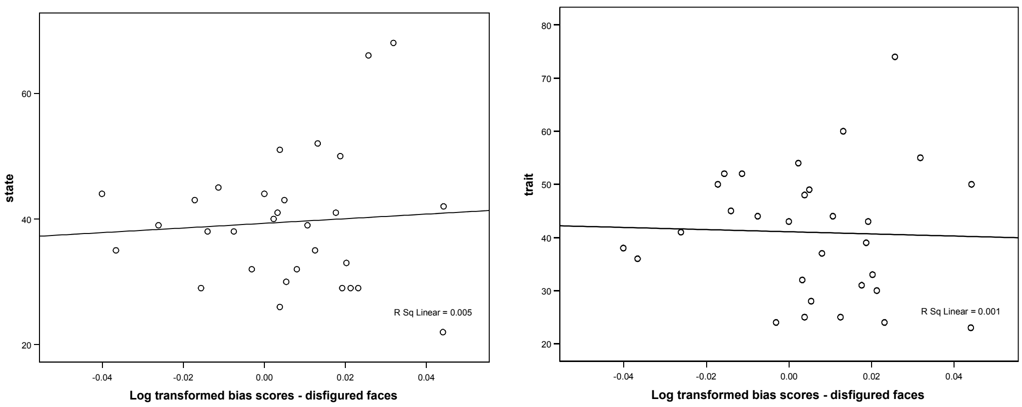


Figure 12.4. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for disfigured faces.

A Pearson's correlation addressed the relationship between state anxiety scores and disfigured faces bias scores. This found no significant relationship *r* (N=30) = .07, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and disfigured faces bias scores. This also found no significant relationship *r* (N=30) = -.03, *p* = *ns*.

Happy faces

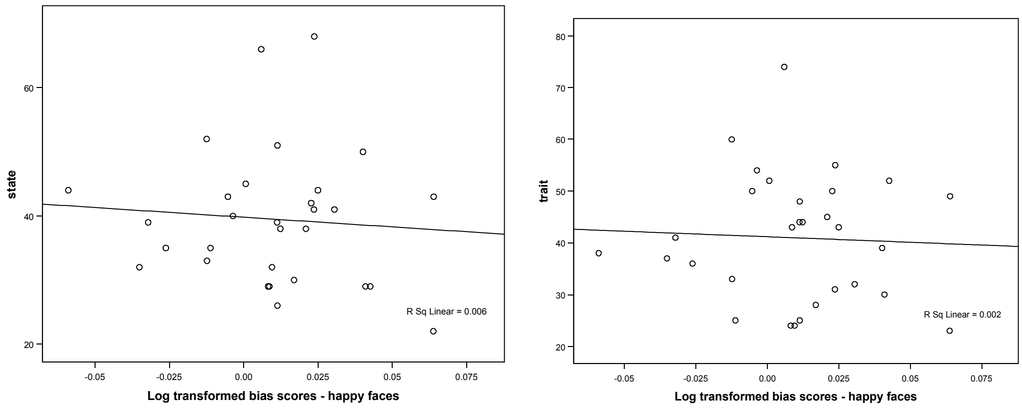


Figure 12.5. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for happy faces.

A Pearson's correlation addressed the relationship between state anxiety scores and happy faces bias scores. This found no significant relationship *r* (N=30) = -.08, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and happy faces bias scores. This also found no significant relationship *r* (N=30) = -.05, *p* = *ns*.

Neutral faces

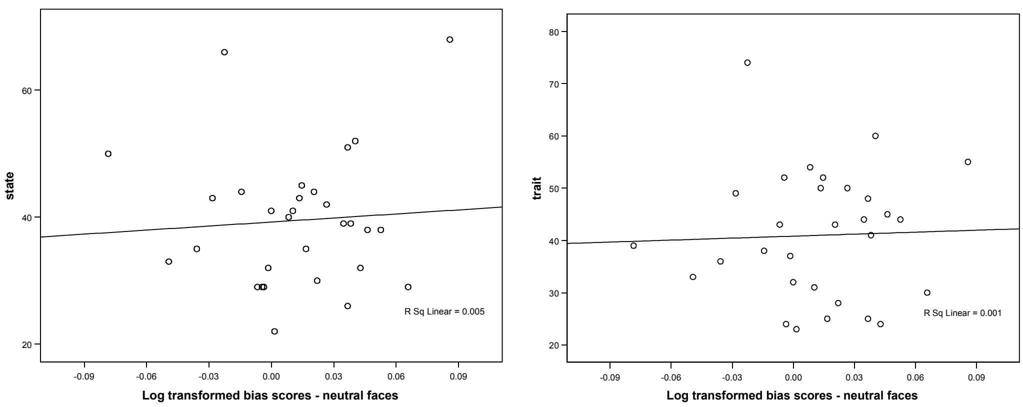


Figure 12.6. Scatter plots showing state and trait anxiety correlated with the log transformed bias scores for neutral faces.

A Pearson's correlation addressed the relationship between state anxiety scores and happy faces bias scores. This found no significant relationship *r* (N=30) = .07, *p* = *ns*. Further, a Pearson's correlation addressed the relationship between trait anxiety scores and happy faces bias scores. This also found no significant relationship *r* (N=30) = .04, *p* = *ns*.

Discussion

The primary aim of this study was to determine whether real facial disfigurement produced a stronger behavioural effect than artificial disfigurement within the cueing paradigm. The data suggest that the effects with real disfigured faces are no different than with artificial faces. Therefore, with reasonable confidence, the argument for retaining the artificial disfigured faces, and for the use of artificially disfigured faces throughout this thesis, is justified. In support, within the attention to faces literature, the published studies are not consistent in their use of real emotional expressions and schematic expressions, and their use of both monochrome and colour images, yet similar conclusions have been reached with the same paradigms (e.g. Fox, Russo & Dutton, 2002; Georgiou *et al.* 2005).

With regards to overall response time, this study found that high state anxious participants were significantly slower to respond to the probe than low state anxious participants. This indicates that anxiety influences speed of response, and this is consistent with previous literature using attentional paradigms (see Williams *et al.,* 1997, for a review). To note, in this particular study, anxiety did not interact with face type to affect performance. Thus, no inferences can be drawn concerning whether or not a particular expression or face type influenced the speed of responding for high state anxious individuals.

Previous results in this thesis have indicated that high anxious individuals avert their attention away from angry faces. First, with the RSVP studies, there was an overall effect of angry faces with all participants (chapter 5) showing processing difficulty of angry faces when they were second targets at lag 2 position. Secondly, in the cueing studies (chapters 8-11) angry faces generally averted attention for high and low anxious participants. It was assumed that these results reflected a threat reaction in an attempt to reduce the negative effects caused by a threat stimulus. This threat reaction, however, is not evident with disfigured faces. Given these results, it was deemed reasonable to investigate the current trend for face type to interact with trial validity.

When this was examined, there was an indication of aversion of attention away from angry faces only. That is, in terms of an emerging behavioural tendency, on valid trials attention was averted away from the angry face to the opposite location, so that when the probe appeared, attention needed to orient back to facilitate a response, and so response was slow. Similarly, there was an indication of aversion away from angry faces on invalid trials too. On these invalid trials, when the angry face was shown, attention tended to quickly orient away to the opposite location, so that response was quick to the probe at the new location. This pattern of results converges with the cueing data in this thesis.

This suggestive pattern of results goes against the literature arguing for capture of attention by such faces (e.g. Georgiou *et al.,* 2005). However, the capture effect is tenuous, and the present results do converge with the existing literature documenting avoidance to angry faces (Isaacowitz, 2006; Isaacowitz *et al.,* 2006; Lau & Viding 2007; Rohner, 2004). For example, even under restricted awareness, when capture effects could be assumed to be at their strongest, Stone and Valentine (2007) failed to find any capture effects to angry faces compared to neutral and happy faces. Further, Koster, Verschuere, Burssens, Custers and Crombez (2007) have found delayed responding to emotional compared to neutral faces using an exogenous cueing task with an SOA of 100 msecs. That is, participants were quick to respond to neutral faces compared to angry and happy faces. Again, even under restricted awareness, there were no capture effects to angry faces. Koster *et al.* (2007) suggested that participants may develop attentional control settings (ACS) that affect how their attention is allocated. This notion of ACS has been identified before in terms of default and top-down driving motivations (Folk, Remington & Johnston, 1992). It may tentatively be argued that aversion effects driven by angry faces found in this thesis are a product of ACS to avoid stimuli that have the potential to increase anxiety levels. In support of this top-down influence on the ACS, Hahn and Gronlund (2007) manipulated task goals so that even when an angry face was present in a visual search display as a non-target item among neutral faces, it could not capture attention away from searching for a happy face. This suggests that ACS can be adjusted in line with task goals and self-motivation and therefore it is necessary to carefully examine and interpret the data.

As with the other cueing studies, an analysis of the effect of block was conducted to determine whether effects were more apparent at the start of the experiment. (See Appendix F for full analysis). This found that there was only a main effect of block, with no factors interacting with block, which indicates that participants generally become faster at the probe task as the blocks progressed. Again, this suggests that participants were getting better at the actual task as blocks progressed, and were less focused on the faces as there were no interaction effects with block. This faster response to the probe in later blocks compared to the first block is a pattern that seems to have occurred within all the cueing studies in this thesis. The results suggest participants were becoming quicker at the task overall, especially as there were no interacting effects with block, i.e. the increase in speed is consistent across different face types and validity type. Hence, participants may have become faster as they become used to the study design, and thus aimed to finish the task as quick as possible, and therefore these results may indicate boredom with the study. Future studies may want to examine the role of number of trials and blocks to determine whether or not this influences the effects gained in a cueing task, and may also want to include a questionnaire to examine the participants' level of boredom and motivation with the study.

It is noted that the present study did not directly compare artificial and real images of facial disfigurement within the same study. Whilst such a design would have been optimal, it was reasoned that it would not reflect the rarity of facial disfigurement in real life. Individuals with facial disfigurement are in the minority in the general population. Therefore, this study aimed to retain the disfigured stimuli as a minority in the face pool, as in real life, by presenting only one quarter of faces as disfigured.

As with the other cueing studies, the correlation analyses with trait and state anxiety and bias scores for each face was carried out. Unfortunately, this revealed no significant relationships. However, this does concur with the correlation results of chapter 9 when the SOA was set at 250 msecs, as well as when the SOAs were 100 msecs and 500 msecs, which indicates consistency in the results across chapters.

To summarise, this study has first addressed the realism of the disfigured faces used in previous chapters within this thesis. It was found that the response when using real disfigurements did not differ compared to the response using artificially created disfigured faces. Again, with this study, no threat effect was evident with the disfigured faces. Second, this study revealed an emerging pattern indicating that regardless of anxiety, participants tended to avoid angry faces. Importantly, this is consistent with the pattern of results found so far in this thesis, and with some evidence in the published literature.

The findings so far in this thesis indicate that the response to disfigurement may be a combination of emotional responses. This is particularly plausible given that in the social psychological literature, there are reports of both staring at and avoidance from individuals with facial disfigurement (e.g. Bull & Stevens, 1981; Clarke, 1997; Partridge, 1990; Rumsey, Bull & Gahagan, 1982). Given that in this thesis so far the reaction to angry and disfigured faces has not been comparable, it is unlikely that the response to disfigurement is one of basic threat; although the response may contain an *element* of threat. Although facial disfigurement may be perceived as threatening, because it is so unusual and different, facial disfigurement may warrant further analysis and therefore attention is not averted. This may be motivated by disgust, fear, or curiosity. Conflicting emotional responses may therefore make it difficult to tease apart the emotions at an early stage. Indeed, other stimuli elicit complex emotional responses. Vernon and Berenbaum (2002) suggested that the response to spiders in phobics may be a mixture of fear and disgust, but the demonstration of this may depend on the measure(s) used. If a stimulus such as a spider can elicit a blend of emotional responses, it may be plausible to suggest that a complex stimulus such as facial disfigurement could also elicit two (or more) responses by the perceiver.

It is reasonable to suggest that this blend of emotions may contain an element of a disgust response, as well as a threat response. This is hypothesised based on the work of Park and colleagues (Park, Faulkner & Schaller, 2003; Schaller, Park & Faulkner, 2003) who have argued that stimuli in the environment that appear to look odd are often avoided based on a reaction of disgust. The disgust response is an evolutionarily adaptive response that appraises such stimuli as a possible contaminant and so it is avoided to prevent disease (Curtis, Aunger & Rabie, 2004; Curtis & Biran, 2001; Haidt, McCauley & Rozin, 1993; Rozin, Millman & Nemeroff, 1986). Thus, in the initial moments of perception, disfigurement may be appraised as a potential contaminant, and triggers a disgust response. This may manifest itself in part as a freeze response, as has been reported upon presentation of mutilated bodies (Azevedo *et al.,* 2005). At the same time, the disfigured face may also elicit a threat response, as it is a stimulus that appears to elicit general avoidance behaviour (e.g. Bull & Stevens, 1981; Rumsey, Bull & Gahagan, 1982). Consequently, there may be conflict between the need to avert attention and the need to dwell attention on the disfigurement. This certainly highlights the complexity of the response to disfigurement, and again demonstrates that disfigurement may not elicit a simple threat response as shown with angry faces.

Hence, within this thesis so far, there have been mixed results in terms of the similarity of response to angry and disfigured faces. A similarity did exist in the detection advantage for both faces in the RSVP studies, yet only angry faces appear to avert attention in the cueing paradigm. It has been suggested that disfigured faces elicit a threat response which is part of a more complex emotional reaction. For this reason, the next chapter will present a novel paradigm that hopes to address this and tease apart such reactions.

Chapter 13
Experiment 10: Moving faces: The effect of approaching and withdrawing emotional and disfigured faces on attention

Introduction

This chapter introduces an alternative attentional task that attempts to tease apart the complex reactions toward facial disfigurement in order to determine whether threat is a component of the reaction. The results generated from the experiments in this thesis so far converge on the conclusion that the reaction toward angry faces, and toward disfigured faces, are not completely comparable. Whilst it has been shown that angry faces required fewer resources, as evidenced by recovery from the attentional blink, and posed a threat as indicated by aversion of attention, disfigured faces have not attracted such behavioural responses. Thus, there is as yet no evidence to indicate the disfigured faces are perceived as purely threatening stimuli like angry faces. Therefore, a more sensitive methodology is adopted in this chapter, first to examine reactions between angry and disfigured faces, and second, to understand the complexity of the reaction toward disfigurement.

It is possible to understand an emotional response in terms of the specific movement of the observer in relation to the stimulus. Schulkin, Thompson and Rosen (2003), much like Darwin (1859/1985) agreed that emotions are about actions, and emotions physiologically prepare the observer to attend to the situation. This has been developed through evolution to provide the best possible response to increase survival. Schulkin *et al.* (2003) went on to say that the brain mechanisms associated with appraisal and response are intimately linked with emotion processing areas, such as the amygdala, and thus certain stimuli through time begin to elicit an almost immediate response. This fits well with Le Doux's (1998) thesis of a rapid, yet crude, threat processing brain circuit that involves the amygdala. This in turn makes it near-impossible not to react to a threat-inducing stimulus (Schulkin *et al.,* 2003).

The movement toward an object can be understood in terms of the behavioural motivation. Behavioural motivation is broadly divided into two systems: the behavioural activation system and the behavioural inhibition system

(Carver & White, 1994; Gray, 1990; Harmon-Jones, 2003). These basic responses of approach and avoidance are associated with appetitive and aversive motivations respectively (Lang, Bradley & Cuthbert, 1997; Marsh, Ambady & Kleck, 2005). Marsh *et al.* (2005) described aversive as something that elicits avoidance, whilst appetitive as something that elicits approach although such a stimulus is not necessarily appealing given the root 'appetitive' meaning 'to go to, head for, or strive after' (Marsh *et al.,* 2005). As a consequence, potential threat is likely to motivate an aversive response and therefore produce withdrawal behaviour (Lang, *et al.,* 1997; Ohman & Mineka, 2001). Appetitive stimuli, on the other hand, are likely to attract approaching behaviour.

Importantly, these behavioural motivation systems are intimately linked with emotions (Carver & White, 1994; Harmon-Jones, 2003). By extension therefore, the appraisal of emotional expression is linked to behavioural motivation. In the case of anger, since this expression signals threat and danger, the behavioural consequence of the observer to the angry face is to avoid and escape (Ekman, 1999; Ekman & Friesen, 1971; Heuer, Rinck & Becker, 2007; Le Doux, 1998; Ohman, 1997, 2002). This is a rapid response, not mediated by higher cognitive processing (Ohman, 1997; Schulkin *et al.,* 2003). This is reflected in the behavioural literature documenting an avoidance response to angry faces, and indeed within this thesis. That withstanding, it is important to bear in mind that some studies report exactly the opposite pattern of results through the demonstration of capture effects with angry faces (e.g. Mogg & Bradley, 2002). Given this debate in the literature it makes it even more imperative to examine the angry face effect using a range of different paradigms to establish the time scale and properties of the threat effect.

One prominent paradigm that exposes this behavioural motivation to avoid a threat stimulus upon initial perception is the approach-withdraw task. This is when stimuli appear to move toward or away from the observer and reaction time to classify the movement is measured. Using this approach-withdraw paradigm with lever responses, Marsh *et al.* (2005) demonstrated that threatening facial stimuli do elicit an avoidance response. They showed participants a series of angry and fearful faces. The participants' task was to make an emotion categorisation judgement by pushing or pulling a lever depending on the emotion. Direction of lever movement was counterbalanced across participants. Thus, half the participants pushed the lever to angry faces and pulled to fearful faces, and the other half did the reverse. Analysis across the participants showed that the angry faces elicited a quicker push than pull, whilst the fearful faces elicited a quicker pull than push. Marsh *et al.* (2005) interpreted these results as indicating that participants were eager to escape from the angry facial expressions as they displayed potential danger. Conversely, they suggested that fearful faces were more appetitive, in that they elicited sympathy in the observer, not threat, thus inviting approach.

Heuer, Rinck and Becker (2007) provide a recent complement to this study. Using the same lever pushing methodology, they showed angry, happy and neutral faces, and a non-face control image (a puzzle). A measure of participants' social anxiety was also obtained. One improvement from the previous design included not requiring participants to make a response in relation to emotion, and therefore it was a more implicit measure of reaction. They implemented two conditions. The approach condition asked for participants to pull the lever when a face appeared, and push when a puzzle appeared. In the avoid condition, the instructions were reversed. Upon movement of the lever, the image would grow (when the lever was pulled) or shrink (when the lever was pushed) in size. As predicted, those with high levels of social anxiety exhibited a stronger tendency to push away from angry faces. This was interpreted as an evolutionary tendency to avoid threat given that pushing would decrease the size of the image on screen. This avoidance was also found with happy faces, indicative of a bias to avoid all emotions. Heuer *et al.* (2007) suggested that happy faces invite a social situation, and so they are an anxiety-producing stimulus for socially anxious individuals. There was no evidence of approaching or avoidance strategies directed at the neutral faces or puzzles for either high or low anxious participants.

It was also found that whilst high socially anxious participants explicitly rated the happy faces as positive, their actual behavioural reaction was to avoid these faces, much like the angry faces. This demonstrates that the approach-withdraw task can tap into the implicit, or initial, emotions that a stimulus elicits, thus making it a sensitive and powerful method to use to ascertain initial reaction to stimuli. Further, Heuer *et al.* (2007) agreed that this method is better at revealing attentional biases, especially given that anxious individuals show an unstable attentional bias which can have confounding effects on attentional tasks (Mogg & Bradley, 1998). This paper has shown that an expression effect can be found with emotional faces, but the picture is not complete since only a general emotion effect, rather than a threat effect, was found with socially anxious, and therefore highly sensitive, individuals.

A recent paper has further improved on the design of the approach-withdraw task to reduce the influence of motor function on response. Specifically, Adams, Ambady, Macrae and Kleck (2006) used keyboard responses rather than congruent or incongruent participant motion, to assess reaction. Adams *et al.* (2006) instructed participants to look at an image of a face, either angry or fearful, which subsequently got smaller, giving the illusion of going further away, or larger, giving the illusion of movement toward the viewer (study 1). They also created the illusion of movement through manipulating eye gaze direction (study 2). Participants were instructed to make a key response to indicate whether the face was coming toward or going away from them. For both studies, participants were quicker to detect angry faces that were moving toward them than angry faces moving away from them, or fearful faces that were moving away from them. Adams *et al.* (2006) also reported that participants were quicker on response to angry faces approaching compared to fearful faces approaching (although they did not adjust their alpha level to take account of multiple comparisons which would have rendered their effects in study 1 and 2 as trends only). In their summary, this quick response to an approaching angry face was interpreted as the facial expression being able to convey a sense of threat or danger to the perceiver, and thus the perceiver was able to determine this as approaching behaviour. Response was made quickly. On the other hand, the reaction to the approaching fearful faces was taken to indicate a 'freeze' response, produced by behavioural inhibition. Adams *et al.* (2006) suggested that 'approach motivation is defined by appetitive behaviour and avoidance motivation by aversive behaviour' (p.180). However, within the context of this experimental paradigm, the response interpretation they provide for their results may be counterintuitive. Indeed, it does not follow from the other approach-withdraw studies and the literature on avoidance of threat, that participants would be approaching a threatening stimulus. One could argue that the quick reaction to the approaching angry face may actually be interpreted as a move to quickly escape from the situation, rather than approach it. Threat itself causes a fight or flight response, and thus by quickly responding to the approaching angry face, given that the participant has the opportunity to remove him/herself from the image, the potential for confrontation can be reduced. This interpretation is all the more reasonable given that the face remained on screen until a response was made. Incidentally, this would fit well with the results found in the cueing studies in this thesis. Participants were quick to avert their attention away from the angry faces, which could be seen as the motivation to escape from the threat. As Darwin (1859/1985) and others, such as Le Doux (1998), have suggested, angry faces convey the intention to attack or harm. Unless prepared to fight, it is of adaptive sense to escape the situation if such an action is available. Importantly, the quick reaction to an approaching face interpreted as avoidance fits well with the literature presented so far.

A second point of criticism concerning Adams *et al's* (2006) study is that they included no neutral face image against which the responses of the angry and fearful images could be assessed. In the field of investigating reaction to expression, it is crucial to obtain this measure, as has been done in the studies within this thesis and some published papers.

Another point of concern is that none of the approach-avoid studies make use of a no-movement control condition, where the image does not change size at all, but instead moves to a different location. It may be necessary to compare the extent of response in relation to a condition where the face does not appear to get closer, or further away from, the observer. This may determine how a response is made when the face simply moves location rather than apparent distance.

With this is mind, the present study will adopt the approach-withdraw methodology as used by Adams *et al.* (2006) using keyboard responses with some changes to take account of control conditions. First, it will include a neutral image so that we are able to assess the baseline response when the face displays no sign of emotion. Second, there will be three movement conditions. Movement toward will be created by *increasing* the critical image size from the original, whilst movement away will be achieved by *decreasing* the critical image size from the original. There will also be a displacement condition, presenting the critical image to the left or right of centre screen, without altering the size of the original image. This will allow for an examination of response when there is no apparent movement of the face toward or away from the observer. With reference to the influence of facial expression on response, it is predicted that the response to angry faces will be quick when they appear to approach the participant, as motivated by a need to avoid threat.

To continue with the central research question under investigation, the stimuli will include disfigured faces, as well as angry and neutral faces. Within this task, participants have the opportunity to react quickly, or to stare and react slowly, since the response is made directly to the face rather than to a probe or a subsequent target. Given what is already known about the negative reaction to facial disfigurement via anecdotes and social psychological experiments (e.g. Bull & Rumsey, 1988; Partridge, 1990), it is expected that participants will be quick to react when the disfigured face approaches them. It may be expected that participants are also quick to respond to the disfigured faces compared to the angry faces when they are approaching so as to quickly escape from the stimulus. Some support for this prediction comes from the research by Stevenage and Tinati (in preparation) who found that participants were quick to make a judgement of emotion onset and offset of angry facial emotions when a face was disfigured. However, when the face was non-disfigured, this quick response was only observed in terms of the onset of angry facial expressions. This indicates that regardless of emotion display, participants wanted to quickly release themselves from viewing the disfigured image when this opportunity was available. If this quick response to approaching disfigured faces can be found, it would indicate that a threat effect is elicited by facial disfigurement, much like angry faces, but can only be witnessed given the right circumstances.

In support of this prediction, Marsh *et al.* (2005) also presented faces with cranio-facial deformity, comparing them to a set of ‘attractive’ faces. They found that like the angry faces, participants were quicker to push the lever compared to pulling upon presentation of the deformed faces, indicating an avoidance response. Marsh *et al.* (2005) used such faces as negative images in opposition to attractive faces. Hence, such research does indicate that in terms of an approaching face, angry and ‘different’ faces may evoke a similar response.

Whilst some differences may arise, differences in response between angry and disfigured faces may emerge in the withdrawing face and displacement face conditions. When the face is disfigured, participants may still make a quick response when the image has only moved left or right, so as to again avoid the image. Conversely, when the disfigured face appears to withdraw by getting smaller, participants may keep the image on screen for longer when disfigured than when angry, as it no longer poses a threat, but it is at a distance to allow for further examination of the face to satisfy curiosity. Thus, in this study the image will only disappear once a response is made, allowing the participant to gaze if they choose to do so.

For this study, a measure of anxiety will also be taken as before. Although there is a lack of research with this paradigm exploring anxiety levels, given the literature of anxious individuals being more sensitive to threat, it is expected that any effects found will be greater for high state anxious participants in this task.

To summarise, the approach-withdraw task has several advantages in revealing the reaction to expression and disfigurement. First, it is designed to examine the implicit response to a face but with no mention of attending to the actual emotion/disfigurement. Second, the task requirement of a speeded response reduces the likelihood that the reactions are dependent on higher-level processing (Adams *et al.,* 2006). It is thus hoped that this paradigm will expose the core reaction to the different face types. Finally, this task makes use of a third paradigm which may be more sensitive than the other paradigms used in this thesis, and so it may reveal similarities and complexities of responses to angry and disfigured faces.

Method

Participants

Thirty students (8 males, 22 females, mean age = 19.93 years, SD = 2.72) participated on a voluntary basis for course credit. They were unfamiliar with the stimuli used and had not taken part in previous studies in this thesis. All participants had normal, or corrected-to-normal, vision.

Materials

The same two angry, two neutral, and two artificially disfigured faces were used as in the previous cueing experiments, giving 6 images. Again, thes were from the NimStim face set, full frontal, Caucasian, male faces. (See

Appendix E for faces used). Three image sizes were used for each face[10]: 2 x 3 inches (small), 3 x 4 inches (normal/original), 4 x 5 inches (large) yielding 18 images. The experiment was run on Presentation software, and participants made keyboard responses. A measure of anxiety was also taken, using the STAI (State Trait Anxiety Inventory).

Design

A 3 (face type: angry, disfigured, neutral) by 3 (face size: large (coming toward), small (withdrawing) and same size (displacement) within-subjects design was employed. State anxiety was the between-subjects variable. Angry, neutral and disfigured faces were presented on screen as larger, smaller or the same size as the original image on each trial to simulate apparent movement of the image. The dependent variable was the reaction time of the size judgement.

Procedure

After providing written informed consent, participants were individually seated approximately 60 cm away from the computer screen in a quiet cubicle. Following on-screen instructions, a practice block was initiated consisting of six random trials, and then the main experiment began. Each trial began with the presentation of a face sized 3 x 4 inches at the centre of the screen for 1 second. This was followed by a fixation cross of 500 msecs. The second image was then presented, either appearing to come toward, go away from the participant, or move to the left or right of centre. Participants were instructed to determine if this second (critical) face appeared to move toward them (the second face would get larger, 4 x 5 inches), away from them (the second face would get smaller, 2 x 3 inches) or stay the same size but move left or right (displacement condition, image size remains 3 x 4 inches). Participants were instructed to make a keyboard response (‘Z’ away, ‘V’ same size, ‘M’ toward), and were instructed that response time and accuracy were recorded. The next trial was initiated after a response was made. (See Figure 13.1 for an example of a trial).

[10] The methodology is a partial replication of that designed by Adams, Ambady, Macrae, and Kleck (2006). Both image sizes and toward/away conditions are the same. The present study also includes the displacement condition, of presenting the second image at the same size, but to the left or right of fixation, so as to have a baseline condition, which was lacking from the original paper.

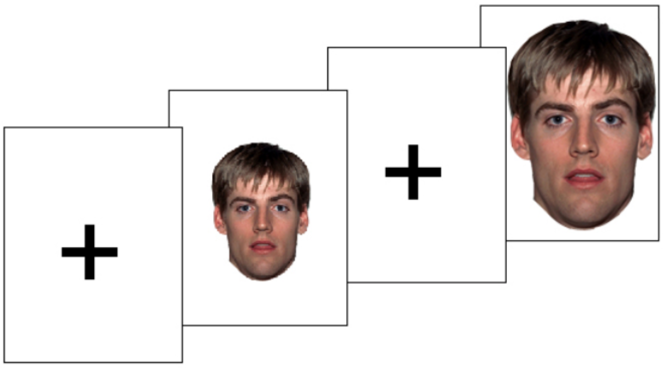


Figure 13.1. An example trial of the face getting larger.

For each trial, identity was always the same across the original and the critical face. Each face appeared six times per image size, yielding 108 trials. Each face type (angry, neutral, and disfigured) was shown 12 times per each size. The trials were blocked into three blocks, consisting of 36 trials per block, showing each face type (angry, disfigured, neutral) twice per image size. The trials were presented per block in a random order, which allowed for a short break between blocks to minimise fatigue effects. The order of image presentation was randomised.

Participants were also asked to complete the STAI to gain a measure of anxiety level. After the experiment, participants were debriefed and thanked. The study lasted approximately 20 minutes.

Results

Self reported anxiety scores

Participants completed the STAI measure of anxiety. The mean state anxiety score was 36.33 (SD = 2.73) out of 80. The mean trait anxiety score was 40 (SD = 7.48) out of 80. Again, since the sample is non-clinical, state anxiety was chosen to be a more accurate reflection of current individual anxiety level. To divide participants into high and low state anxiety groups, the median state score was found (34). Individuals above the median were grouped as high state (N = 15, mean state score = 43.73, SD = 8.08) and individuals below the median were grouped as low state (N = 15, mean state score = 28.93, SD = 4.2). Accordingly, these two groups were statistically different on their state anxiety (t (28) = -6.29, $p < .001$).

Data preparation

Reaction times (RT) from incorrect trials were excluded (M = .05% incorrect responses). As the reaction time data was skewed, based on a significant Shapiro-Wilks test, the mean RTs were log transformed[11]. To remain consistent in this report, all reported means are the log-transformed mean RTs. The log transformed mean RTs are displayed as a function of face size and face type for each anxiety group in Figures 13.2 and 13.3.

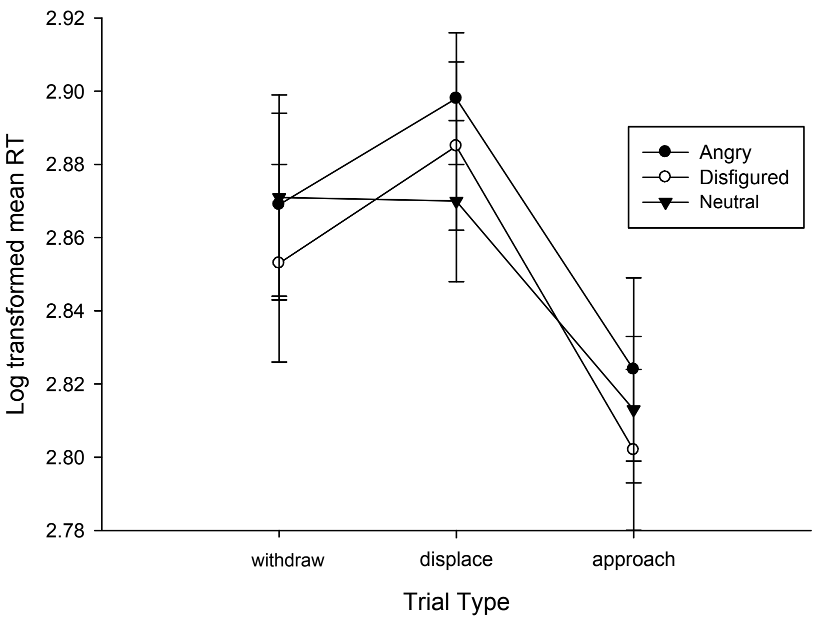


Figure 13.2. Log transformed mean RT (with SE) for low anxious participants as a function of face type and face size (withdraw – face became smaller, approach – face became larger, displace – face remained same size).

[11] This is not uncommon within such a task; see for example Adams *et al.* (2006) and Marsh *et al.* (2005) who used log transformed data.

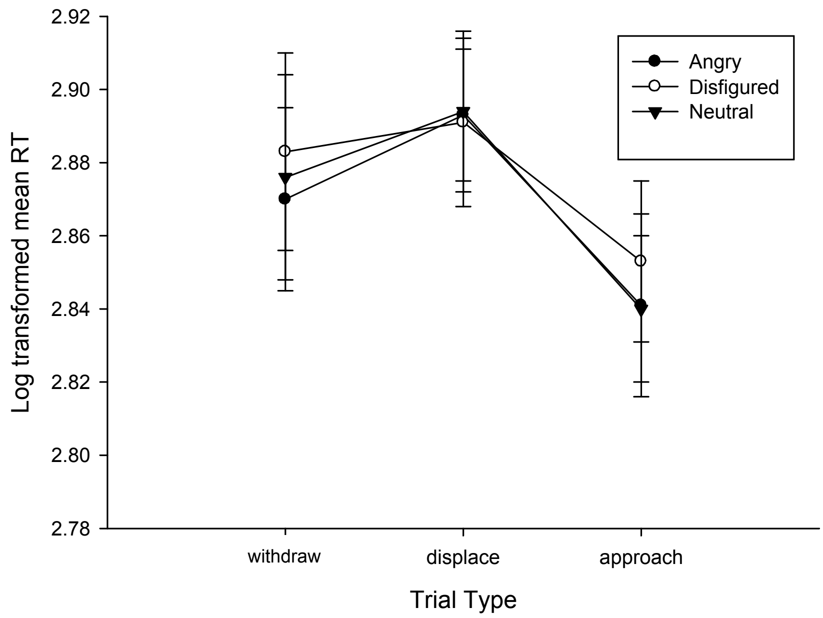


Figure 13.3. Log transformed mean RT (with SE) for high anxious participants as a function of face type and face size (withdraw – face became smaller, approach – face became larger, displace – face remained same size).

To examine all conditions, a 3 (face type: angry, disfigured, neutral) by 3 (face size) mixed ANOVA was conducted with state anxiety as a between-subjects variable and the log-transformed mean RT as the dependent variable. Given the literature, a main effect of face size was expected, and a three way interaction was hoped for.

As expected, there was a main effect of face size (F (2, 56) = 18.57, $p < .001$). However the other main effect of face type was not significant (F (2, 56) = .39, *ns*) and there was no between-subjects effect of anxiety (F (1, 28) = .37, *ns*). None of the two-way interactions were significant: (largest F (2, 56) ≤1.8, p = *ns*). Counter to predictions, the three way interaction was also not significant (F (4, 112) = .59, *ns*).

This experiment attempted to tease apart the reactions to angry and disfigured faces. A main effect of face size was established, but no face type differences were exposed when examining all conditions in the mixed ANOVA above. No anxiety effects were apparent either. To examine the face size effect, the face groups were collapsed together to conduct paired t-tests on the three face size conditions. Alpha was corrected to .01.

This found a significant difference between RTs on trials where the face came toward the participants compared to it moved away from the participants (t (29) = 4.14) $p < .001$). There was also a difference between trials when the face came toward the participants compared to when it was displaced to the left or right (t (29) = 5.93, $p < .001$). However there was no difference between RTs when the face moved away compared to displacement trials (t (29) = -1.83, *ns*). To summarise, participants were significantly quicker to respond when the face got larger, and therefore closer on screen (mean = 2.82, SE = .014), than when the face was displaced either side of centre but remained the same size (mean = 2.88, SE = .013) or moved further away (mean = 2.87, SE = .017) from the original.

Replicating Adams et al. (2006) and the use of the displacement condition

Given what was found by Adams *et al*. (2006) with angry faces, it was deemed important to provide a direct replication of the analysis conduced in their paper to determine whether the results here converge with their conclusions. Thus, the following results provide an examination of the data in more detail. Excluding the displacement condition, the face size (2: small, large) by face type (3: angry, disfigured, neutral) ANOVA on log transformed RT as the dependent variable found a main effect of face size (F (1, 29) = 17.11, $p < .005$), but no main effect of face type (F (2, 58) = .09, $p = ns$) and no significant interaction (F (2, 58) = .18).

Although there is no interaction, separate ANOVAs were performed for each face type to determine whether there were any effects of movement per face. As this is a novel method, it is important to explore the data, but conclusions must be drawn with caution given the exploratory nature of this analysis.

Angry faces: The one-way ANOVA with face size focusing on angry faces found a significant effect of face size (movement) on reaction time (F (2, 58) = 11.43, $p < .001$).

Disfigured faces: There one-way ANOVA here also found a significant effect of face size with disfigured faces (F (2, 58) = 10.76, $p < .05$).

Neutral faces: Finally, a significant effect of face size was also found with neutral faces (F (2, 58) = 9.32, p < .005).

Paired t-tests were therefore conducted to compare movement for specific conditions. To take account of multiple t-tests, alpha was adjusted to 0056.

Angry faces: This found a significant difference in RTs when the face was going away from the participants compared to coming toward the participants (t (29) = 3.08, p = .004) with faster reaction time when the angry face was coming toward the participants (mean = 2.83, SE = .02) compared to moving away mean = 2.87, SE = .02). There was also a significant difference between the displacement condition (mean = 2.9, SE = .01) and the face moving toward the participants (t (29) = 4.36, p < .001), again with faster RT when the angry face become larger. However, there was no difference between the displacement condition and the face moving away from the participants in the angry face condition (t (29) = -1.96, p = *ns*).

Disfigured faces: Comparisons showed that there was a significant difference between the approaching and withdrawing disfigured faces (t (29) = 3.34, p = .002) and between the approaching and displacement condition (t (29) = 4.7, p < .001). In each case, RT was faster on the approaching disfigured face (mean = 2.83, SE = .01) compared to both the displacement disfigured face (mean = 2.89, SE= .02) and the withdrawing disfigured face (mean = 2.87, SE = .02). There was no difference when comparing withdrawing and displacement conditions (t (29) = -1.36, p = *ns*).

Neutral faces: For neutral faces, there was one significant difference, with slower RTs to displacement neutral faces (mean = 2.88, SE = .02) compared to approaching neutral faces (mean = 2.83, SE= .01; t (29) = 4.33, p < .001). The comparisons between approaching and withdrawing neutral faces, and withdrawing and displacement conditions were non significant (t (29) = 2.94, p = *ns*, and t (29) = -.68, p = *ns* respectively).

The following analysis presents the results without the displacement condition in replication of Adams *et al.* (2006), whereas the second one includes the displacement condition. This shows that the inclusion of the baseline condition dramatically influences the interpretation of the data. This analysis required nine paired t-tests to look at all conditions, so to remain conservative, alpha was Bonferroni corrected .0056.

Direct replication. When one undertakes an analysis that replicates Adams *et al.* (2006) looking at conditions of approaching and withdrawing only it becomes clear that both angry and disfigured faces are different from the neutral face. RT is significantly quicker when the *angry* face is coming toward the participant compared to going away from the participant (t (29) = 3.08, $p = .004$), mirroring Adams *et al.'s* (2006) results. Similarly, RT is significantly quicker when the *disfigured* face is coming toward the participants compared to going away (t (29) = 3.34, $p = .002$). However, there is no significant difference when the face 'moves' toward or away from the participant when the face is *neutral* (t (29) = 2.94, p = *ns*). This indicates that using this paradigm when replicating the analysis with only 2 size conditions, there is a similarity between angry and disfigured faces, but they are both different compared to the neutral face.

Displacement condition. However, when we call upon the displacement condition (when the face moves left or right but does not change size) the picture becomes more complex. Participants' response is faster when the face is larger, and thus coming toward them compared to the displacement condition for all face types: angry (t (29) = 4.36, $p < .001$), disfigured (t (29) = 4.7, $p < .001$), neutral (t (29) = 4.33, $p < .001$). This therefore does not discriminate the angry and disfigured faces from the neutral face. Further, there are no significant effects for any face when comparing the speed of reaction in the smaller condition to the displacement condition: angry (t (29) = -1.96, *ns*), disfigured (t (29) = -1.36, *ns*), neutral (t (29) = -.68, *ns*).

To summarise, the use of the displacement condition may have weakened the power of results to expose differences between the approach-withdraw conditions in the mixed ANOVA. When paired t-test were conducted, it was found that when approach and withdraw conditions were compared, participants were faster when the face was approaching compared to withdrawing for both angry and disfigured faces, but not for neutral faces. RTs were also faster when the face was approaching compared to the displacement condition for angry and disfigured faces, but also for neutral faces. There is no difference in RTs when comparing displacement condition to the face moving away for any face type.

Discussion

This experiment was designed to replicate previous approach-withdraw studies using angry faces, with the addition of neutral face and displacement conditions. Facially disfigured stimuli were also presented to assess the degree of similarity between response to disfigured and angry faces.

The study primarily found a face size effect. This demonstrated that the change in face size had a significant effect on participants' response. Reaction times were significantly quicker to faces that appeared to approach the participant, compared to faces that receded or did not move at all. This suggested that any stimulus that appeared to come toward the viewer elicited a quick reaction. One interpretation of this may be that any approaching stimulus was appraised as threatening, given that time constraints do not allow for an interpretation of reasons for the approach. This would fit well with Le Doux's (1998) idea of a rapid and crude danger detection system that responds quickly to objects that appear to be threatening. Given that reactions were quick, it is likely that little high level appraisal of the face could be accessed, and so all faces that approached the perceiver elicited a rapid avoidance response. This study indicates that reaction to an approaching face will be quick in order to facilitate escape away from it. In support, Adams *et al.* (2006) also found a similar main effect, indicative of quicker reaction times to faces that approached the participant.

Given that this chapter aimed to replicate the results found by Adams *et al.* (2006) it was deemed necessary to conduct a replication of the results here without including the baseline displacement condition. To remain as conservative as possible, the alpha was adjusted accordingly.

When a replication was made, it was found that in this study, participants were quicker to respond to the approaching face compared to withdrawing face for both angry and disfigured faces. In contrast, response time was no different to approaching neutral faces compared to withdrawing neutral faces. A quick response to an approaching angry face replicates Adams *et al.*'s (2006) results. In addition, there were no effects observed with neutral faces in recent study by Heuer *et al.* (2007). It could thus be assumed that the quick reaction to approaching angry faces is one of threat.[12] By extension, this would then apply to the quick reaction to the disfigured face within this paradigm, which may also be deemed to have elicited a threat response. One must be cautious in making claims given the exploratory nature of this analysis, but this does indicate that under some circumstances, the response to angry and disfigured faces appear to mimic each other, as distinguished from the neutral face.

This picture becomes more complex when the baseline displacement condition is taken into account. For all face types, response was significantly quicker when the face was approaching compared to when it was displaced. However, there was no difference when the face was moving away compared to displaced. Thus, the difference between the angry and disfigured faces when compared to the neutral face was no longer evident when the displacement condition was used as the baseline. This may be explained in terms of motion and direction of eye gaze. The displacement condition created only a sideways motion, rather than apparent motion towards or away from the participant. Hence, the sideways motion may be likened to the effect of eye gaze movement, and thus when the face was displaced sideways, eye gaze was no longer directed at the perceiver, and so no effects were apparent. Conversely, when the face approached or withdrew from the perceiver, eye gaze was always directed at the perceiver, and so an approaching and direct face quickened response, especially when the face was threatening. So, no observed effects with the displacement condition is less surprising in the context of a threat response. In support, Adams and Kleck (2003) showed that participants recognised angry faces with direct gaze quicker than angry faces with averted gaze. Adams and colleagues suggested that the interaction of emotion and gaze is an important issue that deserves more research attention, especially given that gaze signals the location of attention (Adams, Gordon, Baird, Ambady, & Kleck, 2003).

It is interesting to note that no effects of anxiety were found in this study. Heuer *et al.* (2007) showed that socially anxious participants avoided both angry

[12] It is noted that this present study did not include a happy face condition, and thus does not rule out an emotionality effect. However, in defence, so far within this thesis there have been no effects found with the happy face.

and happy faces, even though they explicitly rated happy faces as positive. This indicates that the approach-withdraw paradigm can tap into immediate and untainted cognitions of anxious individuals; cognition that is evaluated by Le Doux's (1998) crude danger detection system. In the case of the present study, the task may have exposed a general threat reaction to faces on approach, regardless of anxiety, which may possibly be stronger toward angry and disfigured faces. Unfortunately, there are relatively few papers looking at the effect of anxiety with this approach-withdraw paradigm, and so this study may stimulate further investigation to clarify the effects of such characteristics.

In terms of the disfigured face, one previous study has used similar stimuli within the approach-withdraw task. Marsh *et al.* (2005) compared faces that had cranio-facial abnormalities to 'attractive' faces, and found that there was an avoid response to deformed faces as evidenced by quick reactions on approach conditions. Although they did not compare angry and deformed faces within the same task, they did argue that the response to the deformed faces mirrored that of the angry faces, and thus was an indication of an avoidance response, and by implication, a threat response.

To refresh the reader, one aim of this thesis was to establish the comparability of response between angry and disfigured faces. Thus far, it has been found that the similarity between these two stimuli is minimal, with angry faces exhibiting a threat (avoidance) response, and disfigured faces exhibiting a far weaker avoidance response. Within the AB studies, both angry and disfigured faces had a detection advantage when they were second targets (chapters 5 and 6). Again, within the present study, using the approach-withdraw paradigm, both angry and disfigured faces elicited a threat response, although this conclusion is accepted with caution. This indicates that the actual paradigm used may expose different facets of the response to facial disfigurement. Under temporal and spatial constraints, no clear threat effect was observed (RSVP and cueing studies), yet when the disfigured face was central to the observer's response task, there was a quick reaction to the approaching disfigured face. Importantly, this mirrors the reaction to angry faces in this paradigm. Therefore, the position of the disfigured face on screen is very important, eliciting a threat response when direct gaze is apparent. Taking the results of this thesis as a whole, this suggests that for disfigured faces, the threat response is only elicited when the gaze of the face is directed at the perceiver, as in this study. However, when there is no direct gaze (as in the cueing paradigm) or the face is presented so quickly so as not to engage with the perceiver (as in the RSVP paradigm), no threat effect is apparent. This suggests that the apparent threat response elicited by disfigured faces is weaker than the response elicited by angry faces, requiring direct gaze.

When the opportunity to react to the face and make a direct response is available, and a sensitive paradigm is used, a threat effect to disfigured faces may be indicated. Given the previous data in this thesis, one must be cautious in establishing the underlying motivations for this reaction. For the purpose of this present chapter, it is possible to conclude by saying that within this paradigm, cursory analysis indicated that angry and disfigured faces may both elicit a threat response when they approach an observer. Caution is given to overstating the claim, but it does indicate that methodology plays an important role in exposing reactions. These conclusions will now be expanded upon in the final discussion section of this thesis (chapter 14).

Chapter 14
Discussion

This thesis set out to understand initial perceiver reaction to facial disfigurement. Its purpose was to investigate what drives initial cognitive perception at the basic level of processing, before social cognition is called upon.

The results of ten experiments using three different paradigms were presented to address the main aims of this thesis. First, this thesis aimed to demonstrate the behavioural reaction to emotional faces, and specifically demonstrate a threat response elicited by angry faces. Second, this thesis aimed to determine whether facial disfigurement elicits a threat reaction in the same way as observed with angry faces. Finally, the third aim was to investigate in an area that has little controlled or systematic research to examine the issue of why negative reactions are reported by those with facial disfigurement. Thus, the studies conducted throughout this thesis facilitated an examination of the central hypothesis of whether the reaction to facial disfigurement was comparable to that exhibited by angry faces, and therefore one of threat.

Given the paucity of literature in the field of response to disfigurement, the theoretical and empirical principles from an established body of literature were adopted and empirically examined. This was to enable a theoretically driven body of research regarding perception of facial disfigurement. From the outset, the knowledge of how attention is affected by angry faces was utilised with the aim of extending this understanding to facial disfigurement. This chapter will now bring together the research within this thesis to provide the reader with a coherent understanding of the empirical studies, grounded within a theoretical framework.

This discussion chapter will first briefly summarise the experimental results before moving onto how the three aims have been addressed. Finally, a theoretical model will be proposed, with a discussion of future work.

14.1 Summary of experimental results

Chapters 3 to 6 used the rapid serial visual presentation (RSVP) design to examine the influence of faces under temporal attentional constraints. Chapters 3 and 4 demonstrated the use of the RSVP with faces, presenting upright and inverted faces. The experiments showed that faces were not processed capacity free, but exerted processing demands on cognitive resources, and this increased when face orientation was inverted. Specifically, chapter 4 showed that whilst an attentional blink (AB) was present with upright faces in the second target position (T2), this was extinguished for inverted faces due to their overbearing processing demands at all time points. Having established the use of the RSVP with faces as both targets and distractors, chapter 5 used emotional faces. This study revealed that only angry faces affected attentional processing. An apparent AB was found only when the first target was neutral and the second target was angry, with a quick blink at lag two and rapid recovery by lag 3. It was argued that this demonstrated a threat effect given that no effects were found with happy or neutral faces. Interestingly, the results did not converge with other RSVP studies, which found that a threat face typically reduced the AB. However, in light of the subsequent cueing and approach-withdraw studies in this thesis, it is now suggested that the apparent blink at lag 2 may actually be driven by an *aversion* away from the angry face. This will be elaborated upon in the next section. Having established a threat effect, chapter 6 investigated whether or not disfigured faces would be responded to in the same way as angry faces. Surprisingly, very little similarity was found between angry and disfigured faces. This was limited to both faces receiving good detection accuracy compared to other faces. The use of the RSVP paradigm was then put under scrutiny. As a dual-task methodology, it may hide small behavioural effects. As discussed in the interim summary (chapter 7), one problem with the RSVP method is that it does not distinguish between whether there are problems with T1 consolidation which then affects T2 performance, or whether attention is being averted away from the T2 item. Given the inability of this temporal design to differentiate between these two possibilities, it was decided that a spatial paradigm was required, that allowed for a measure of attentional allocation within a pre-defined spatial area. The issues of attentional capture, maintenance and avoidance could then be addressed.

Chapters 8 – 12 used the exogenous cueing method, and improved upon the previous studies in this thesis by presenting both emotional and disfigured faces within one task to allow for direct comparisons. They were designed to examine the issues of (i) attentional capture, and (ii) delayed disengagement of attention. At a rapid stimulus onset asynchrony (SOA), it seemed as though faces were all but ignored, creating quick response times and validity effects (chapter 8). With a longer SOA of 250 msecs (chapter 9) there was a clear effect of attentional aversion away from angry faces by high anxious individuals. There was no evidence of attentional capture. There was a trend effect of aversion from angry faces, with no affect of anxiety, in chapter 12. The threat effect was therefore displayed as an avoidance response to the angry face within this thesis, which converged on the explanation of the aversion during the RSVP with angry faces found in chapter 5 (experiment 3b). In terms of extending this theoretical explanation to facial disfigurement, there was no observable avoidance of disfigurement in any of the cueing experiments. This was the case even when real, as opposed to artificially created, disfigured faces were presented (chapter 12). It was therefore concluded that there was no support for extending the theoretical interpretation of a threat effect elicited by angry faces to the reaction elicited by disfigured faces. Up to this point in the thesis, there was no evidence to indicate that disfigured faces were perceived as purely threatening.

The lack of a threat effect was interesting given that within the social psychological literature, individuals with disfigurement commonly report negative responses such as staring as well as avoidance (Cole, 1998; Grealy, 2004; Partridge, 1990), and this is mirrored in the research looking at responses in ecological settings (Bull & Stevens, 1981; Johnston, 2002; Rumsey, Bull, & Gahagan, 1982). This indicates that the response to disfigurement could be driven by two opposing forces: First, a pull toward something that looks 'different' and second, a push away from something that looks threatening and with contamination potential. Indeed, these reactions may occur in parallel, and thus are difficult to distinguish between in either temporal or spatial paradigms. Given this idea of movement toward or away from a stimulus, a final attempt was made to examine the issue of reaction through the use of a novel methodology – the approach-withdraw paradigm (Adams, Ambady, Macrae & Kleck, 2006). This was used to determine whether participants would avoid or approach a particular stimulus within the first milliseconds of perception.

The final experiment therefore presented a novel paradigm within the context of this thesis (chapter 13) and was able to show for the first time that there was a similarity in response to disfigured faces compared to angry faces, exhibited as an avoidance reaction. Participants were quick to respond to both approaching angry and disfigured faces compared to withdrawing angry and disfigured faces. This result was most evident when the displacement condition was excluded. As the threat response to angry faces within this thesis has been aversion, and this quick response was interpreted as aversion in this novel paradigm, it was possible to indicate that under some circumstances, this threat reaction seen with angry faces was also elicited by disfigured faces. Importantly, it appears that this is the case only when the threat is directed immediately toward the participants, as in chapter 13. However, when the individual with facial disfigurement is not directly staring at the perceiver, as in chapters 8 - 12 where faces were presented either side of a fixation point, or appeared and disappeared so rapidly so as not to indicate staring (chapter 6), the threat reaction is then not elicited by facial disfigurement.

It is important to understand these findings within the context of theoretical explanations. This chapter will therefore now return to the main aims of the thesis, and demonstrate how the empirical results have addressed these aims in light of the theoretical frameworks.

14.2 Demonstrating the behavioural response to angry faces

The first aim of this thesis was to demonstrate the behavioural response to angry faces. Although there is a wealth of literature concerning this topic, it is often contentious with conflicting results. Results from a number of different attentional paradigms typically converge to conclude that angry faces can both capture attention and delay disengagement of attention (e. g. Cooper & Langton, 2006; Fox, Russo & Dutton, 2002; Koster, Crombez, Verschuere & de Houwer, 2004; Milders, Sahraie, Logan & Donnellon, 2006; Yiend & Mathews, 2001). These results are generally found only with high (clinically and non-clinically) anxious samples. However, there is an emerging literature that has revealed quite the opposite pattern of results. That is, studies have begun to report an avoidance of threat with participants actively averting their attention away from the location of threat (e.g. Koster, Crombez, Verschuere, Damme & Wiersema, 2006; Lau & Viding, 2007; Stirling, Eley & Clark, 2006).

Interestingly, the results obtained with the angry faces in this thesis have converged onto the same ‘aversion’ conclusion. Using a range of different paradigms, this thesis has revealed that participants actively averted their attention away from the angry face, and thus, away from the potential threat. This was shown under both temporal and spatial constraints, and under apparent movement of the faces.

This early reaction to threat is theoretically an advantageous and adaptive one. Ohman (1997) supports the position that humans (and indeed animals) have evolved to be responsive to threat in their environment. This is seen by the way in which threat is actually processed in the brain. Le Doux (1998) proposed that there are two routes to processing threat and fear. A rapid and crude amygdala-thalamus route and a more elaborate, higher cognitive route involving the thalamus and the cortex. The amygdala is highly sensitive to threatening stimuli, including threatening faces (Breiter, *et al.,* 1996; Morris, Friston & Buechel, 1998). An aversion response may quickly enable the perceiver to remove him/herself from the dangerous situation, and thus increase the likelihood of survival.

14.2.1 Rapid serial visual presentation design

To produce temporal constrains on attention, the rapid serial visual presentation task was used. This dual-task requires identification and detection of two targets presented in rapid succession. First, T1 must be selected and processed (stage 1), and to facilitate report, it must be consolidated. Given that this takes between 200–400 msecs, if a second target appears within this time frame there is not enough processing capacity left to consolidate T2 (Broadbent & Broadbent,1987; Chun & Potter, 1995; Raymond, Shapiro & Arnell, 1992). This leads to an attentional blink (AB) for that second target. Chun and Potter (1995) interpreted these results in terms of a two-stage model of processing and consolidation. When T2 appears 200-400msces after T1, resources are still occupied with T1 processing and consolidating, resulting in poor T2 detection.

If the second target is directly behind the first target, it may be processed alongside T1 and so may be reported. This is because the attentional window operates with a sluggish mechanism allowing a stimulus immediately following the first target to be processed as well (Chun & Potter, 1995; Giesbrecht & DiLollo, 1998; Potter, Straub & O'Conner, 2002). Once out of the attentional blink timeframe, reporting of T2 returns to an optimal level. This definition of an attentional blink, with lag one sparing, performance deficit and subsequent performance recovery, has been applied consistently throughout the chapters using the RSVP methodology.

Whilst the AB phenomenon has been well established using alpha-numeric items (e.g. Chun & Potter, 1995; Raymond, Shapiro & Arnell, 1992), its use with socially significant items such as faces is much more limited and only just is it being utilised. So far, there is evidence to indicate that socially relevant items such as one's own name can reduce the size of the AB when it is in the T2 position, but not when in the T1 position (Shapiro, Caldwell & Sorenson, 1997).

To go one step further, this thesis showed that the RSVP can speak to the issue of faceness. Chapters 3 and 4 showed that orientation of the face can have an impact upon processing resources. Chapter 3 also indicated that the experiment was too long, and so the second experiment used a between-subjects design in an attempt to reduce study time. An AB was evident when T2 faces were upright, but this was extinguished when T2 was inverted (chapter 4). Inverted faces placed so much cognitive load on processing resources that performance was poor throughout and so no AB could be established. As Styles (1998) commented, dual-tasks, by virtue of their difficultly, place significant demands on processing capacity, and introducing inverted faces would stress this limited resource further. Regardless of what face type (upright or inverted) appeared as the first target, when the second target appeared, resources were already very limited. Moreover, when the second target was an inverted face, this placed even more demands on processing ability, and so performance was impaired at all lags. This reduced the ability to expose an AB. These results may be interpreted in light of Awh, Serences, Laurey, Dhaliwal, van der Jagt and Dassonville's (2004) two processing routes. They argued that faces in the RSVP require configural and featural processing. Whilst inversion disrupts configural processing, participants may have attempted to mentally rotate the inverted faces and thus needed to draw on significant resources (Itier & Taylor, 2004; Leder & Bruce, 2000; Rossion, *et al.,* 2000; Rossion & Gauthier, 2002; Thompson, 1980; Valentine, 1988; Yin, 1969). Given that this process would be time consuming, both identification and detection in a dual-task would be poor when processing under time constrains.

Having established the use of this method with faces in chapters 3 - 4, chapter 5 went on to examine the influence of emotionality in the RSVP. Interesting, there was no effect of emotionality, nor of threat specifically, when the first target was emotional in terms of T2 detection.

The clearest results were revealed when T1 was neutral and T2 was emotional. Specifically, it appeared that there was a significant impairment in T2 detection when the second target was angry, occurring only at lag 2. This is counterintuitive given the previous literature from which it was expected that angry faces would grab attention rather than needing to wait for T1 to finish consolidation processing. Theoretically, angry faces are socially relevant stimuli that require priority processing (Vuilleumier, 2002). It could be suggested that although there was an apparent blink, performance recovered rapidly, indicating the power of the threatening faces to pull attentional resources. Importantly, no attentional blink was apparent for happy or neutral T2 faces which helped to rule out an emotionality effect.

These results however do not converge with other RSVP studies that have used emotional faces. Fox, Russo and Georgiou (2005) presented participants with an RSVP that consisted of T1 pictures (mushrooms or flowers) and T2 happy and fearful faces, with neutral face distractors. They found an AB for high and low anxious participants when T2 was a happy face, with the blink occurring when T2 appeared between 220-440 msecs after T1. The same blink was found for fearful T2 faces for low anxious participants, although it was reduced to only 220-330 msecs post T1 for high anxious. Fox *et al*. (2005) argued that faces, even when threatening, do not receive automatic processing. However, the fearful faces were able to quickly escape from the AB for the high anxious individuals because of their heightened threat relevance (Fox *et al*., 2005)

This interpretation does agree with the present results of chapter 5 in that even emotional faces did not receive priority processing in both studies. However the reduced AB that Fox *et al*. (2005) found was actually very small in comparison to the other face types, as indicated by a recovery in T2 performance by fearful faces at only 110 msecs before recovery occurred for happy faces. Moreover, the differences in results between this study and the results from chapter 5 may come from differences in methodology. First, Fox *et al.* (2005) used non-face pictures as T1, which, along with a categorisation task for T1, present an easier task than face identification used here. Also, because neutral faces were used as distractors in their study, there was no possibility of having neutral faces as targets to ascertain a baseline response. Finally they did not use angry faces, and given that angry and fearful faces do not necessarily exert the same threat (Adams, Ambady, Macrae & Kleck, 2006), the results cannot be directly comparable. Chapter 5, however, used emotional and neutral faces as first and second targets, as well as presenting faces as distractors. Also, images were presented at a rate of 80 msecs, rather than 110 msecs as used by Fox *et al*. (2005). These differences may have made the task of the present study inherently harder in terms of cognitive load, and so no comparable AB effects were evident.

Milders, Sahraie, Logan and Donnellon (2006) similarly found a reduced AB when they presented fearful faces as second targets, compared to happy faces at a presentation rate of 80 msecs. As an improvement, they used neutral faces as T1s, and scrambled faces as distractors. They found an AB for both happy and fearful T2 faces, although at the lag 160 msecs post T1, fearful faces had significantly better detection rates compared to happy faces (experiment 1). Milders *et al.* (2006) argued that this indicated the ability of significant faces to escape from the AB. However, given that detection rates did not differ at other SOAs (240 msecs, 400 msecs and 560 msecs) this suggests that the fearful faces did not have a significant advantage over happy faces at other time points. Conversely, in their first experiment, where T1 and T2 were fearful and neutral faces counterbalanced, they found that the only difference in detection rates occurred at 560 msecs post T2, which indicates that fearful faces were only just able to exit from the AB earlier than neutral faces. Thus, given that the AB duration for the fearful face was not consistent in their paper, this would suggest a transient nature of the effect. Unfortunately the paper did not speak to the issue of lag 1 sparing and so it is not known whether a particular face had better survival advantage when immediately following T1.

Again, the discrepancy between Milders *et al's* (2006) study and chapter 5 may be a consequence of design differences. For example, Milders *et al.* (2006) made T1 classification a less cognitively demanding task by presenting the face with a green tint. Rather than an identification task, a gender classification task was used. Also, the scrambled faces were created from combining male and female faces, which reduced the similarity between distractors and targets. This is important considering that Visser, Bischof and DiLollo (2004) argued that similarity between targets and distractors is necessary in an RSVP design in order to maintain task difficulty and thus reveal stimulus competition.

De Jong and Martens (2007) presented angry and happy faces as both T1 and T2 in an RSVP with rotated faces as distractors, at a presentation rate of 120 msecs. Participants were instructed to detect the number of upright faces that they saw and state the emotion. Regarding T1 performance, they found that correct identification of T1 was worse when T1 was happy and T2 was angry, and similarly when face type was reversed. Rather than the influence of a particular expression capturing attention, this might suggest that processing is more difficult on incongruent trials. Regarding T2 performance, again, performance was worse on T2 when the two targets displayed incongruent expressions. They argued that when T2 was angry, the AB was smaller than when T2 was happy. Upon examining the data, there seems to be poor performance for happy faces, even at lag 8, although because only lags 2, 3 and 8 were examined, the point at which performance for both faces reached a similar level cannot be assessed. Nevertheless, their results may indicate that happy faces in their study produced a greater processing demand and so this gave rise to what appeared to be a reduced AB for angry faces. Also, given what this thesis revealed about inverting faces in the RSVP (chapters 3 - 4) having rotated faces as distracters may influence the results by increasing cognitive load, or even distracting attention in an attempt to rotate the faces back to upright. Alternatively, the rotated faces may not be perceived as faces at all in that orientation under such high processing demands when looking for other targets. Whilst this is one of the first RSVP studies to use faces as both targets, and to include an angry facial expression, it again lacked a neutral face control condition. Further, there was no indication as to whether the emotional faces had been rated for degree of expression. This is crucial, as one expression may have been more powerful than the other, thus putting the results into question.

More recently, Maratos, Mogg and Bradley (2008) found that compared to happy and neutral faces in the T2 position, identification of facial emotion was significantly better for T2 angry faces at the time of the blink (200-400 msecs after a neutral T1) compared to neutral and happy T2 faces. They argued that because angry faces were more socially salient, they needed fewer processing resources. However, they also found some improvement in performance for happy compared to neutral T2 faces at 200-400 msecs post T1, suggestive of a more general emotionality effect rather than a pure threat effect. Additionally, methodological issues may have impacted upon the discrepancies between results here and with Experiment 3b in this thesis. They used schematic faces as the targets and jumbled schematic faces as the distractors, which may have reduced faceness and instead processing was based on detecting particular shape configurations. Compared to other studies, this one had a particularly long presentation rate of 128.5 msecs per item. Finally, participants were only required to state how many target faces they had seen (one or two), and the emotion of the final face. These again may have reduced the cognitive difficulty of the task.

Such discrepancies between the results from chapter 5 and the published literature, and in light of the aversion effects away from angry faces found in the cueing studies in this thesis, indicate that the effects found in chapter 5 were not necessarily a classic AB effect. Rather than calling the effect seen with T2 angry faces an 'attentional blink' perhaps it would be more appropriate to label it as an aversion effect to the angry face. This is based on several lines of reasoning.

First, the timing of the AB: Traditional RSVP studies, along with the more recent ones, find AB effects about 200-400 msecs post T1 typically lasting across 2 lags. However, the effect seen in chapter 5 (experiment 3b) occurred at only 160 msecs post T1, and lasted only up to 240 msecs post T1. This is far earlier than the typical timing of a blink. Second, and most importantly, the pattern of results throughout this thesis supports an aversion effect of attention away from angry faces. Within the cueing studies of this thesis, there has been a consistent pattern of aversion of attention away from angry faces at 250 msecs and 500 msecs SOA. Further, in the approach-withdraw paradigm, there was an indication of an aversion effect when angry faces appeared to approach the perceiver. Thus, it seems reasonable to suggest that what looked like a 'blink' to angry faces may have actually been an aversion of attention in chapter 5. Rather than an issue of inability to consolidate the angry face when at lag 2, participants may have actually been avoiding the face. At lag 1, participants did not have time to avoid T2 as it was quick enough to attract processing resources given a sluggish attentional window (Giesbrecht & DiLollo, 1998; Potter, Straub &

O'Conner, 2002). By lag three, the aversion effect was reduced. Perhaps at lag 2, the combined effect of seeing a neutral face followed very closely by an angry face enhanced the degree of threat as the two faces compounded the potency of the threat given that the neutral face may be ambiguous in its intention. The consequence of this may have been aversion of attention. However, by lag three, it became clear that these two faces were not 'acting together' as they were more temporally far apart. Given these findings and interpretations, the study would require replication, but it does open up new insight into placing emotional faces into the RSVP design and the effect of two temporally close faces on attention.

It is also important to note the possible influence of masking within the RSVP method. That is, because the faces were presented at such a quick rate (80 msecs per face), faces may not have been adequately attended to because they were masked by the preceding face. Indeed, when one inserts a blank space into the RSVP, in place of a distractor, detection of a target is generally easier (Chun & Potter, 1995; Visser *et al.,* 2004). This indicates that items may have the power to mask each other within the RSVP. Indeed, when items do not share similar properties, the AB produced is much smaller than when distractors and targets share similar properties, which is another indication that two items may mask each other given their similarity, and thus making it difficult to distinguish between such items under quick temporal constraints (Visser *et al.,* 2004). Indeed, without the presence of any item following the first target, no attentional blink is induced (Giesbrecht & DiLollo, 1998). Thus, it may be that the faces in the RSVP experiments within this thesis masked each other to such an extent that participants were unable to make accurate responses. This is essentially what is known as repetition blindness within the RSVP. Repetition blindness refers to the phenomenon that individuals are less likely to detect a target stimulus when it is repeated competed to when a different target is presented (Kanwisher, 1987). Keysers and Perrett (2002) suggested that masking can be conceptualised as a type of competition between two stimuli. This becomes more apparent when the two items share similar properties; Keysers and Perrett (2002) argue that they become fused together and it then increases the cognitive difficulty to separate them into two individual items. They also point towards the RSVP as having a high potential to produce masking effects. This issue of masking becomes most apparent when a full lag analysis was conducted to compare each lag with every other lag (as conducted in chapter 5). This revealed that for happy and neutral faces, detection performance was generally significantly better at lag 7 compared to other earlier lags. This may be a result of having no distractor following the T2 face when it is in the final lag 7 position. Hence, detection performance is good at lag 7 compared to other lags because there is no face to mask the target and so processing the target is much easier than when embedded within the RSVP. Thus, the results of the full lag analyses for each face type (experiment 3b in chapter 5) may indicate an AB for happy and neutral faces given that detection was worse at early compared to later lags. However, because of this issue of masking, it is much more difficult to make such a claim. Further, the results do no lend themselves to the operational definition of an attentional blink as used in this thesis, which requires lag 1 sparing as well as recovery of performance. Thus, more research is needed to clarify these results further.

Three possible lines of research could be explored further to examine the problem of masking. First, the RSVP could be designed to always have a distractor item end the sequence of items. Second, one could vary the presentation rate of the face, say for example use 100 msecs, 150 msecs and 200 msecs rates. A longer presentation rate may decrease the influence of masking on the target item. Finally, one may explore the use of stimuli that share similar properties to faces such as clocks, and use these as distractors rather than faces, to reduce the degree of masking with the RSVP, but to retain some similar features. Hence, this issue of masking could be addressed in future studies.

Unfortunately, the stimuli in chapter 5 were only rated for extent of emotional expression, but it would be interesting to replicate the study using faces that are rated as being high or low in arousal or potency level to determine whether these impact upon the AB. In this thesis, all faces were presented in colour, with open mouths which may have enhanced the perception of emotion, and thus increased the arousal they produced. Consequently, because of the nature of angry faces, arousal may have been greater for these faces compared to happy and neutral faces, and so rather than a typical AB effect, an aversion effect was produced to minimise the anxiety caused by arousing faces. A replication of chapter 5 with a measure of anxiety would also be necessary to examine the potential influence of anxiety on responding. The present results suggest that the effects hold with a group of non-clinically anxious participants, but this should be explored further.

Having said all this, one fundamental issue of concern is the RSVP methodology itself. A major problem of the RSVP is that it is not possible to conclude whether an AB is driven by problems of consolidation, or aversion of attention. This issue becomes particularly important when the stimuli are arousing and/or threatening. Given the differences between the designs of experiments 1-3 (chapters 3 – 5) with other RSVP studies using emotional faces, it may be appropriate to interpret the results within this thesis as an aversion away from angry faces. Thus, the apparent AB in experiment 3b with T2 angry faces occurred very early, before other reported AB effects. There was no evidence of ABs with happy or neutral faces, which does not support the idea that angry faces act to weaken the AB. Therefore, what looks like an AB, especially when illustrated on a graph, may actually be an avoidant response to the angry faces. In support, the subsequent studies in this thesis revealed that participants were averting their attention away from angry faces only.

14.2.2 Cueing task

Given the interpretation problems of the RSVP paradigm, the exogenous cueing paradigm was adopted in chapters 8 - 12. The cueing paradigm measures speed of attention allocation across two different locations. Typically, participants are cued with a target, which is followed by a probe. The probe can appear in the same location as the preceding target, known as a valid trial, or in the opposite location, known as an invalid trial. In the attention literature, it is typically shown that when the trial is valid, response to the probe is quick as attention has already been allocated there (Posner, 1980). However, on an invalid trial, attention has to re-orient to the opposite location and so response time is slower (Posner, 1980). Attentional allocation at different points in time can be examined by manipulating the time between the cue and target, known as the stimulus onset asynchrony (SOA).

A modified cueing task has been extensively used within the attention to threat literature. This has revealed that on valid trials, attention is typically grabbed by angry faces as shown by fast reaction times to angry compared to happy and neutral faces (e.g. Bradley, Mogg, Falla & Hamiliton, 1998), especially for those high in anxiety. This has been interpreted as a threat effect. At longer SOAs, an effect known as delayed disengagement of attention has been found, whereby participants dwell for longer on angry, compared to happy and neutral faces, and are slow to disengage their attention away from such faces (Fox, Russo & Dutton, 2002). The majority of these results have been found with high anxious individuals since they are more predisposed to be sensitive to stimuli of a threatening nature (Chen, Ehlers, Clark & Mansell, 2002; Williams, Watts & MacLeod, 1997). More recently the published literature reveals some inconsistencies over whether angry faces capture attention. For example, at an SOA of 300 msecs and with 75 % of trials being valid, Fox *et al.* (2002) still could not find capture to angry faces. In fact, there is now a growing body of evidence to indicate that threatening scenes and angry faces may actually avert attention (e.g. Koster, Crombez, Verschuere, Damme & Wiersema, 2006). This converges with the data found in this thesis.

Chapter 8 was designed to examine quick capture effects through the use of an SOA of 100 msecs. Such a short SOA was used given the suggestion from Cooper and Langton (2006) that the stimuli had to be presented at a quick rate to find capture within a non-clinical sample. However, there was no evidence of capture by angry faces in chapter 8. Instead, the participants may have been so quick at the task that they effectively ignored all the cueing faces and concentrated their efforts on probe detection. Indeed, Folk, Remington and Johnston (1992) argued that individuals are able to develop top-down attentional goals. In terms of this task, participants may have been able to override the influence of the preceding targets so as to focus solely on the probe. In support, Koster, Leyman, Raedt and Crombez (2006) also found that within their exogenous cueing paradigm, there was no evidence of attentional bias with any emotional faces. As here, Koster *et al.* (2006) also used a single face design, rather than face pairs, had a 50 per cent validity design, and used SOAs of both 200 msecs and 1000 msecs. Despite analysis of extreme high and low scorers on measures of anxiety and depression, no significant effects were evident. They suggested that null effects were due to the participants' ability to develop good attentional control. They also suggested this was most likely in an undergraduate (non-clinical) population, given the intellectual challenges of university and the adoption of top-down goals.

Cooper and Langton (2006) presented face pairs (emotional-neutral) at an SOA of 100 msecs and actually did not find significant capture effects to angry faces. Yet, at 500 msecs SOA, there was evidence for aversion of attention away from the angry faces, much like the results found in this thesis, especially for high anxious participants at 250 msecs SOA. Thus, the present results here and their findings converge, as both show aversion from angry faces, but neither show significant capture effects. It is noted that because Cooper and Langton (2006) presented face pairs, it is difficult to differentiate between whether attention was avoiding one face, or attending to the other. Hence, the results of this thesis take this a step further by presenting only one face cue, and finding similar results when SOA was 250 msecs. This indicates that angry faces were eliciting an avoidance response, which has been found with both anxious and non-anxious participants.

In chapter 9, when the SOA was 250 msecs, there was aversion of attention away from angry faces for high anxious participants only. This was shown by fast reaction times to the probe on invalid trials when the probe was preceded by an angry, compared to a neutral face. This was interpreted as a threat effect, and not one of emotionality, because no effect was found with the happy faces. However, this aversion effect was not revealed when the SOA was increased to 500 msecs. It was suggested that perhaps this is then too long a presentation rate when working with a non-clinical sample.

The strongest effects were found with high anxious participants at an SOA of 250 msecs (chapter 9). One would expect such anxiety effects given the research indicating that anxiety increases vigilance for threat and affects attentional biases (Williams, Watts, MacLeod & Mathews, 1997). This thesis is suggestive of a quick *aversion* away from angry faces by high anxious participants.

For all the cueing studies, correlation analyses were also carried out to determine whether there was a relationship between bias scores for each faces and state/trait anxiety. To refresh the reader, a bias score is calculated by taking the RT on valid trials away from the RTs on invalid trials per each face type. A positive score would thus indicate attention to a face; where as a negative score would indicate aversion away from a face. Over the five cueing studies, there were no significant relationships between anxiety score and bias score. This may be a result of having a non-clinical sample, and this no extreme high anxiety scores. To note, however, at 100 msecs SOA, a significant relationship was found, indicating that as trait anxiety increased, the tendency to avoid a happy face increased. It is reasoned that this may reflect the tendency to avoid social interactions, and indeed a happy face would invite interaction. In support, researchers have found that socially anxious participants also averted their attention away from positive faces (e.g. Chen *et al.,* 2002; Mansell, *et al.,* 1999). They argued that this was becomes happy faces invite interaction, which, for socially anxious individuals, would cause some distress. However, the correlation analyses across the cueing studies did not find any relationship with angry faces. This was disappointing given the literature showing general attentional biases with angry faces (e.g. Fox et al., 2001; 2002). Further, no relationships were found with disfigured faces. Future studies may want to expand their sample population by including clinically anxious individuals, which may expose significant relationships, especially with negative faces, as the samples used here may not include high anxiety scorers.

Taken together, the data overall converge with the results from the RSVP study (Experiment 3) showing avoidance of angry faces. Perhaps under temporal constraints it is possible to show this for all participants, but under spatial constraints, response is influenced by the SOA according to anxiety level. Theoretically, this avoidance may be interpreted as a strategy to minimise the stress caused by the threatening images (Isaacowitz, 2006; Lau & Viding, 2007). Koster, Crombez, Verschuere, Damme and Wiersema (2006) also found that high trait anxious participants averted their attention away from threatening scenes in a cueing task. This was evident both at 200 msecs and 500 msecs presentation rates. Furthermore in a sample of socially anxious children, Stirling, Eley, and Clark (2006) found a significant relationship between self-reported social anxiety and aversion from negative faces. Face pairs (negative-neutral, positive-neutral, and positive-negative) were presented in a dot-probe paradigm with faces presented for 1 second. They concluded that avoiding the negative faces helped to reduce the fear induced by stimuli. Whilst the authors cautioned over reliance on preliminary data, and that presenting face pairs can make it difficult to determine avoidance verses attentiveness, it does indicate that negative stimuli can elicit an avoidance response. Hence, rather than stay and face the threat, it may be more adaptive to escape from it.

One must bear in mind that to avert attention necessitates the ability to detect the angry face to begin with. This avoidance may therefore be preceded by rapid vigilance. To fully examine this hypothesis of very rapid vigilance followed by avoidance, it may be necessary to record eye movement. This may reveal very rapid movement of the eyes to the source of threat, followed by quick aversion compared to non-threat stimuli.

There is evidence to indicate a vigilance-avoidance pattern of behaviour in responding to threat. This has been eloquently demonstrated with spider phobics. Pflugshaupt *et al.* (2007) measured spider phobic and non-phobic individuals eye movements as they scanned spider pictures paired with neutral images. In the exploratory task, participants were told to scan the photographs for as long as they felt comfortable. They found that, compared to non-phobics, phobics showed fewer eye fixations, and significantly shorter viewing times on spider photos. The authors concluded that spider phobics were exhibiting occulomotor avoidance of the spider photos, and suggested that this may be a controlled process to reduce the potential of threat. This would fit with Folk *et al.*'s (1992) theory of attentional control settings, where default settings can be overridden by top-down motivations. It again supports the notion that avoidance helps to minimise the distress caused by threat. Pflugshaupt *et al.* (2007) suggested that spider phobics may first be hyper-vigilant to the spider pictures, followed by quick avoidance. Earlier work by Pflugshaupt and colleagues examining eye movement data also supports this. Spider phobics detected spiders in everyday scenes faster, fixating closer to the images initially, but subsequently fixating further away compared to non-phobics (Pflugshaupt, Mosimann, Wartburg, Schmitt, Nyffeler & Muri, 2005). This was interpreted as a hypervigilance-avoidance pattern. The avoidance shown by the spider phobics occurred at around 1700 msecs from initial presentation of the scene. The task required them to look for the spiders, yet they preferred to avoid them once found as indicated by shorter viewing times. Although 1700 msecs may not appear 'hyper-vigilant', it does take time to search for a spider in a complex visual scene and so the timings they found may be limited to their study. Nonetheless, it does indicate a hypervigilant-avoidance pattern of behaviour in relation to perceiving a threat stimulus given the pattern of results. In the cueing tasks of this thesis, the avoidance may have occurred much earlier due to the task demands and presentation timing, and so participants developed a quick avoidant response motivated by top-down goals to orient away from threat.

Neuropsychological data also suggests that angry faces activate an aversion response. In an fMRI study, Strauss *et al.* (2005) found that only angry faces activated the hippocampus and multiple regions of reward/aversion circuitry such as the caudate and putamen. Similarly, the behavioural data indicated that angry faces were aversive, indicated by an overall negative evaluation of such faces as compared to happy, neutral and fearful ones, as well as the only expression to be labelled as having the greatest likelihood to harm. Therefore, Strauss *et al.* (2005) concluded that angry faces are processed behavioural and physiologically as an aversive stimulus. In support, Vuilleumier (2002) reviewed behavioural and neuro-physiological studies and concluded that emotional stimuli draw attention pre-attentively, because of their social importance through evolution. This was even more apparent for processing threatening stimuli, such as angry faces. Participants in this thesis showing avoidance of angry faces may first have pre-attentively detected the threat, and subsequently averted their attention as a way of reducing the distressed caused.

Ohman (1997) argued that humans have developed a mechanism to detect danger quickly. The results here can be reconciled with such a hypothesis, in that participants could very quickly, perhaps sub-consciously, perceive the threatening stimuli (angry faces) and then avert attention away as evidenced by the behavioural results. Indeed, threatening scenes can be appraised at very rapid rates of presentation (Junghofer, Bradley, Elbert & Lang, 2001; Li, van Rullen, Koch & Perona, 2002). Further, in terms of the fight/flight/freeze response to threat (Bracha, 2004), avoiding the source of threat is an appropriate response, especially when the individual under attack may not have the physical resources to fight back. To avoid the threat is to avoid confrontation.

To summarise, although the results here are small, or sometimes appear as trends, a consistent pattern was revealed across the cueing studies showing that only angry faces were avoided. Whilst these data do not converge with some literature finding capture and dwell effects, they do converge with the papers finding avoidance of threat. After reviewing attentional paradigms, Bar-Haim *et* *al.* (2007) concluded that although capture effects existed in some attentional studies, it was often only small. This indicates that the effect may be very sensitive and transient, and thus small changes in design or method of selecting participants may be influential. A consideration of methodological differences may also account for why some studies have shown avoidance and others have not. For example, colour images were shown in the present studies, rather than in monochrome or schematic images and this may have enhanced the attentional bias (Koster *et al.,* 2006). Furthermore, the cueing studies in this thesis presented 50% valid, 50% invalid trials, and this may have prevented an attentional set from developing, thus watering down a tendency to reveal capture effects.

As a final note, supplementary analyses examining block as a factor within each of the cueing studies typically showed that response time to the probe was quicker on later blocks as compared to the first block. This indicates that participants may have become more familiar with the study design over time, and thus was able to make a quicker response to the probe. No interacting effects with block indicate this to be a consistent effect regardless of face type and validity type. Again, this may reflect boredom or fatigue with the task and so response became quicker in order to finish the task as quick as possible, rather than pay full attention to everything on screen. An alternative argument may be that participants were simply getting better at the task overall, due to practise effects, although this would suggest significant effects should be established in the initial block before practise could take place. A third possibility, as suggested before, would be that participants exerted a good degree of attentional control, and this enabled them to become quicker at the task over time (indeed, this is related to practise effects). In support, Koster, Leyman, Raedt and Crombez (2006) found that there was no evidence of attentional bias with any emotional faces within their exogenous cueing paradigm. Koster *et al.* (2006) also used a single face design, rather than face pairs, and used presentation rates of both 200 msecs and 1000 msecs. Regardless of examining extreme scorers on measures of anxiety, no significant effects were evident. They suggested participants were able to develop good attentional control. They also suggested this was most likely in an undergraduate population, given the intellectual challenges of university and the adoption of top-down goals. Hence, all studies in this thesis, including the cueing studies, used an undergraduate sample, and so they may have exerted good attentional control.

There are a number of ways that the above issues could be addressed. A range of participants may be recruited, from different age groups and from clinical and non-clinical samples. Possibly in future studies, the number of blocks and trials may be manipulated between subjects to determine the influence of these factors; perhaps a short, quick study may show clearer results before participants become bored and/or familiar with the task. A measure of boredom or motivation may also be taken upon completion of the study to determine if and how this correlates with speed. To summarise, in the case of the cueing studies in this thesis, the effect of block appears consistent across the cueing studies, as in faster reactions over blocks compared to the first block.

14.2.3 Approach-withdraw paradigm

To provide a three pronged approach within this thesis, a final methodology was employed in chapter 13. This adopted the approach-withdraw paradigm, which is a relatively novel method to examine the attentional effects of social stimuli. This paradigm makes use of apparent movement, with the hypothesis that threatening and negative stimuli that appears to come toward the perceiver will elicit an avoidant response (Adams *et al.,* 2006).

Adams, Ambady, Macrae and Kleck (2006) adopted this paradigm, moving from a traditional lever response to keyboard responses in the aim of reducing the influence of motor control processing. They presented angry and fearful faces in the approach-withdraw task and found approaching angry faces were responded to faster than withdrawing faces. No such effects were found with fearful faces, and they interpreted this null result as a freeze reaction. They concluded that only angry faces were perceived as threatening and therefore participants were motivated to move quickly away.

Chapter 13 in this thesis used Adams *et al.*'s (2006) study as a basis of replication. It modified the design slightly by making use of both a displacement condition and a neutral face condition. These modifications were used to provide a baseline of response which the previous study lacked. Chapter 14 showed that response time was quick to approaching angry faces compared to withdrawing angry faces. Given that this result was not evident with neutral faces, it was argued that this indicated a threat effect. That is, participants wanted to actively avoid the approaching angry face. This converges with the results found in previous studies by Adams *et al.* (2006). It is duly noted that this effect was most apparent when the analysis was conducted to replicate the conditions used by Adams *et al.* (2006). When the displacement condition was used as a point of comparison, these effects were not as clear. Nonetheless, the replication also included the neutral face and showed no effect of movement on response times, which strengthens the results found with angry faces.

Using the approach-withdraw task, Marsh, Ambady and Kleck (2005) found similar results as found in this thesis. Participants pushed a lever if they wanted to approach a face, or pulled a lever to avoid a face that appeared on screen. Whilst fear faces elicited approach behaviour, angry faces clearly elicited avoidance behaviour. They suggested that fear faces actually encouraged approach because they are perceived as more submissive and elicit a desire for affiliation. On the other hand, angry faces clearly signalled threat, and when the gaze was directed at the perceiver, as was the case in this study, this threat was even more potent. An avoidance response, therefore, enables escape.

In partial support, Heuer, Rinck and Becker (2007) found that high socially anxious individuals were quick to respond to approaching angry faces, although the same result was found with happy faces. This attentional bias to all faces may reflect an underlying social phobia, but it does indicate the utility of this paradigm in revealing initial behavioural response.

Bamford and Ward (2008) recently argued that humans can rapidly determine what behaviour, be it approach or avoid, is needed to achieve a desired goal upon presentation of a stimulus. In the case of an angry face, they argued, threat appraisal leads to a need to escape and so a quick avoidant response is revealed. Muhlberger, Neumann, Wieser and Pauli (2008) found enhanced valence ratings to approaching unpleasant images, compared to those that withdrew or remained static. No such pattern was evident with neutral or pleasant images. They argued that unpleasant and approaching stimuli require immediate response, and often this response will be to increase the distance between the stimulus and the self. A positive stimulus, on the other hand, does not require such an immediate response, and further, the response will typically be one of approach because of the pleasant nature of the stimulus.

Thus, the results found in Muhlberge *et al.'s* (2008) study follow a similar pattern of results found within this thesis, and converged with the literature. It was concluded than angry faces, by virtue of their potential threat to the perceiver, elicited an avoidance response to minimise the possibility of confrontation. This again supports Le Doux's (1998) proposition that when confronted with a threat, an adaptive response would be to escape from the situation. This also converges with physiological data. Springer, Rosas, McGetrick, and Bowers (2007) found that when viewing faces, angry faces elicited a greater startle reflex than other emotional expressions, including fear. They suggested that the anger expression represents a clear and unambiguous threat and a heightened startle reflex facilities a quick avoidant/escape response by the perceiver. Conversely, the source of threat by the fear face is more ambiguous and so does not elicit avoidant behaviour.

14.2.4 Summary

In summary, the experiments presented here have addressed the first aim of this thesis and have attempted to provide a valuable empirical and theoretical contribution to the literature. Using three different attentional paradigms, a demonstration of the behavioural response to angry faces has been shown. In this case, this has been revealed as an avoidant response, which has been shown with high anxious participants. Further, it is possible to rule out this effect as one of emotionality, as no effects were found with happy faces. It was argued that this avoidant response is adaptive in reducing both the anxiety caused by the threat, and reducing the possibility of a dangerous confrontation. This may be a product of motivating top-down goals providing the impetus to avert attention away from a potential threat. Indeed, an angry human face may signal impending attack, and the appraisal of anger appears to be a universal response across cultures (Ekman, 1999; Ekman & Friesen, 1971; Ekman, Friesen & Ellsworth, 1982; Ekman, Sorenson & Friesen, 1969; Ekman *et al.,* 1987), indicative of its universal signalling power.

14.3 Understanding the behavioural response to disfigured faces

The second aim of this thesis was to determine whether or not it was possible to generalise our present understanding of the threat reaction to angry faces to a threat reaction to disfigured faces. A comparison between angry and disfigured faces was initiated because relatively little is known about disfigured faces. The empirical studies required a good theoretical framework with which they could be directed and understood and the literature on angry faces provided this. Throughout the thesis there has been a conscious effort to compare angry and disfigured faces whether in the same study or across parallel studies. Consequently, a comparable result between the two face types was sought so as to support the hypothesis that disfigured faces were perceived like angry faces.

Again, three different paradigms were employed to address this aim. The RSVP task showed an indication of similarity between angry and disfigured faces in that both received good detection accuracy compared to other faces. But there was no other evidence of a similarity using this task. Within the cueing studies there was again no evidence of a comparable result for disfigured faces compared to angry faces. However, with a novel paradigm, the first empirical support for a threat response to disfigured faces was established. As before, each of these paradigms will be discussed and interpreted in light of the theoretical frameworks.

14.3.1 Rapid serial visual presentation design

Having established the use of the RSVP with faces (chapter 4), and then finding a threat effect with angry faces (chapter 5), chapter 6 sought to find evidence of the same threat effect with disfigured faces. Given that with T2 angry faces an apparent aversion effect was found at lag 2, similar results were necessary with disfigured faces to justify a threat response explanation. No such response was evident with disfigured faces. Overall, performance was better with non-disfigured compared to disfigured faces. So, just like inverted faces, disfigured faces elicited poor identification. This indicates that it took more time to process a disfigured face, either because the disfigurement disrupted the processing, or because too much attention was given to the location of the disfigurement on the face. Either explanation would affect processing ability when under time constraints. Again, we can see this processing disadvantage of facial disfigurement when examining the T2 detection rates. Overall, T2 detection was better for disfigured faces compared to non-disfigured faces. However, there was poorer performance of T2 detection when T1 was also a disfigured face compared to a non-disfigured face indicating an inability to process two unusual looking faces when under time constraints. To reiterate, no AB effect, as defined by this thesis, was observed with disfigured faces.

At this point, it was necessary to consider the virtues of presenting faces under temporal constraints in a dual-task. To reiterate the interim summary (chapter 7) it was concluded that the RSVP would be redundant in examining the reaction to facial disfigurement if the face cannot be processed rapidly. Given that the RSVP demands that an item is detected, processed and consolidated at a high speed (Chun & Potter, 1995), if the disfigurement increased the processing time of the face, the method would most likely fail to show any effects. This may explain the null results of chapter 6. Again, as discussed before, masking may have played a large part in negatively affecting participants' ability to identify and detect faces. It may have been even more apparent here because both the disfigured faces and the distractors were unusual face types as compared to non-disfigured, non-scrambled upright faces, and thus the unusual faces become more difficult to distinguish between. As Keysers and Perrett (2002) suggested, there may have been a lot of confusion between items that were presented so quickly within an RSVP, thus an increase in cognitive difficulty and ultimately poor performance.

Furthermore, it may be that there are two or more reactions elicited in response to disfigurement, which may not be a pure threat response. This could produce opposing forces that may both avert and grab attention and this may make it more difficult to expose effects when processing has to occur under time constraints. Indeed, in support of this notion, spider phobics often experience both hyper-vigilant attention towards spiders to locate the threat, as well as avoidance to stay clear of danger (Cavanagh & Davey, 2001; Pflugshaupt *et al.,* 2007). These dual attentional biases may be at play with individuals in a general sample upon the presentation of facial disfigurement, as there is a need to look at the face whilst at the same time to avoid it.

In a similar vein, it was important to change the paradigm given that it was now apparent that interpretation of the data may be difficult using the RSVP. Considering that the use of the RSVP with emotional faces did not find conventional AB effects, null effects with the disfigured faces may again point to design issues rather than the absence of an effect.

There were several other reasons as to why a threat effect with disfigured faces could not be established. For example, it may be necessary to show the angry and disfigured faces with the same study so that a direct comparison can be made within subjects. Given this, a second attentional paradigm was adopted to examine the issue from a different angle. Thus, the cueing paradigm was used to determine the spatial attentional biases when presented with a disfigured face. To address the second aim of this thesis more stringently, disfigured faces appeared with angry faces within the same study. It is recognised that this means that within the cueing studies, 40% of faces were negative (angry and disfigured) in chapters 8 – 10, (and 50% of faces in chapters 11 - 12), but the incidence of negative faces in the real population may be a lot lower than this, as one is more likely to come into contact with neutral or happy non-disfigured faces. However, it was felt necessary to directly compare angry and disfigured faces within the same study. As an alternative for future studies, one could use a between-subjects design, showing angry faces to one group and disfigured to another, and happy and neutral to all groups, but this may weaken the ability of direct comparisons. Alternatively, one could present angry, happy, disfigured and neutral faces within the same study, but manipulate the proportion of each face type, so that the positive faces have a greater presentation proportion than the negative faces.

14.3.2 Cueing paradigm

As an aversion effect was found with angry faces in the cueing studies (chapters 8 - 12), a similar aversion effect needed to be shown with the disfigured faces. That is, evidence of participants averting their attention away from disfigured stimuli needed to be established if the threat reaction theory was to be extended to disfigured faces.[13]

Overall, there was no indication of an aversion effect elicited by disfigured faces. Compared to the neutral face, angry faces averted attention, but disfigured faces did not. It was expected that a strong threat reaction to disfigured faces would be shown using the cueing paradigm, given what is known about attention to threat. Le Doux (1998) argued that humans are highly responsive to

[13] Just to note, all the issues discussed previously concerning the design of cueing studies, and the effects of blocks and practise, apply here. As the issues remain the same, they will not be repeated again for sake of brevity.

threat in the environment, and that a quick response is evolutionary adaptive. Further, social psychological evidence indicates that non-disfigured individuals do not like to be in contact with, or sit near, someone with a facial disfigurement (Houston & Bull, 1994) so it was expected that this would be borne out by an aversion effect. On the other hand, if the dominant reaction was one of curiosity, one would have expected at least a capture effect to the disfigured faces, especially given our responsiveness to new events in the environment (Ohman 1997). Neither was revealed.

Chapter 12 provided the opportunity to examine whether the lack of effects were due to the disfigurement being artificial. Thus, in a more ecologically valid experiment, images of individuals with real facial disfigurements were shown. In terms of the results, there were no unexpected findings, and the disfigured images did not elicit any effects that were markedly different from the previous cueing experiments. In general, the pattern of results with the other faces in this experiment was consistent with the previous cueing studies. This justified the use of the artificial disfigured faces, and minimised a simple explanation of the likelihood of null effects due to weak stimuli. This further fuelled the flames of the argument that again the paradigm was not suitable for revealing reaction effects with facial disfigurement. It was hoped that the cueing paradigm would reveal a similar aversion effect. Yet, if we take this idea of dual attentional biases/motivations, just like with the RSVP, the cueing study may only show null results because of the conflicting influence of both attentiveness towards, and aversion away from, the disfigured face. Hence, in a final attempt to make the case for a threat response to facial disfigurement, a novel paradigm was adopted. This novel paradigm – the approach-withdraw task – was employed to try to tease apart dual reactions.

14.3.3 Approach-withdraw paradigm

In a last attempt to reveal attentional biases to facial disfigurement, the final study was indicative of an aversion of attention away from facially disfigured images. Importantly, this was the same pattern of results as found with angry faces within the same study (chapter 13). Within this thesis, this was the clearest demonstration of a comparable reaction elicited by angry and disfigured faces.

The results suggested that approaching disfigured faces were responded to quicker than withdrawing disfigured faces. This was the same pattern of results as found with angry faces. Importantly, however, no such effects were found with neutral faces. This was interpreted as disfigured faces motivating an avoidant response, which was behaviourally similar as the response elicited by angry face. This was therefore theoretically interpreted as a threat response. Again, it is duly noted that this effect was most apparent when excluding the displacement condition, and therefore the conclusions are drawn with caution and further replication is required.

When one takes into consideration all three paradigms, it becomes clear why a threat effect was found in the approach-withdraw paradigm with disfigured faces, and not before. In this final paradigm, the actual faces were presented to apparently gaze directly at the perceiver, and this directness appeared to become even more intense as the image got larger. In the cueing paradigm, the actual image was never in the centre of screen and thus the gaze was never directed *at* the perceiver. In terms of the RSVP, although the image was at the centre of the screen, the image came and went very quickly, minimising engagement with the perceiver. Thus, it is argued that a threat effect with facial disfigurement will only be revealed when the face is clearly oriented and directed towards the perceiver. Further, when it appears as though the image is getting even closer to the perceiver, this threat effect becomes stronger. Similarly, Springer *et al.* (2007) found a stronger startle reaction to angry faces than to fear faces because the threat of an angry face was clear and unambiguous. Taking this further, perhaps the ‘threat’ of a disfigured face is only realised when it is directed toward the perceiver, making it less ambiguous as to where the focus of attention, and by implication threat, is directed. In support, Muhlberger *et al.* (2008) argued that the motivational needs underlying the perception of a negative stimulus such as threat demands an immediate response, unlike when encountering something more positive. Thus, when a stimulus that is unpleasant and negative appears to approach the perceiver, the quickest and safest response is to escape from the situation. Behaviourally, this would reveal itself as an avoidant response.

Unfortunately, dual attentional biases were not revealed with disfigured faces, i.e. quick response on approaching faces, and slow response on withdrawing faces, the latter of which may have indicated staring. However, the instructions given to participants may have made the latter results less likely as participants knew their response time was being recorded. A replication could be employed that made no mention of response times being recorded so as to avoid this limitation.

Recent literature highlights the importance of looking at the influence of gaze direction on attentional allocation. In a review, Langton, Watt and Bruce (2000) argued that eye gaze direction is processed and analysed rapidly. For example, Friesen, Moore and Kingstone (2005) simply manipulated the eye direction of a face cue, and found faster response times to a subsequent target when the eyes 'looked' in the direction of the target compared to looking in the opposite direction. Hietanen and Leppanen (2003) found similar results, and also included different emotional expressions. However, expression appeared not to be influential. What was influential was the apparent orientation of the face toward the perceiver through gaze direction, no matter what expression that face portrayed. On the other hand, Holmes, Richards and Green (2006) showed that participants were sensitive to the direction of gaze and the emotional display in faces. This was particularly the case when the face displayed angry or fearful expressions. They suggested that eye gaze may play an important role in appraising emotional information. By implication, therefore, the threat of disfigurement here becomes less ambiguous when the face, and thus gaze, was directed at the perceiver. Furthermore, this may explain why the aversion effects held for all participants in the approach-withdraw experiment (chapter 13) with angry faces, as they commanded a greater threat due to their directed gaze. Conversely, the aversion effect in the cueing studies was most evident with high anxious participants as peripheral angry faces elicited this reaction only in the most anxious individuals. Directed gaze also plays a significant role when movement is involved. Pelphrey, Viola, and McCarthy (2004) showed that when an avatar on screen appeared to walk toward the participants, there was greater activity of the superior temporal sulcas (STS) when gaze was directed to rather than averted away from the participant. Importantly, the STS is involved in analysing social information. Further, behavioural data showed quicker response times to directed gaze than averted gaze. Pelphrey *et al.* (2004) argued that gaze is extremely important in social interactions, and can signal behavioural intentions. The intentions of someone coming towards oneself are much clearer than if that person is further away.

The interpretation of the reaction elicited by disfigured faces is based on the theoretical interpretation of the threat effect elicited by angry faces. A general aversion affect has been found in this thesis. In the published literature, an aversion effect to angry faces has been explained as a way of moderating the degree of discomfort generated by such faces. Specifically, Adams *et al.* (2006) and others have shown that there is an aversion to angry faces in the approach-withdraw paradigm. When threat appears to approach, there is a need to get away from the situation, thus giving rise to aversion and exhibited as a quick response time. Given the similarity of results here, this explanation can be extended to results with disfigured faces. The quick reaction time to approaching disfigured faces is motivated by a need to escape as these faces are also being appraised as threatening.

In partial support of the results found in chapter 13, Marsh *et al.* (2005) also found an aversive response to images of individuals with craniofacial deformities. They compared responses to female faces that were ‘attractive’ and female faces with craniofacial abnormalities. Participants were more likely to pull than push the lever when the face was attractive, but when the face was disfigured, they preferred to push rather than pull. Marsh *et al.* (2005) interpreted this as an aversion away from the disfigured images. Given that in the same paper they accounted for a similar avoidance of angry faces as a threat response, it may be assumed that craniofacial images were also perceived as threatening. Hence, this may indicate that different facial disfigurements, from mild differences such as port wine stains in this thesis, to configural changes in their study, all elicit an avoidant response when directed at the perceiver. Further, it occurs whether the individual with disfigurement is male (as in this thesis) or female (as found in Marsh *et al.,*’s study). These points certainly merit further replication.

14.3.4 Summary

In summary, it can be concluded that the studies were able to address the second aim of this thesis. Whilst the RSVP and cueing studies found little evidence of response comparability across angry and disfigured faces, the approach-withdraw study did find such a comparable result. It can be suggested therefore that this thesis was able to extend what is known about angry faces and apply it to disfigured faces. Importantly, what this thesis has uncovered is that this threat reaction to disfigured faces may only be displayed under crucial conditions. That is, the face must be directly gazing at the participants so as to induce a direct threat. The intention of the individual with disfigurement to get closer to the perceiver is clear when approach behaviour is apparent. Given that the threat effect only occurred with direct gaze, it suggests that the potency of the threat is not as strong as found with angry faces, where the threat is elicited even with peripheral faces. This difference has theoretical implications, and these will now be discussed.

14.4 Pushing the literature forward

This chapter so far has discussed how the first two aims of this thesis have been met. It is now important to combine these to develop a unified theory of how we respond to angry faces and facial disfigurement, in terms of both similarities and differences.

It is proposed that both stimulus types can elicit a threat reaction, with the more potent angry faces eliciting threat reaction under general conditions, whilst facial disfigurement eliciting a threat reaction under more specific conditions. The reasons for this difference are based in the evolutionary basis for the threat type. From the outset, this thesis wanted to present a cognitive-evolutionary explanation, and the present results suggest that this is possible. At the outset of this thesis, attention was defined as being shaped by human evolution (Lang *et al.,* 1997). Schulkin, Thompson and Rosen (2003) also stated that emotional responses are intimately linked with human evolution. This thesis therefore sets the theoretical explanation of a threat reaction to angry and disfigured faces within an evolutionary framework, and the following discussion will present this argument.

Within this thesis it was found that angry faces tended to elicit an aversion response, interpreted as a threat reaction, under both spatial and temporal constraints, and under simulated movement conditions. On the other hand, facial disfigurement appeared to only elicit this aversion response under the movement condition. As far as the author is aware, this is one of the first demonstrations of a threat response to disfigured faces in the early stages of attention. Importantly, unlike for angry faces, a threat reaction is only apparent when the disfigured face is gazing directly at the perceiver. This suggests that the underlying reason for the threat reaction may be slightly different for disfigured and angry faces. This becomes more apparent when considering the evolutionary basis of the threat reaction for each face type.

Regarding the angry faces, the threat reaction has been conceptualised as a response to attend to potential danger (Le Doux, 1998; Ohman & Mineka, 2001). This has led to a fight/flight/freeze reaction (Bracha, 2001), and this thesis has demonstrated the flight reaction amongst high and low anxious individuals. Ohman and Mineka (2001) stated that the attentional system is highly responsive to detecting danger in the environment. Le Doux (1998) argued that threat/danger can be detected in one of two ways: either via the amygdala in a crude and rapid fashion or via the cortex in a more elaborate manner.

The significance of the angry face is apparent from different lines of evidence. First, angry faces are detected very quickly, indicative of pre-attentive hyper-vigilance for threat (Le Doux, 1998; Vuilleumier, 2002). Second, mirroring of angry faces as measured by the muscle movement in participants' faces is evident even when the images are presented under masked conditions (Dimberg, Thunberg & Elmehed, 2000). Third, angry faces appear to have more potency compared to other negative faces. This can even be seen relative to fearful faces. Whilst fearful faces may be threatening, they do not necessarily signal immediate threat to the perceiver, and they may even elicit feelings of sympathy (Adams *et al.,* 2006). For example, Ohman, Lundqvist and Esteves (2001) found that in a visual search study, the angry faces were detected more quickly and more accurately than other negative faces, including 'scheming' and sad faces. Finally, there is growing evidence showing that angry faces elicit an aversion of attention (perhaps occurring quickly after the hyper-vigilant bias) so as to minimise the anxiety such faces cause, which is not apparent with happy faces. The results of this thesis converge with this body of literature.

So, if angry faces elicit a threat reaction because of the appraisal of potential threat, why do disfigured faces elicit this same response only under specific conditions? As this thesis has shown, this reaction is only evident when the threat is directed toward the perceiver and when the face appears to move.

Indeed, moving rather than static images create greater arousal (Simons, Detenber, Reiss & Shults, 2000). This leads the author to argue that perhaps the threat reaction to disfigured faces may involve the fear of potential contamination from the disfigured face, which motivates avoidance away from the source of contamination. This interpretation of the threat reaction in this thesis is hypothesised from two lines of evidence. First, the social psychological research on facial disfigurement, and second, the parasite-avoidance model (Park, Faulkner & Schaller, 2003; Schaller, Park & Faulkner, 2003).

Social psychological research on reactions to facial disfigurement provides studies in an ecological context. They have shown that the general public do not feel at ease with individuals who have a facial disfigurement. They prefer not to sit next to them on the train (Houston & Bull, 1994), nor talk to them about a charity issue (Bull & Stevens, 1981). Anecdotal reports from individuals with facial disfigurement reveal instances of when others avoided them (Cole, 1998; Grealy, 2004; Partridge, 1990). This even extends to poor recruitment outcomes for individuals with disfigurements compared to controls (Stevenage & McKay, 1999). Whilst these responses are the consequence of much elaborate processing involving social cognition, it is felt that these responses may reveal the initial threat response that this thesis has uncovered. Furthermore, it is argued that this initial threat avoidance response is based on an evolved mechanism.

The evolved mechanism in question is based on the parasite-avoidance model. This thesis proposes that the initial threat reaction to facial disfigurement may be a function of our evolutionarily-developed parasite-avoidance behaviour (Park, *et al.,* 2003; Schaller, *et al.,* 2003). Park, Faulkner and Schaller (2003) argued that visible signs of disease elicit an avoidance response, which occurs without rational thought. Although the stimulus may not be harmful, like facial disfigurement, it may still be appraised as contagious since a bias for false positives is evolutionarily safer than a bias for false negatives. It is safer to label something as harmful and avoid it even if it is safe, rather than label it as safe, and come into contact with it, when it is harmful. Evolutionarily speaking, there were times when visible signs of abnormality were fatal, such as with leprosy, and so contact was avoided for adaptive reasons. Such an evolved parasite-avoidance mechanism may still exist, given that the rapid detection of threat is a product of evolution. Thus an avoidance reaction to facial disfigurement may be unavoidable in the very early stages of perception. In support, Blascovich, Mendes, Hunter, Lickel and Kowai-Bell (2001) proposed that humans often experience feelings of perceived threat when interacting with individuals who have been stigmatised. In their study, they recorded the physiological responses of participants interacting with an actor who had a port wine stain artificially applied to one cheek. They found that participants exhibited greater cardiovascular activity, and generated fewer words in a word-finding task compared to participants interacting with non-disfigured actors. Blascovich *et al.* (2001) therefore argued that this demonstrated the perceived threat when interacting with a stigmatised group. Indeed, in this example, the interaction required direct contact on a one-to-one basis and this may have increased the perception of threat. Their results therefore fit well with the cognitive-behavioural results found in this thesis as both suggest a threat response.

Visibility of the disfigurement plays a part in the response. The more visible the cue of contagion, the easier it is to detect and avoid. This may be explained in terms of our preference for symmetry in nature (Park, Faulkner & Schaller, 2003). This extends to our preference for symmetrical faces (Chen, German & Zaidel, 1997) which is often equated with attractiveness (Perrett, Burt, Penton-Voak, Lee, Rowland & Edwards, 1999). The more a disfigurement pushes the face away from the ideal of symmetry, the greater the likelihood of negative appraisal. The risk of contamination may then look greater.

Thus, it is proposed that the threat elicited by the disfigured face is a contamination threat, and for this reason it is only evident when the potential contamination is directed at the perceiver. On the other hand, angry expressions are much more powerful, and can elicit threat based on potential danger, in a less specific way. Figure 14.1 shows how this theoretical explanation might be conceptualised.

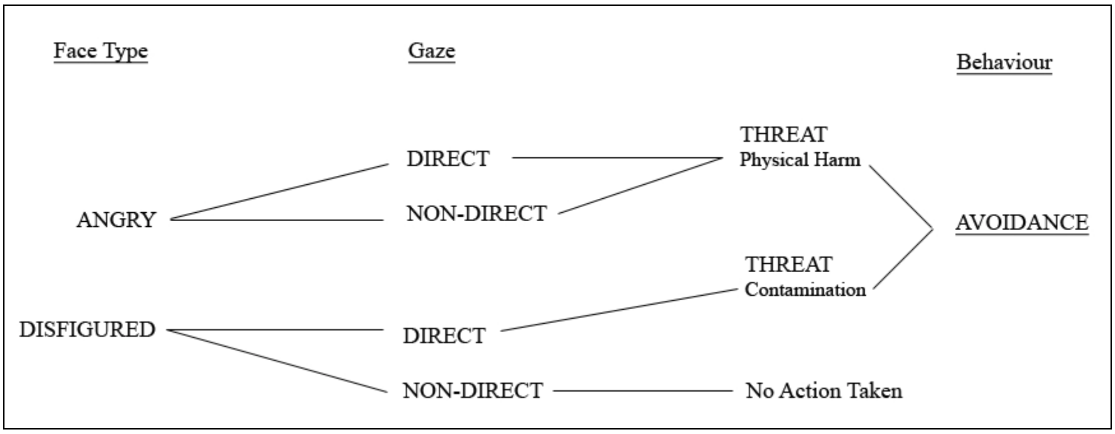


Figure 14.1. A conceptualisation of the threat reaction to angry and disfigured faces.

Figure 14.1 suggests that a threat reaction, based on physical harm, will be elicited by both direct and non-direct angry facial expressions. On the other hand, the threat reaction elicited by disfigured faces is based on contamination threat and so is only evident when the threat is directed at the perceiver. This model accounts for the results found in this thesis, as well as the published papers on avoidance of angry faces and avoidance of deformed faces (Marsh *et al.,* 2005)

It is important to note here that the threat effect for both face types was evident with all participants, albeit at different stages for angry faces in the cueing studies for high and low anxious participants. The influence of non-clinical anxiety requires further attention to determine the precise conditions under which threat affects high and low anxious individuals for both face types. It would also be interesting to recruit clinically anxious participants to see whether the effect is more pronounced given their heightened threat sensitivity.

It is also noted that this conceptualisation of the threat elicited by angry and disfigured faces (Figure 14.1) may be interpreted in the opposite way: One may have a fear of contamination regardless of whether the individual with disfigurement is looking at them or not. An angry person may be more of a threat only when such threat is directed at oneself. However, there are several reasons why these interpretations seem less likely in light of the present thesis. First, within this thesis and published papers, avoidance of angry faces occurred when the face was presented in the periphery, as well as when it was directed at the perceiver. Second, the threat effect with disfigured faces was apparent only when the face was gazing directly at the perceiver and appeared to approach. Finally, the contamination threat here refers to contamination based on touch, and thus requiring direct contact, rather than air-borne contamination. Nonetheless, researchers may take an alternative interpretation of the model, and/or develop it further, and this is seen as a positive step because it would stimulate further research into the area of initial reaction to facial disfigurement. This would help to develop a body of research that can build upon the work presented here. Indeed, the model may only hold with certain types of disfigurements, such as ones that look sore or contain open wounds that may indicate potential for contamination. Thus, there are many avenues for further research that are crucial to conduct.

The contamination threat effect presented here may itself be motivated by feelings of disgust. Disgust has been defined as a defensive emotion, protecting against the consumption of dangerous substances and protecting against the recognition of our animality (Charash, McKay & DiPaolo, 2006; Curtis, Aunger & Rabie, 2004; Haidt, McCauley & Rozin, 1993; Rozin, Haidt, McCauley, Dunlop & Ashmore, 1999). The word disgust has evolved from 'distaste' and is primarily an oral defence to prevent consumption of harmful substances (Haidt *et al.,* 1993). Like other basic emotions, disgust is universally expressed and understood (Curtis *et al.,* 2004; Curtis & Biran, 2001; Ekman & Friesen, 1986; Haidt *et al.,* 1993). Disgust also elicits an avoidance response (Curtis & Biran, 2001). Elicitors of disgust are diverse, and seven domains have been identified: i) food, ii) animal, iii) body products, iv) sex, v) body envelope violations, vi) death, vii) and hygiene (Haidt *et al.,* 1993; Rozin *et al.,* 1999; Rozin, Haidt & McCauley, 2000).

One facet of disgust identified by Haidt *et al.* (1993) was body-envelope violations, including things like blood, veins, tissue, and deformity. They argued that envelope violations remind humans of their own fragility and this therefore disgusts them. In an internet based study, Curtis, Aunger and Rabie (2004) found that pictures of individuals who looked spotty and feverish, or showed signs of skin lesions with inflammation were rated as more disgusting relative to both a normal individual and someone with old lesions respectively.

Disgust perception may involve sympathetic laws of magical thinking (Haidt *et al.,* 1993). The law of contagion (once in contact, always in contact) refers to the unfounded belief that even brief contact with a substance will create permanent transfer of properties. For example, people will generally not drink from a glass that held dog faeces even when the glass has been sterilised (Haidt *et al.,* 1997). By extension, this could relate to the appraisal of facial disfigurement. Non-disfigured individuals may believe that being in contact with someone who has a disfigurement may cause contamination and thus they try to avoid such a situation.

Olatunji and colleagues have suggested that fear of some animals and insects may actually be mediated by a disgust reaction that is rooted in a disease avoidance mechanism (Olatunji, Lohr, Willems, & Sawchuck, 2006; Olatunji & McKay, 2006; Olatunji, Sawchuk, Lohr, & de Jong, 2004). For example, Mulkens, de Jong and Merckelbach (1996) showed that spider phobics were more disgust-sensitive than non-phobics, and they argued that fear of spiders is actually rooted in feelings of contamination disgust (De Jong & Merckelbach, 1996; Olatunji & McKay, 2006; Sawchuck, Lohr, Tolin, Lee & Kleinknecht, 2000). Given the research so far, this thesis therefore suggests that the initial reaction to disfigurement may be an avoidant threat response that is rooted in a disease-avoidance mechanism. Cutis and Biran (2001) stated that

'disgust may motivate the avoidance of faeces, vomit, and people who may be contagious and that disgust is one of the mechanisms crafted by natural selection to keep our distance from contagion' (p.22).

The suggestion of contamination threat may in part be an aspect of mate fitness. Hence, in mate selection, both males and females desire to select the healthiest choice to safeguard future offspring (Park *et al.,* 2003). Since the face is one of the signals of health, a face that deviates from the norm may be, albeit erroneously, associated with 'bad genes' (Edler, 2001; Perrett *et al.,* 1999). Thus, an effort is made to avoid such an individual. Once again, this demonstrates that the threat reaction toward facial disfigurement is rooted in our evolutionary biology. This thesis thus suggests another avenue for further research.

To summarise, this thesis has provided further evidence of the complexity of the attention to-threat system, showing that attention can be responsive to threat at different levels, and most likely through different motivations. Although the threat elicited by angry and disfigured faces may occur for different reasons, both seem to have their roots within evolution. One motivates away from danger, another prevents from contamination. This thesis has provided further demonstration of a threat avoidance response to angry faces, and a threat response to disfigured faces when the contamination threat is directed at the perceiver. The first two aims have therefore been addressed, and it is hoped the thesis has provided valuable preliminary understanding as to how we initially react to facial disfigurement.

14.5 Provision of controlled and systemic research into a novel area

The final aim of this thesis was to provide controlled and systematic research into a novel area. This was to examine the issue of why negative reactions are reported by those with facial disfigurement. It is hoped this will advance our understanding of facial disfigurement from the view of the perceiver, and address the concerns by some commentators that this is an under-researched area (Grandfield, Thompson & Turpin, 2005; McGrouther, 1997). Given the use of controlled methodology, from an established body of literature, it is argued that this third aim has been achieved. Throughout this thesis, a conscious attempt has been made to be rigorous in methodological design to provide a good level of scientific inquiry. This has resulted in the application of existing theory and empirical design, with some novel adaptations to develop our theoretical and empirical understanding of how facial disfigurement is responded to in the first milliseconds of perception.

The results from this thesis may assist in our understanding of the previous social psychological research that showed an avoidant response. Furthermore, it goes one step further by suggesting that the initial response is based in evolution and therefore most likely to be automatic and unstoppable. This may be a good point at which to begin future research programmes. It is so important to understand why the initial reaction to facial disfigurement is often negative because of the anxiety and depression that is often reported by those with disfigurements. As Naini, Moss and Gill (2006) stated 'facial beauty has always been the most valued aspect of human beauty' (p.278) and thus deviations from a 'normal' face can have marked detrimental consequences.

It is argued that whilst the initial reaction may be a negative one, it need not extend into the more elaborate social cognitive processing. Now that we are aware of initial negative reactions, we need to develop ways to prevent them from persisting in our ongoing interactions, and instead enhance positive social cognition. Thus, it is proposed that the body of knowledge from this thesis can be used as a foundation upon which research can begin on how to enhance the perception of those with facial disfigurement, and create a more inclusive atmosphere. Unfortunately, from an early age, children from both eastern and western societies tend to have a negative response to disfigurement (Crystal, Watanabe & Chen, 2000; Harper, 1999), and so positive campaigns would be more than beneficial.

Naini *et al.* (2006) agree that providing education about facial differences is extremely important in reducing the distress caused by those living with a facial disfigurement. They suggest that changing public attitudes may reduce intolerance towards differences in appearance. Already, the provision of effective coping strategies for individuals with facial disfigurement has put research into good practise (Bessell & Moss, 2007; Moss & Carr, 2004; Partridge, 2006; Robinson, Rumsey & Partridge, 1996). It is hoped that the systematic research within this thesis will provide preliminary results, which could be used and developed further to help guide educational strategies to complement existing ones (Frances, 2000), and make the issue of disfigurement more prominent within society. This could be done through indicating that although the initial response to disfigurement is negative, it is a consequence of our evolutionary attentional system. But this should not persist into further social cognition, and indeed research now needs to examine how best to enhance positive interactions.

We cannot modify an automatic response, but we can help to prevent it from muddying further social cognition. Thus, we need to reduce, and preferably extinguish, the link between initial reaction and subsequent interaction. This may be achieved by informing both individuals with and without disfigurements about why the initial response to disfigurement is likely to be one of threat. The evolutionary basis of this reaction needs to be highlighted, and stressed that although this means the response is automatic, it is not necessarily a correct appraisal of the disfigurement. Hence, the contamination threat elicited by the disfigurement is unfounded as one cannot be ‘contaminated’ by contact with an individual who has a facial disfigurement. This is the point at which greater media attention can begin; dismissing the idea that it is harmful to be in contact with disfigurement. Furthermore, greater exposure of individuals with facial disfigurement needs to occur, especially portraying positive examples of individuals within the community who have facial differences. This is to show that each individual has their own personal qualities, even though their appearance does not fit with the ‘norm’ face. This has already begun with profile posters of individuals with facial disfigurement displayed on London Underground tube stations, supported by the charity Changing Faces. This acceptance of facial disfigurement is even more important when one considers the number of soldiers coming back from war who will be severely facially scarred. Armed with the results from this thesis, we can inform both those with and without disfigurements that the basis of an initial response is likely to be negative and aversive, and that it may be unstoppable due to its grounding in evolution. But then this can be reduced, perhaps from both exposure and an understanding of how contamination works, to promote better social relations. Indeed, the nature of psychological inquiry is to improve the interactions between humans and so it is hoped that this thesis can take one step toward this.

14.6 Future Directions

It is imperative to replicate the experiment in chapter 13. That is, it must be shown again that both angry and disfigured faces are avoided as compared to neutral when the face approaches compared to moving away. The issue of the inclusion verses exclusion of the displacement condition also needs attention. To extend this further, it is also necessary to conduct another approach-withdraw study using happy as well as angry faces. Based on the results found in this thesis that happy faces did not elicit a threat response, it is predicted that even when happy faces appear to approach the perceiver, they will not elicit an avoidance response as they do not signal any type of threat. In this respect, they should act much the same as a neutral face.

It is important to conduct studies which manipulate the gaze of the stimulus face given the hypothesis that eye gaze direction of the disfigured face affects the elicitation of a threat response. This could be carried out with both angry and disfigured faces, as well as happy and neutral faces. It needs to be determined whether eye gaze alone, without any movement of the face at all, can affect the reaction driven by facial disfigurement.

To gain further understanding into initial reactions to both angry and disfigured faces, the use of eye tracking could be adopted. There has been a recent trend toward re-examining attentional issues with the use of eye-tracking facilities, and this is evident within the field of reaction to emotional faces (e. g. Isaacowitz *et al.,* 2006). For example, Mogg, Garner and Bradley (2007) presented face pairs in a dot-probe design and measured both response times and eye movement information. They found that highly anxious participants tended to focus on angry and fearful faces compared to neural faces. However, there were no differences in attentional biases when stimuli were mildly threatening (created through blending an angry and neutral face). As far as the author is aware, to date there have been no published eye tracking studies examining the reaction to facial disfigurement. This could be initiated from a basic level, by simply presenting a disfigured face on screen and examining first and last saccades, engagement and disengagement with areas of the face. Accordingly, this would allow us to determine whether the behavioural responses as found here converge with physiological response. The model presented in this chapter could also be empirically tested with the use of eye movement data.

In a similar vein, further physiological data could be obtained from brain scanning techniques such as fMRI and CT scans. This research is really crucial as the physiological response to angry and disfigured, as well as other face types, could be directly compared. This would reveal whether the threat areas are activated upon perception of disfigurement, and at what point in time these area are activated It would therefore be interesting, and theoretically important, to examine how facial disfigurement affects the amygdala, along with other brain areas in comparison to how angry faces affect these areas.

It is also now important to examine different types of facial disfigurement. This should be explored in two ways, looking at both the cause of the disfigurement and the type of disfigurement. In terms of the perceived cause, there may be a difference in reaction when it is an inherited disfigurement, compared to an acquired one. Even how it is acquired may be influential in the elicitation of a response. This could be examined in light of the model proposed in this chapter (Figure 14.1), and thus threat of contamination may differ depending on degree of visibility and cause of a disfigurement.

The results of this thesis do not speak to the issue of whether familiarity with facial disfigurement influences the elicitation of a threat response. It would be interesting to recruit individuals who come into frequent contact with facial disfigurement to participate in similar experiments as presented in this thesis. This may include surgeons or family members of individuals with disfigurement. If it is found that a threat reaction is reduced through familiarity, this would provide a good starting point to enhance a positive reaction right at the level of initial response. This again could be achieved through positive exposure of individuals with facial disfigurement. Given that the threat reaction is most likely a product of evolution, it is hypothesised that the reaction will not be completely extinguished. Indeed, the threat reaction to angry faces has not been extinguished, even though there are many means to defend oneself in the modern day. Nonetheless, it may provide insight into how to reduce the initial reaction from affecting the subsequent interaction.

14.7 Concluding remarks

This thesis aimed to demonstrate a threat effect with angry faces and extend this by examining whether disfigured faces also elicited a threat effect. Three different attentional paradigms indicated that attention was averted away from angry faces for high and low anxious participants. Yet, neither the RSVP paradigm, nor the cueing paradigm revealed an aversion of attention away from disfigured faces. Thus, apart from a similar detection advantage for angry and disfigured faces in the RSVP studies (chapter 3 - 4), there was no indication that disfigured faces were perceived as a threat stimuli in the same way angry faces. However, in the final study (chapter 13), using the approach-withdraw paradigm, the aversion reaction was evident for both angry and disfigured faces when the displacement condition was excluded. This indicated that disfigurement may only elicit a threat response when it is directed toward the perceiver, through fear of contamination. Finally, addressing the two main aims of this thesis facilitated controlled and systematic inquiry into an under-researched area. This may help bridge our understanding between initial reaction and subsequent interactions. It is hoped that the preliminary results presented here in this thesis stimulate further research into the area of initial perceiver reaction to facial disfigurement as there is still much work to be done. Such research may help to ensure positive social interactions for all members of society, regardless of appearance.

Appendix A

Examples of stimuli (not to scale, original size 6x8cm) used for Experiments 1 and 2

Distractors

Upright Faces
T1

T2

Inverted faces

T1

T2

Practise faces

Appendix B

Examples of stimuli (not to scale, original size 6x8cm) for Experiment 3a and 3b (the same distractors and the same practise faces were used as in Experiments 1 and 2)

Experiment 3a

T1 angry

T1 Happy

T1 Neutral

T2 Neutral

Experiment 3b

T1 Neutral

T2 angry

T2 happy

T2 Neutral

Appendix C

Examples of stimuli (not to scale, original size 6x8cm) for Experiment 4 (the same distractors and the same practise faces were used as in Experiments 1 and 2)

T1

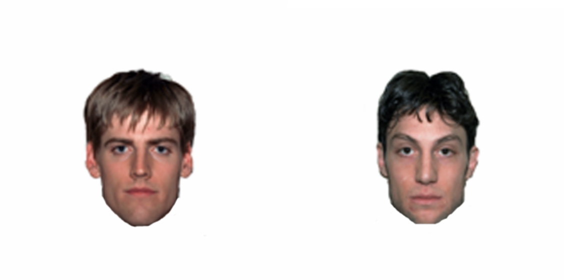
Disfigured

Non-disfigured

T2

Disfigured

Non-disfigured



Appendix D

Examples of stimuli (not to scale, original size 4.5x6.5cm) for Experiments 5 - 9

Neutral

Angry

Happy

Disfigured

Inverted

Real Disfigured images (experiment 9 only)

Appendix E

Examples of stimuli (not to scale) for Experiment 10

Angry

Disfigured

Neutral

Appendix F

Analyses of Data to examine effects of length of study

This appendix re-examines the data from study 1, and from all the cueing studies within this thesis. Each analysis will examine first compared to second half of data to determine whether there is statistical support for arguing for fatigue effects occurring in a particular study. Thus, the overarching premise would be that the second half of the data would show worse performance compared to the first half. The converse of this may indicate practise effects occurring with the study.

Chapter 3: The use of the RSVP with upright and inverted faces (experiment 1)

To examine the effects of the length of the experiment in more depth, a supplementary analysis was carried out. Given that the experiment was designed to be fully counterbalanced, it was not possible to compare the first half of the experiment to the second half of the experiment. However, it was possible to look at the response on the first half of each block compared to the second half of each block, to determine whether participants were either getting worse by the second half (indicating fatigue effects) or better, which may indicate practice effects. Therefore, the analysis compared first and second half of the data in each block of trials, and therefore it is important to state that the data is then based on identifying and detecting 5 faces per condition, rather than 10 (given the data split). That is, each half consisted of 35 trials, with T1 and T2 upright and inverted faces amongst distractor faces, with T2 appearing in each of the 7 lags 5 times, yielding the 35 trials. Hence, a direct split of the data.

As before in the main experiment, T1 identification will be presented first, followed by T2 detection (conditional on T1 identification), followed by T2 detection in the control trials when there was no task of identifying T1.

<u>First target (T1) analysis.</u>

The number of correctly identified T1 upright and inverted faces as a function of T2 orientation of face, split by first and second half of the data, is displayed in Table A. Please note that the total number of T1 faces that could be identified is five.

Table A.

The number of correctly identified T1 upright and inverted faces as a function of orientation of T2 face split by first (A) and second (B) half of data.

	T1 Upright		T1 Inverted	
	T2 Upright	T2 Inverted	T2 Upright	T2 Inverted
Mean A	2.63 (.11)	2.66 (.12)	2.29 (.12)	2.24 (.17)
Mean B	2.23 (.12)	2.45 (.12)	2.6 (.15)	2.5 (.18)

As before in the main analyses, the results were analysed using two repeated measures ANOVAs, which separated T1 orientation.

Upright T1 faces. Using upright T1 faces, an ANOVA was applied to the number of correctly identified T1 upright faces using lag (7), T2 orientation (upright, inverted) and first and second half of trials, termed 'timing' (A, B) as factors. This found a main effect of timing (F (1, 23) = 12.49, $p < .05$), with better identification of first compared to second half of data, and a main effect of lag (F (6, 138) = 2.9, $p < .05$), best explained by an order 6 fit (F (1, 23) = 10.36, $p <$ .05). There was no effect of T2 face type (F (1, 23) = 1.08, p = *ns*). There was a significant interaction of timing by lag (F (*6*, 138) = 2.22, $p < .05$), and a significant effect of lag by T2 face type (F (6, 138) = 2.82, $p < .05$), but no interaction of timing by T2 face type (F (1, 23) = 1.64, p = ns). The analyses was qualified by a significant three way interaction (F (6, 138) = 4.65, $p < .05$). This allowed for examination of the first and second half of data separately.

Upright T1 faces, first half. An ANOVA was applied to the number of correctly identified T1 upright faces using lag (7), and T2 orientation (upright, inverted) in the first half of the data. This found no effect of lag (F (6, 138) = .76, p = *ns*), nor of T2 face type (F (1, 23) = .03, p = *ns*). Finally, the interaction was not significant (F (6, 138) = .49, p = *ns*).

Upright T1 faces, second half. The same analyses were then carried out with the second half of the data. This again found no effect of lag (F (*6*, 138) = 1.08, p =

ns), nor of T2 face type (F (1, 23) = .08, p = *ns*). Finally, the interaction was not significant (F (6, 138) = .68, p = *ns*).

Inverted T1 faces. Next, using inverted T1 faces, an ANOVA was applied to the number of correctly identified T1 inverted faces using lag (7), T2 orientation (upright, inverted) and first and second half of trials, 'timing', as factors. This found a main effect of timing (F (1, 23), = 5.23, $p < .05$), with better identification on the second half of trials. There was no effect of lag (F (6, 138) = 1.19, p = *ns*), nor of T2 face type (F (1, 23) = .86, p = *ns*). Neither timing by lag (F (6, 138) = 1.7, p = *ns*), nor timing by T2 face type (F (1, 23) = .05, p = *ns*), not lag by T2 face type (F (6, 138) = 1.09, p = *ns*) were significant. There was, however, a three way interaction that approached significance (F (6, 138) = 2.13, p = .054). Therefore, this allowed for examination of the first and second half of data separately as carried out with T1 upright faces.

Inverted T1 faces, first half. An ANOVA was applied to the number of correctly identified T1 inverted faces using lag (7), and T2 orientation (upright, inverted) in the first half of the data. This found no effect of lag (F (6, 138) = 1.97, p = *ns*), nor of T2 face type (F (1, 23) = .03, p = *ns*). However, the interaction was significant (F (6, 138) = 2.33, $p < .05$). To investigate this interaction, lags were compared against each other, separating T2 face type.

Paired t-tests were conducted with inverted T1 faces, first half of the data, with T2 upright faces, comparing each lag. Bonferroni corrections adjusted alpha to .002 to take account of 21 tests. This found a marginally significant difference between lag 6 and lag 7, with better identification at lag 7 (t (23) = -2.87, p = .009), with better identification at lag 7 (mean = 2.88, SE = .27) compared to lag 6 (2.08, SE = .25). This latter result may be related to the effects of masking, which affected all faces, expect the face in lag 7, as there was no subsequent face on screen. This effect of masking is discussed in more detail in the main text. All other comparison were non significant (largest t (23) = 2.25, p = *ns*).

Paired t-tests were then conducted with inverted T1 faces; first half of the data, with T2 inverted faces, comparing each lag. Again, Bonferroni corrections adjusted alpha to .002 to take account of 21 tests. This found no significant comparisons (largest t (23) = 1.3, p = *ns*).

Inverted T1 faces, second half. An ANOVA was applied to the number of correctly identified T1 inverted faces using lag (7), and T2 orientation (upright, inverted) in the second half of the data. This found no effect of lag (F (6, 138) = .75, p = *ns*), nor of T2 face type (F (1, 23) = .14, p = *ns*). Finally, the interaction was not significant (F (6, 138) = .88, $p < .05$).

To summarise the above, for T1 upright faces, there main result was that identification of T1 faces was significantly better in the first compared to the second half of data. This may indicate fatigue effects with participants becoming more tired toward the end of the trial, with a detrimental effect of performance. However, with T1 inverted faces, identification was better on the second compared to first half of the data. This may be related to practice effects because participants become used to seeing upside down faces, and were then able to identify them more efficiently. Finally, in the first half of the data, when T1 was inverted, but T2 upright, identification was significantly better at lag 7 compared to lag 6. This may be a result of no face masking T2 when in lag 7 position. This notion of masking is discussed in more detail in the main text.

<u>Second target (T2) analyses</u>

The proportion of correctly detected T2 faces, conditional on identifying the T1 face was examined in the first and second half of the data.

Again, two ANOVAs were used to separate out T1 orientation as in the main text. As before, an AB would be established if there was evidence, within a particular condition, of lag one sparing, then impairment in detection, followed by improvement in performance.

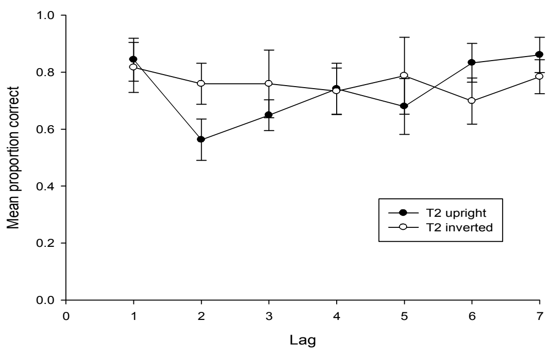


Figure A. Mean proportion (with SE) correct of T2 faces when T1 was upright, in the first half.

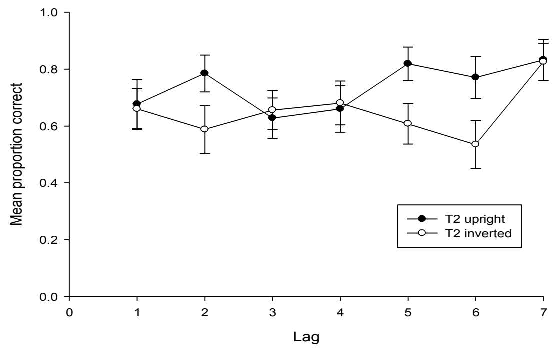


Figure B. Mean proportion (with SE) correct of T2 faces when T1 was upright, in the second half.

Upright T1 faces. An ANOVA with T2 face type (upright, inverted), lag (7) and timing (2) was applied to the proportion of correctly detected T2 faces when T1 was upright. This found a main effect of lag (F 6, 138) = 2.39, $p < .05$), best explained by a quadratic fit (F (1, 23) = 7.08, $p = .01$) but no effect of timing (F (1, 23) = 3.88, p = *ns*), nor of T2 face type (F (1, 23) = .42, p = *ns*). There was no significant interaction of timing by lag (F(6, 138) = 1.26, p = *ns*), nor of timing by T2 face type (F (1, 23) = 2.51, p = *ns*), nor of lag by T2 face type (F (6, 68) = 1.21, p = *ns*). The three way interaction was not significant (F (6, 138) = 1.66, p = *ns*). Thus, no further analyses could be carried out, and thus no AB was present.

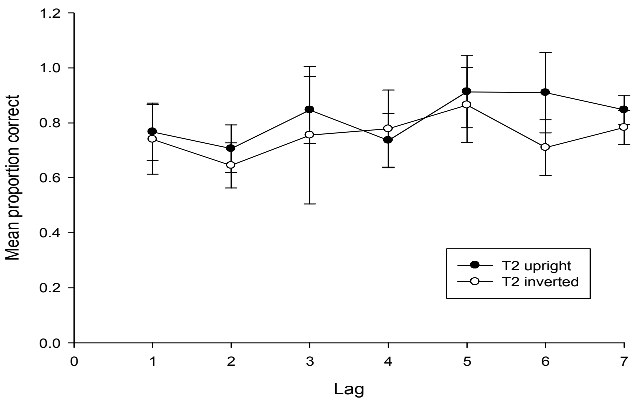


Figure C. Mean proportion (with SE) correct of T2 faces when T1 was inverted, in the first half.

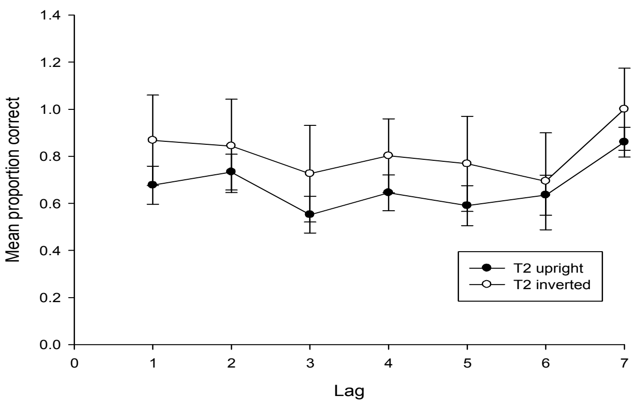


Figure D. Mean proportion (with SE) correct of T2 faces when T1 was inverted, in the second half.

Inverted T1 faces. An ANOVA with T2 face type (upright, inverted), lag (7) and timing (2) was applied to the proportion of correctly detected T2 faces when T1 was inverted. This found a main effect of lag (*F* 1, 138) = 6.68*, p* < .05), best explained by a cubic fit (*F* (1, 23) = 11.77, *p* = .002) but no effect of timing (*F* (1, 23) = 1.74*, p* = *ns*), nor of T2 face type (*F* (1, 23) = 2.53, *p* = *ns*). There was a significant interaction of timing by lag (*F* (6, 138) = 17.88, *p* < .05), and of lag by T2 face type (F (6, 68) = 12.2, *p* < .05). There was no effect of timing by T2 face type (*F* (1, 23) = .02, *p* = *ns*). The analyses was qualified by a significant three way interaction (*F* (6, 138) = 9.85, *p* < .05). This allowed for an analysis to look at the first and second half of data separately.

Inverted T1 faces, first half. An ANOVA was applied to the number of correctly detected T2 faces using lag (7), and T2 orientation (upright, inverted) in the first half of the data. This found no effect of lag (*F* (6, 138) = 1.09*, p = ns*), nor of T2 face type (*F* (1, 23) = .27, *p = ns*). Finally, there was no significant interaction (*F* (6, 138) = .34, *p* < .05).

Inverted T1 faces, second half. An ANOVA was applied to the number of correctly detected T2 faces using lag (7), and T2 orientation (upright, inverted) in the second half of the data. This found a main effect of lag (*F* (6, 138) = 5.65, *p* < .05), explained by a quadratic fit of the data (*F* (1, 23) = 14.6, p < .001) but no effect of T2 face type (*F* (1, 23) = .88, *p = ns*). Finally, there was no significant interaction (*F* (6, 138) = .52, p < .05).

To summarise the analyses on T2 proportion correct, it was found there was no significant difference between detection rates in the first half compared to the second half of the data. Finally, as in the main analyses, there as no indication of an AB in any condition. Therefore, the effects of fatigue have not been shown statistically here, although it may be argued that this is best revealed in the T1 identification task, as the actual task is more cognitively difficult as compared to detection, and would thus require more attentional resources.

Control T2 trials

Here, only T2 detected ion is required, although the T1 face per trial is still shown. To note, because of the first and second half analyses, detection is based on 5 faces rather than 10 per trial. As before, T1 upright and inverted faces are analysed separately to retain consistency of results.

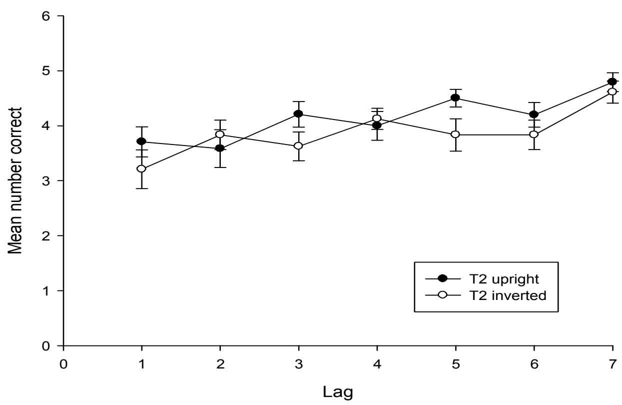


Figure E. Mean number (with SE) correct of T2 faces when T1 was upright, in the first half.

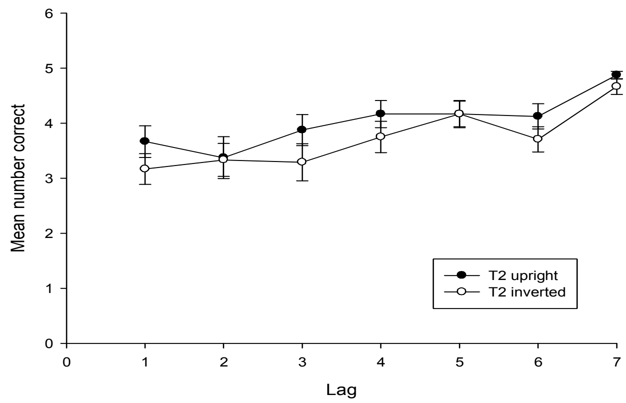


Figure F. Mean number (with SE) correct of T2 faces when T1 was upright, in the second half.

Upright T1 faces. The number of correctly detected T2 faces in the T1 upright condition was examined using an ANOVA with lag (7), T2 face type (upright, inverted) and timing (A, B) as factors. There was a main effect of lag (*F* 6, 138) = 13.81, $p < .05$), best explained by a linear fit (F (1, 23) = 28.89, $p < .001$) but no effect of timing (F (1, 23) = .57, p = *ns*), nor of T2 face type (F (1, 23) = 3.03, p = *ns*). There was no significant interaction of timing by lag (F (6, 138) = 1.08, p = *ns*), nor of timing by T2 face type (F (1, 23) = .04, p = *ns*), nor of lag by T2 face type (F (6, 68) = 1.66, p = *ns*). The three way interaction was not significant (F (6, 138) = 1.21, p = *ns*). Thus, no further analyses could be carried out, and no AB was present.

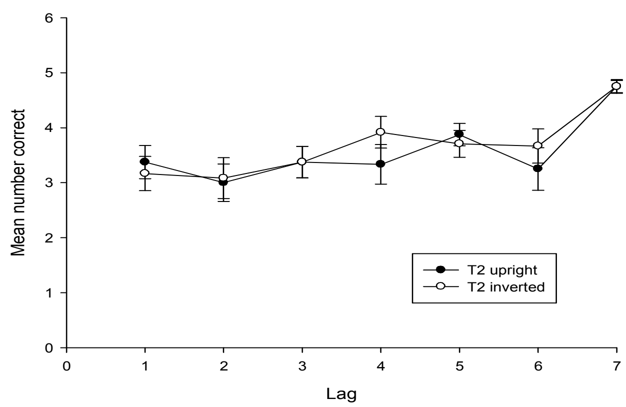


Figure G. Mean number (with SE) correct of T2 faces when T1 was inverted, in the first half.

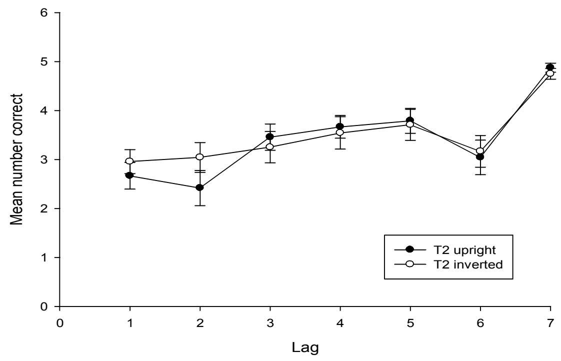


Figure H. Mean number (with SE) correct of T2 faces when T1 was inverted, in the second half.

Inverted T1 faces. The number of correctly detected T2 faces in the T1 inverted condition was examined using an ANOVA with lag (7), T2 face type (upright, inverted) and timing (A, B) as factors. This found a main effect of lag (F (6, 138) = 19. 32*,* $p < .05$), and a marginally significant effect of timing (F (1, 23) = 4.14, p = .054) with detection better in the first half (mean = 3.62, SE = .19) compared to the second (mean = 3.45, SE = .19) half. There was no effect of T2 face type (F (1, 23) = .47, p = *ns*). There was no significant interaction of timing by lag (F(6, 138) = 1.43, p = *ns*), nor of timing by T2 face type (F (1, 23) = .03, p = *ns*), nor of lag by T2 face type (F (6, 68) = .86, p = *ns*). The three way interaction was not significant (F (6, 138) = 1.53, p = *ns*). Thus, no further analyses could be carried out, and no AB was present.

To summarise the results from the control trials when only detecting T2 faces, there were no significant effects when T1 was upright. However, when T1 was inverted, T2 detection was significantly better in the first half compared to the second half of the data, which again may indicate participants getting tired and thus performance was adversely affected by the second half. All results are discussed in the main text.

Chapter 8: Presenting emotional and disfigured faces in a rapid cueing task.

As before in the main text, the RT was log transformed. The same ANOVA was run, with the added factor of 'block' to examine any possible effects of fatigue. Thus, the ANOVA used block (5), validity (2: valid, invalid) and face (5: angry, disfigured, happy, inverted, neutral) as within subjects factors, and state anxiety (high, low) as a between subjects factor, with log transformed RT as the dependent variable. Given this is a supplementary analysis, only significant effects with 'block' will be examined further, given the main analyses within the main text.

The analysis found a main effect of block: F (4, 112) = 10.63, p<.005, and a main effect of validity F (1, 28) = 23.59, p <.005. There was no effect of face type F (4, 112) = .49, p = *ns*, and no effect of state anxiety F (1, 28) = 2.34, p = *ns*. There was no effect of block by state anxiety (F (4, 112) = .94, p = *ns*), nor of validity by state anxiety (F (1, 28) 3.19, p = *ns*), nor of face type by state anxiety (F (4, 112) = .58, p = *ns*), nor of block by face type (F 16, 448) = 1.68, p = *ns*), nor of validity by face type (F (4, 112) = 1.21, p = *ns*). There was an effect of block by validity (F (4, 112) = 4.66, p <.005). In terms of the three way interactions, there was no effect of block by validity by state anxiety (F 4, 112) = .41, p = *ns*), nor of block by face type by state anxiety (F (4, 112) = .16, p = *ns*), nor of block by validity by face type (F (16, 448) = 1.5, p = *ns*). Finally, there was no four-way interaction (F (16, 448) = 1.01, p = *ns*).

Given the block by validity interaction, this will be explored further. To do so, all faces within each block were collapsed as a function of validity type (valid/invalid).

Valid trials: Ten paired t-tests were conducted on valid trials to compare each block against each other. Alpha was thus Bonferroni corrected to .005. There was a significant different between valid blocks 1 and 2, valid blocks 1 and 3, valid blocks 1 and 4 and valid blocks 1 and 5 (all df = 29, t = 3.55, 4.58, 4.10, and 4.97 respectively, all p <.005). (Means: block 1 = 2.69 (SE = .01), block 2 = 2.67 (SE = .01, block 3 = 2.65 (SE = .01), block 4 = .2.66 (SE = .01), block 5 = 2.65 (SE = .01). There was also a significant difference between block 2 and block 5 (t (29) = 4.01, p <.005). In each case, participants were *slower* in block 1 compared to the other blocks, and *slower* in block 2 compared to block 5. All other paired tests were non significant.

Invalid trials: Again, ten paired t-tests were conducted, and alpha corrected to .005. This found no significant differences (all df = 29, largest t = 2.6).

Taken together, these results are indicative of practise effects on the valid trials, as participants appeared to become faster on valid trials, in terms of making a response to the probe, through each block as compared to the first block. This concurs with the arguments put forward in the main text that participants were able to focus on the validity task, and were not affected by the face type.

As before, the RT was log transformed. The same ANOVA was run, with the added factor of 'block' to examine any possible effects of fatigue. Thus, the ANOVA used block (5), validity (2: valid, invalid) and face (5: angry, disfigured, happy, inverted, neutral) as within subjects factors, and state anxiety (high, low) as a between subjects factor, with log transformed RT as the dependent variable. Given this is a supplementary analysis, only significant effects with 'block' will be examined further, given the main analyses within the main text.

Only one effect with block was significant, which was the main effect of block (F (4,112) = 11.13, p <.005).

All other interactions with block were non significant: (block by state anxiety F (4, 112) = .25; block by validity F (4, 112) = .35; block by validity by state anxiety F (4, 112) = .41; block by face type F (16, 448) = .94; block by face type by state anxiety F (16, 448) = .81; block by validity by face type F (16, 448) = .61, and the four-way interaction F (16, 448) = 1.15; all p = *ns*). To note, other significant effects were: face type (F (4, 112) = 2.74, p <.05), validity by face type by state anxiety (F (4, 112) = 2.64, p <.05) and a trend for validity by face effect (F (4, 112) = 2.35, p = .059). All other effects were non significant: state anxiety (F (1, 28) = .13; p = *ns*); validity (F (1, 28) = 2.91, p = *ns*); validity by state anxiety (F (1, 28) = .14, p = *ns*); face by state anxiety (F (4, 112) = 1.19, p = *ns*).

To explore the main effect of block, all face types and validities within each block were collapsed to perform paired t-tests to compare each block with each other block. Alpha was corrected to .005 due to ten paired t-tests. This found a significant difference between blocks 1 and 3 (t (29) = 4.31, p <.005); blocks 1 and 4 (t (29) = 3.71, p <.005); blocks 1 and 5 (t (29) = 4.16, p <.005) and between blocks 2 and 5 (t (29) = 3.67, p <.005). No other comparisons were significant. Thus, the significant effects indicate that response was slower in block 1, and was slower in block 2 compared to block 5. Means: block 1= 2.66, (SE = .01), block 2 = 2.64, (SE = .01), block 3 = 2.62, (SE = .01), block 4 = 2.62, (SE = .01), block 5 = 2.61, (SE = .01). This indicated that performance speed was slowest in block 1.

Chapter 10: Examining delayed disengagement effects with emotional and disfigured faces.

As before, the RT was log transformed. The same ANOVA was run, with the added factor of 'block' to examine any possible effects of fatigue. Thus, the ANOVA used block (5), validity (2: valid, invalid) and face (5: angry, disfigured, happy, inverted, neutral) as within subjects factors, and state anxiety (high, low) as a between subjects factor, with log transformed RT as the dependent variable. Given this is a supplementary analysis, only significant effects with 'block' will be examined further, given the main analyses within the main text.

This analysis found a main effect of block (F (4, 112) = 22.82, p <.05), and this will be discussed shortly.

All other interactions with block were non significant: (block by state anxiety F (4, 112) = 1.43; block by validity F (4, 112) = .79; block by validity by state anxiety F (4, 112) = 1.18; block by face type F (16, 448) = .85; block by face type by state anxiety F (16, 448) = .57; block by validity by face type F (16, 448) = .43, and the four-way interaction F (16, 448) = 1.65; all p = *ns*).

No other effects were significant: face type (F (4, 112) = .30, p = *ns*), validity by face effect (F (4, 112) = .99), state anxiety (F (1, 28) = .011, p = *ns*); validity (F (1, 28) = .62, p = *ns*); validity by state anxiety (F (1, 28) = 1.11, p = *ns*); face by state anxiety (F (4, 112) = 1.3, p = *ns*), validity by face type by state anxiety (F (4, 112) = 1.168, p= *ns*).

To explore the main effect of block, all face types and validities within each block were collapsed to perform paired t-tests to compare each block with each other block. Alpha was corrected to .005 due to ten paired t-tests.

The paired t-tests found a significant difference between blocks 1 and 2 (t (29) = 3.66, p <.005), blocks 1 and 3 (t (29) = 4.48, p <.005); blocks 1 and 4 (t (29) = 5.64, p <.005); and blocks 1 and 5 (t (29) = 6.32, p <.005. There were also significant difference between block 2 and block 4 (t (29) = 4.42, p<.005), block 2 and block 5 (t (29) = 5.43, p <.005), block 3 and block 4 (t (29) = 3.87, p <.005), and block 3 and block 5 (t (29) = 4.26, p <.005). Means: block 1= 2.68, (SE = .01), block 2 = 2.65, (SE = .01), block 3 = 2.64, (SE = .01), block 4 = 2.62, (SE = .01), block 5 = 2.61, (SE = .01). No other comparisons were significant. These results suggest that participants were generally slower to respond to the probe during the first block, and subsequent blocks showed signs of increased response time to the probe. Given that there are no other effects interaction effects with block, this general increase in speed of response indicates that participants may have been bored with the study and so were simply responding as fast as possible to reach the end of each block, rather than focus on the actual study. This indicates either fatigue effects or the negative effect of boredom were at play in this experiment.

Chapter 11: Examining delayed disengagement effects with emotional and disfigured faces II.

As before, the RT was log transformed. The same ANOVA was run, with the added factor of 'block' to examine any possible effects of fatigue. Thus, the ANOVA used block (5), validity (2: valid, invalid) and face (4: angry, disfigured, happy, and neutral) as within subjects factors, and state anxiety (high, low) as a between subjects factor, with log transformed RT as the dependent variable. Given this is a supplementary analysis, only significant effects with 'block' will be examined further, given the main analyses within the main text.

This found a main effect of block (F (4, 112) = 10.19, p <.001). This will be examined shortly.

All other interactions with block were non significant: (block by state anxiety F (4, 112) = .65; block by validity F (4, 112) = .9; block by validity by state anxiety F (4, 112) = .69; block by face type F (12, 336) = .54; block by face type by state anxiety F (12, 336) = .19; block by validity by face type F (12, 336) = 1.32, and the four-way interaction F (12, 336) = .98; all p = *ns*).

No other effects were significant: face type (F (3, 84) = 1.19, p = *ns*), validity by face type (F (3, 84) = 1.31), state anxiety (F (1, 28) = .76, p = *ns*); validity (F (1, 28) = .97, p = *ns*); validity by state anxiety (F (1, 28) = .85, p = *ns*); face type by state anxiety (F (3, 84 = .21, p = *ns*), validity by face type by state anxiety (F (3, 84) = .82, p= *ns*).

To explore the main effect of block, all face types and validities within each block were collapsed to perform paired t-tests to compare each block with each other block. Alpha was corrected to .005 due to ten paired t-tests.

This found a significant difference between blocks 1 and 4 (t (29) = 4.22, p <.005), blocks 1 and 5 (t (29) = 3.83, p <.005), blocks 2 and 4 (t (29) = 3.97, p <.005), blocks 2 and 5 (t (29) = 3.48, p <.005), blocks 3 and 4 (t (29) = 3.54, p <.005), and blocks 3 and 5 (t (29) = 3.39, p<.005). Means: block 1 = 2.69 (SE = .01), block 2 = 2.67 (SE = .01), block 3 = 2.67 (SE = .01), block 4 = 2.66 (SE = .01), block 5 = 2.65 (SE = .01). All other comparisons were non-significant. These results indicate that participants became quicker at the probe response task over the blocks.

Chapter 12: The influence of real images of facial disfigurement in the cueing task.

As before, the RT was log transformed. The same ANOVA was run as in the main text, with the added factor of 'block' to examine any possible effects of fatigue. Thus, the ANOVA used block (5), validity (2: valid, invalid) and face (4: angry, disfigured, happy, and neutral) as within subjects factors, and state anxiety (high, low) as a between subjects factor, with log transformed RT as the dependent variable. Given this is a supplementary analysis, only significant effects with 'block' will be examined further, given the main analyses within the main text.

This found a main effect of block (F (4, 112) = 22.50, p <.001). This main effect will be examined shortly.

All other interactions with block were non significant: (block by state anxiety F (4, 112) = .34; block by validity F (4, 112) = 1.75; block by validity by state anxiety F (4, 112) = 2.22; block by face type F (12, 336) = 1.15; block by face type by state anxiety F (12, 336) = .89; block by validity by face type F (12, 336) = .96, and the four-way interaction F (12, 336) = 1.75; all p = *ns*).

The only other effect that was significant was state anxiety (F (1, 28) = 7.31, p < .05). All other effects were non significant: face type (F (3, 84) = .46, p = *ns*), validity by face type (F (3, 84) = 1.43), validity (F (1, 28) = 3.73, p = *ns*); validity by state anxiety (F (1, 28) = .17, p = *ns*); face type by state anxiety (F (3, 84 = 1.22, p = *ns*), validity by face type by state anxiety (F (3, 84) = .89, p= *ns*).

To explore the main effect of block, all face types and validities within each block were collapsed to perform paired t-tests to compare each block with each other block. Alpha was corrected to .005 due to ten paired t-tests.

This found that there was a significant difference in speed of response between blocks 1 and 3 (t (29) = 4.20, p < .005), blocks 1 and 4 (t (29) = 6.65, p < .005), blocks 1 and 5 (t (29) = 5.99, p < .005), blocks 2 and 4 (t (29) = 6.38, p < .005), blocks 2 and 5 (t (29) = 5.17, p < .005) and blocks 3 and 4 (t (29) = 3.11, p < .005). Means: block 1 = 2.69 (SE = .01), block 2 = 2.68 (SE = .01), block 3 = 2.66 (SE = .01), block 4 = 2.65 (SE = .01), block 5 = 2.65 (SE = .01). All other comparisons were non significant.

The significant effects indicate that participants became faster at responding to the probe as the experiment progressed, with the slowest performance on block 1. Indeed, this is the general effect that has been found in all the cuing studies in this thesis, and suggests that participants in each cueing experiment gradually became quicker at the reaction task from block to block, especially when comparing to the first block in each case. However, generally there were no other interaction effects with block, suggesting that this increase in speed of response was consistent across different face types and validity type.

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