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The effects of prior experience on the perception of faces

Gomez-Cuerva, Julia

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THE EFFECTS OF PRIOR EXPERIENCE ON THE PERCEPTION OF FACES

Julia Gómez-Cuerva, BSc, MSc 2010

Centre of Experimental and Consumer Psychology School of Psychology Bangor, Wales

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Abstract

This thesis investigated the effect of prior experience on the perception of faces. Firstly, I introduce the methodology used to create an iso-expressive set of face images. These iso-expressive faces were then used to measure sensitivity to facial expression perception in two main experiments in this thesis. One experiment measured facial expression sensitivity to faces that were previously presented as targets or distractors in an attentional task. Then, I present an instrumental learning task used to imbue neutral faces with value. This task was a choice game where participants have to choose the optimal choices in order to maximize payoffs. This technique was used to provide prior experience with faces. I then measured sensitivity to facial expression perception with faces previously associated with those values. Evidence obtained across these experiments supports the notion that facial expressions are malleable. Faces associated with rewards were seen as more expressive than faces associated with punishment. This provides evidence of an influence of top-down signal in the perception of faces. Top-down signals provided by the value-associated faces were further explored in a visual attention task. Target detection was biased in favour of the motivational salience associated to faces.

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Part 1

GENERAL INTRODUCTION TO PERCEPTUAL AND ATTENTIONAL PROCESSING

Chapter 1

General Introduction.

The purpose of this chapter is to examine briefly the theoretical framework of visual attention. In the first section, I review how bottom-up and top-down signals are generated with reentrant theories of visual processing. I then briefly introduce concepts on selective attention. The initial studies on selective attention have focused on the processing of neutral stimuli; here I also review studies that show how familiarity, emotion, and motivation can be used to guide selective attention. Finally, top-down processing in face perception will be revised.

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Neurobiology of objects representation

From the moment a stimulus reaches the eves to the moment we have consciousness of this percept, the initial stimulus has been coded at several levels. Initially, the retina is in charge of transforming the visual information (light) into neural activity. From the retina, 90%¹ of visual information reaches the primary visual cortex (also known as striate cortex or V1) via the lateral geniculate nucleus (LGN). From the primary visual cortex (which is located in the occipital cortex) visual information is further processed via two main pathways, the dorsal and the ventral stream. The dorsal stream forward the information received towards the parietal lobe, whereas the ventral stream directs towards the temporal lobe. These two streams serve different functions with the dorsal pathways processing spatial information (i.e. respond to where is the object?) and the ventral pathway being widely involved in processing information for perception and object recognition (i.e. respond to what object is this?). This hierarchical processing shows that different cortical areas lead to an integrated percept in a remarkably short time. Most connections between different visual areas consist of both feedforward and feedback connections. The initial feedforward sweep of information processing (also called bottom-up) has a driving effect by bringing perceptual information to higher levels of visual processing. Backward connections (also called top-down) transfer the information in the reverse direction and has a role in modulating, coordinating, or providing contextual guidance to bottom-up processing. Initially, objects are represented at the featural level and by forming a

¹ The remaining 10% involves another fast route that projects from the retina to subcortical structures that includes the *superior culliculus* (SC), then to the *pulvinar*, and *frontal eye fields* (FEF) and then project back to extrastriate areas (Tong, 2003).

hypothesis, testing from our previous knowledge and expectations, objects are recognized. Top-down and bottom-up processing work in coordination to direct attention and bias competition. Here I will review how this signals are generated though theories of recurrent processing.

Interactive model of visual processing.

According to studies on macaque monkeys, a vast part of the cortex is involved in visual processing (Felleman & Essen, 1991; for reviews see Bullier, 2001; Lamme 2004; 2006; Lamme &. Roelfsema, 2000; Tong, 2003). Anatomically, V1 is the lowest visual area where the first feedforward sweep or bottom-up processing initiates. The visual information then bifurcates in parallel to higher visual areas in the dorsal and ventral streams. The ventral stream



Figure 1.1. Schematic diagram for the connections between cortical visual areas. Red arrows indicate reciprocal connections within striate and extrastriate areas. Blue arrows show reciprocal connections between extrastriate areas and fronto-parietal areas. Adapted from Tong (2003).

encompasses V2, V3, V4, with the inferotemporal cortex (IT) at the top of the visual cortical hierarchy. The dorsal stream covers V2, V3, V3A, middle temporal cortex (MT), and parietal cortex. Areas V4, MT, and IT project directly to visual areas in the parietal and frontal cortex, which are areas also implicated in attention, working memory (WM), and motor planning (Tong, 2003). Connections between cortical areas are horizontal (or within-area) and reciprocal with recurrent loops with other areas. Recurrent loops exist within striate and extrastriate areas as well as between extrastriate areas with dorsal, temporal and frontal cortex (Felleman & Van Essen,

1991; Lamme & Roelfsema, 2000; Tong, 2003). Figure 1.1 shows a schematic diagram of the main cortical connections. Furthermore, processing between the different visual areas is interactive since V1 directly or indirectly sends information to extrastriate areas (V2, V3, V3A, V4, MT) at the same time that V1 receives feedback projections from areas to which it does not directly project (parieto-occipital, temporal and frontal areas) (Tong, 2003). The interplay of connections between all the above forms a percept from global to local processing. This is achieved by a first feedforward sweep followed by recurrent processing from higher areas. Differences in physiological criteria and latencies in the visual hierarchy show how information sent back via top-down processing, bias processing in lower areas.

Response properties of neurons in their receptive fields indicate how the visual scene is analysed. Neurons in areas V1 and V2 have small receptive fields with very high magnification factors that help in the processing at the featural level with high precision which are then channelled to areas in the dorsal and ventral streams. Neurons at higher levels have larger receptive fields and lower magnification properties, covering larger regions of the visual field and consequently integrating global information with local and precise information (Bullier, 2001). This implies that neurons in areas V1 and V2 perform operations of segmenting visual scenes on the basis of local details, whereas neurons at higher levels have more sophisticated properties such as integrating information.

Feedforward connections are thought to occur within approximately ~100 ms (Bullier, 2001). Analysis of the latencies in neural activation has identified that the first feedforward sweep has multiple parallel pathways that operate at different speeds. For example, activation of area MT is activated as rapidly as neurons in area

V1 within ~40 ms (Bullier, 2001, Lamme & Roelfsema, 2000). This shows that processing in the hierarchy of visual areas is not serial, rather parallel. Figure 1.2 shows time latencies across the hierarchical visual system. In addition, information arriving to V1 from the magnocellular pathway arrives 20 ms earlier than information arriving from the parvocellular pathway (Bullier 2001; Nowak, Munk, Girard, & Bullier, 1995; Lamme & Roelfsema, 2000). The preceding activity of magnocellular over parvocellular pathways extends to higher order areas with visual information arriving to the dorsal stream (area MT) earlier than in the ventral stream (Bullier, 2001; Maunsell, Nealey, & DePriest, 1990). These differences in latencies have important implications in top-down processing.



Figure 1.2. Earliest time latencies from visual input in the macaque cerebral cortex. Regions shown in red indicate areas that have become active after visual stimulation. Regions in yellow indicate areas that have previously been activated. White regions are not yet activated and areas with no information are presented in grey. Adapted from Lamme and Roelfsema (2000).

The rapid activation of dorsal areas through the magnocellular pathway provides an initial analysis of the visual scene. Higher areas create a prediction as to what is seen in the visual scene. The velocity of sending visual information through feedforward and feedback connections between V1 and V2 takes 1 or 2 ms, which is the same velocity as from V1 to MT, despite the longer distance (Bullier, 2001; Girard, Hupe, & Bullier, 2001). Through retroinjection projections, this prediction is

sent backwards to lower areas, where it arrives on time, to influence the information arriving from the parvocellular pathway to V1 and V2 (20 ms later). This suggests a role for feedback connections in figure segmentation that then influence the matching detailed representations in areas V1 and V2. Thus, interactive models of visual processing suggest that visual processing is the result of global-to-local interactions (Bullier, 2001).

Theories of recurrent processing have attempted to explain the dichotomies of pre-attentive and attentive vision and between unconscious and conscious visual processing through the distinction between feedforward and recurrent processing. The feedforward sweep is believed to bring coarse information that can be processed in parallel (pre-attentive vision) and unconsciously whereas feedback processing is required for serial processing (attentive vision) and visual awareness.

Cognitive models of visual re-entrant processing

Behavioural measures of the role of re-entrant processing in perception have extensively been studied through visual masking. A target that is easily visible when presented alone can become invisible when presented along with or after a mask. Visual masking refers to a reduction or elimination in the visibility of a target stimuli caused by the presentation of a second stimuli (the mask). The mask can be presented just after the target in the same spatially location (pattern mask), closely fit the target without overlapping (metacontrast mask) or be four small dots surrounding the target (four-dot mask).

Di lollo, Enns and Rensink (2000) performed a series of masking experiments to study visual processes. To investigate the fate of visual information through reentrant processing, spatial and temporal processes were manipulated. In the spatial domain, the target was either presented alone or surrounded by non-target stimuli with different set size (2, 4, 8, or 16). In the temporal domain, both target and mask had a common onset. The target was present for either 10 ms (in Experiment 1, 2, 3) or 45 ms (in Experiment 4 and 5). After this time, the target display disappeared. Crucially, the mask remained on the screen from 0 ms (target and mask had the same onset and offset) to 320 ms (target and masks had the same onset but masks had a longer offset; see Figure 1.3 for an example).



Figure 1.3. Illustration of a schematic trial for the common-onset masking experiment with four-dot mask. The display was presented for 10ms. Then the display turned off and the mask remained on the display from 0ms to 320 ms. The target was indicated by the four dots showed in the visual display. Subjects' task was to indicate the location of the target's gap. Adapted from Enns and Di Lollo (2000).

Three important results showed evidence for spatio-temporal interactions in re-entrant pathways in visual processing. Firstly, masking was observed in the common-onset paradigm. Target accuracy declined as the temporal interval between the target and the mask increased. When the mask duration was equal to zero

performance was almost at ceiling, however, as the mask duration increased performance decreased. The authors explained the results favouring a re-entrant processing account. When the target and the mask entered equally (mask duration was 0 ms) into the visual pathway, hypothesis testing from high-level areas are easily confirmed in low-level areas, since the information in low-level areas has not been changed. Conversely, when the mask is presented longer than the target (mask duration 320 ms) the hypothesis testing about the target formed in high-level areas cannot be confirmed in low-level areas; when the hypothesis testing arrives, low-level areas information about the target has been overwritten by the mask alone, leaving hypothesis testing unable to be confirmed.

Secondly, set size interacted with mask duration. Masking effects were bigger as the set size in the display increased. When the set size is manipulated the precise number of iterations necessary to identify the target will differ. The authors suggested that attention was not sufficiently narrow to permit the exclusive processing of the target alone; hence some neighbouring items were also included in the hypothesis testing. As the initial processing was not exclusive to the target this might have resulted in more iterative processing from high to low-level areas until a correct hypothesis testing about the target was achieved. If the target is alone in the display hypothesis verification can be accomplished quickly in few iterations. The more iteration between high to low-levels areas are needed, the bigger the masking effects will be.

Lastly, masking effects were observed with just four-dots mask through a process of object substitution. When target and mask finished simultaneously (mask duration was 0 ms) the target was clearly visible with the surrounding four-dots mask.

However, when the mask was presented at longer durations (mask duration 320 ms), the four-dots mask was perceived as a square surface configuration that replaced the target as the object of perception through re-entrant visual processing.

Three accounts have been proposed to explain visual masking. The integration account sees visual masking as a long exposure photograph: both target and mask become integrated into a single blended percept. The image of the target fades away by the overlapping contents of the mask leaving the target unable to conscious access retrieval. The interruption account posits that the processing of the target is disrupted by the arrival of the mask that appears in the same spatial location. This account relies on the temporal presentation between the target and the mask. In this case, the target is not degraded, rather its processing is interrupted by the arrival of the mask. Thereby, target perception is impaired (Di Lollo, et al., 2000). Finally, the competition account postulates that two stimuli appearing at the same spatial location cannot be processed. A conflict occurs between the persistent neural representation of the target and the neural representation of the mask increases and the neural representation of the mask increases and the neural representation of the target weakens (Keysers & Perret, 2002).

Computational model of object substitution (CMOS)

Di Lollo, et al., (2000) designed a model to provide a general scheme based on iterative re-entrant processing to account for a range of perceptual and attentional phenomena. The model assumes the principle that communication between two brain areas is never unidirectional. Instead, communication is achieved through reentrant pathways: if a source area sends signals to another area, this area returns the signal back to the source area. Activity from higher areas forms a perceptual hypothesis that then searches a match with ongoing pattern in low-levels activity. This comparison aims to clarify two objectives. The first objective is to confirm the hypothesis testing created from higher levels because low-level activity might have activated more than one activation; the initial activation might be unclear or ambiguous. The second objective is the confirmation of the spatial resolution since the pattern layer needs to be successfully bound to its actual display location. The need for spatial ensemble onto de stimulus comes from the assumption that perception emerges from a large number of modules (as the one illustrated in Figure 1.4) with at least one module of each spatial location.



Figure 1.4 – Schematic diagram of one module in the computational model of object substitution. Adapted from Enns and Di Lollo (2000).

The model consists of three representation layers as shown in Figure 1.4. Information from a visual stimulus first arrives to the *Input* layer (I) and decays within 100 ms if the stimuli are presented briefly. The contents of the input layer are sent

forward to the intermediate layer, or *Working* layer (W), and then sent to the *Pattern* layer (P). Once the information from the Pattern layer is sent back, the working layer performs a direct comparison (C) to the codes of the Input layer. In masking, the contents in the input layer change with new visual input. Conversely, the contents of the pattern layer change more slowly since their content is the result of the sum of the actual contents in the input layer plus the contents of working layers in the previous iteration. Masking will occur if there is a mismatch between re-entrant signal and the current contents in the input layer. The target stimulus will be deleted by the new coming contents from the input layer, that is, the mask. The input layer will consist of activity from the mask plus decaying activity from the target. When there is this kind of conflict, perception will depend on the number of iterations needed to identify the target. Little iteration will result in correct perception of the target. If more iterations are needed, there will be more chances that the perceptual hypothesis formed by the "target + mask" will be replaced by the "mask alone" percept.

According to Di Iolio and colleagues (2000), the neural correlates of CMOS are considered to be processed in local and global loops. Local loops are fast, span neighbouring brain regions especially the different layers in extrastriate cortex. An initial burst triggers different local loops which all continue to operate concurrently however each loop is attuned to a different attribute of the stimulus. Global loops are superimposed on local loops. Global loops are slower and cover larger brain areas from occipital to parietal, central and frontal and back to occipital regions.

Attentional processes

Selective attention can be defined as a cognitive process that facilitates the limited sources of attention towards task relevant stimuli while inhibiting task irrelevant stimuli. This selection allows the cortical sensory sites to cope with their processing task. Visual attention is limited in capacity for processing information; only a small amount of the information can be further processed. Selective visual attention is the results of dynamic interplay between attentional control systems and sensory brain structures. The control of selection is performed by bottom-up and top-down processes. Bottom-up processing is believed to be automatic (exogenous) and driven by properties inherent to the stimuli, such as salience and sudden movement in the periphery; whereas top-down acts according to the observer's goals, reflecting voluntary (endogenous) control of attention.

Bottom-up processing is characterised by being automatically processed and being independent of cognition and task demands. Treiman's Feature Integration theory (FiT) (Treisman & Gelade, 1980) showed that the saliency of different lowlevel features of stimuli (colour, texture, orientation) captures attention. This model suggests that, in the first stage of visual display processing, features are coded automatically, pre-attentively and in parallel, without the need of focal attention. This has been measured in visual search tasks. Search time for a target that has a unique feature (for example a red circle among green circles) is independent of the number of distractors presented. This implies that a unique feature captures attention to its location. In other words, the most salient part of the scene is the one that receives attentional resources and therefore is fully processed. This is called the attentional *pop-out* effect. According to bottom-up models of attention, stimulus salience in the visual field dominates attentional control, suggesting that selection is primarily stimulus driven. Conversely, top-down processing is believed to take place in a second stage of processing when features are glued together to form conjunctions. Searching for conjunctions requires focal attention. Bottom-up attentional models suggest that the allocation of attention is determined by the relative salience of the stimuli in the visual field (Theeuwes, 1991; 1992; 1994).

Working memory (WM) is believed to generate attentional signals with the aim to aid selectivity in the limited attentional resources (Miller & Cohen, 2001; Miller & D'Esposito, 2005). This selection is achieved by top-down mechanisms, which are considered to be crucial to improve the quality of information processing. A bridge between the gap of information from WM and the source of top-down signals are implemented in the PFC (Curtis & D'Esposito, 2003). Top-down processing modulates the sensitivity of neural circuits that represent the information or goal at task with the aim to improve the control of the quality of information or goal at task (Egeth & Yantis, 1997). Top-down influences involve perceptual tasks, priming, expectation, and hypothesis testing. Top-down mechanism are involved in directing orientation to targets (e.g. gaze control) and in aiding information processing for incoming sensory input (for reviews see Gilbert & Sigman, 2007; Miller & D'Esposito, 2005).

Key findings from single-unit recordings provide evidence for a crucial role for the PFC in top-down signals. Moore and Amstrong (2003) showed that stimulation of the frontal eye fields (FEF) enhanced visual neuron responses in area V4. Firstly, it was identified the FEF's area that produced a movement field that overlapped with the receptive fields of a group of neuron in area V4. Trials that FEF received electrical stimulation resulted in elevated responses in area V4 relative to nonstimulation trials. Moreover, increase in responses in V4 was only present when the target stimuli was in the receptive field compared to when a non-target stimuli was presented instead. Through a posterior-split-brain paradigm, Tomita, Ohbayashi, Nakahara, et al., (1999) showed that visual regions in the inferior temporal cortex were activated from top-down signals in the absence of bottom-up sensory input, while the monkeys were performing a stimuli associations task, supporting the role of PFC top-down control in the temporal lobe.

Inhibitory mechanism of selective attention

According to some selective attention models (Houghton & Tipper, 1994) selection of visual targets can be achieved by excitatory and inhibitory mechanisms. Thus, one mechanism of selection is inhibition of the competing internal representations activated by distractor stimuli. Clark (1996) defines inhibition as "any mechanism that reduces or dampens neuronal, mental, or behavioural activity" (p.128). Tipper (2001) points out that abundant evidence exists showing that visual processes can flow automatically into actions so that such actions can later be evoked with little or no conscious intention to act. If such efficient perceptual processes were unrestrained, then the most dominant perceptual input of the moment would capture action haphazardly. Therefore, inhibitory control is crucial to maintain and prioritize coherent behaviour.

Evidence for this inhibition has been observed experimentally in the response time effects in attentional priming procedures (McLeod, 1998; Posner & Cohen, 1984; Tipper, 1985). Such visual attention studies have demonstrated that the time needed

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to identify a stimulus depend on the task relevance of prior events. For example, the use of inhibition in attentional selection has been studied in the phenomenon of negative priming (Tipper, 1985; 2001, but see Neill, Valdes, Terry & Gorfein, 1992 and MacDonald & Joordens, 2000). Negative priming refers to the slowing of the response to a stimulus that has previously been ignored. A typical negative priming design involves the presentation of two consecutive displays: the prime and the probe. In the prime display, subjects are requested to attend to a target (e.g. blue stimuli) and ignore a distractor (e.g. green stimuli). On some trials, the distractor (e.g. green stimuli) from the immediately preceding prime display is presented as the target to be identified in the subsequent probe display. The results showed that responses to previous distractor were slower than responses to the same stimuli in the baseline condition. Distractor's internal representation in a prime display was associated with inhibition, and then subsequent processing of such stimuli when presented as a target in a probe display was impaired - as suggested by the slowing of the responses. This implies that to recognise an object, internal representations previously created from prior recognition is still present when the stimuli is later reencountered. Thus, negative priming is caused by residual inhibition of the stimulus' internal representation. The idea of active inhibitory processes in selective attention was also observed in other experimental paradigms such as in the Stroop colour naming task (Dalrymple-Alford & Budayr, 1966), directing forgetting (McLeod, 1998) and inhibition of return (Posner & Cohen, 1984) among others.

The inhibitory processes underlying the above experimental paradigms can be accounted for by a neural network model of inhibition developed by Houghton and Tipper (1994; see also Houghton, Tipper, Weaver, & Shore, 1996). One of the assumptions in the model is that selection is comprised of a dual mechanism that boasts a target and inhibits a distractor in parallel and independently from each other. Selection is postulated to involve the interaction of representations of "target fields" with representations of "object fields". Target fields are internal templates containing stimulus' features that specify which object is the target for action; thus, they aim to distinguish target from distractors. Object fields are internal activations of external stimuli that compete for representation via lateral inhibition. In the matching process, both object and target fields are compared to each other; features that match the target become selectively enhanced whereas mismatching objects receive inhibitory feedback. Inhibition is generated locally in a bottom-up fashion whereas top-down processes act to modulate and focus the inhibitory processes. As suggested by one of the properties of the model, the inhibitory processes that feedback to the distractor are reactive. In other words, the level of inhibition is determined by the activation state of the distractor. Thus distractors that are more salient and intrude into the control of action receive greater inhibitory feedback than less salient distractors. Relevant to this thesis is that these inhibitory mechanisms are modulated by emotional evaluations (see Attention and emotion in this chapter and chapter 3) and by motivational associations to stimuli (see the interaction of motivation and cognition in this chapter).

Attention and Familiarity

Familiarity is a type of object feature that can be used to bias attentional competition (Desimone & Duncan, 1995). Several studies addressing the influence of familiarity on attention have suggested that familiar stimuli facilitate visual

processing. Familiarity effects have been studied by comparing unfamiliar versus familiar stimuli. Tong and Nakayama (1999) showed that visual search for one's own face was detected more rapidly than search for other unfamiliar faces, even when the faces were inverted or varied in their viewpoint. The authors explained their results by introducing the term robust representation for highly overlearned stimuli. The intensity at which a stimulus is represented in the brain varies according to the degree of familiarity. Thus, familiarity denotes a learning curve that reflects actual changes in visual representations. Exposure to a stimulus rapidly develops in its representation, giving the subject a degree of familiarity with the stimulus. However, familiarity continues to develop over a much more extended time period. When extensive additional visual experience reaches asymptotic performance in a learning curve, then, at this point, the authors suggest that a robust representation has been formed. Thus, robust representations reflect the end point of visual learning or, in other words, the most extreme form of familiarity. Visual robust representations have the following effects on visual processing: they mediate rapid asymptotic visual processing, thus in Tong and Nakayama's study processing highly familiar faces resulted in faster detection over unfamiliar faces. Robust representations are flexible so that they are capable of generalizing across changes in stimulus (view variant information), as evidenced in this study that one's own face was detected faster independently of the presentation of the face's viewpoint. Robust representations also facilitate a variety of visual and decisional processes across tasks and contexts, and demand less attentional resources.

The authors concluded that robust representations differ from other representations in the nature of its visual code. Robust representations may develop

an *efficient visual code* to facilitate processing efficiency. The visual system deals with the coding of enormous amount of incoming information. With the absence of proper visual experience, neurons have to deal with great redundant visual information. The creation of efficient visual codes would reflect an optimized code for representing the higher order statistical structure of natural images. Thus efficient visual codes for robust representations aim at reducing the number of active neurons coding for that face, which then convey in robust visual codes that promote perceptual fluency, speeded and optimal visual processing.

The notion that familiarity enhances visual processing has been supported by another study involving a change detection task (Butler & Raymond, 2003). In this study, detection of a change in a repeated presentation of a two-face array was better for highly familiar faces than for unfamiliar faces. Familiarity also disrupts performance when stimuli are presented as irrelevant distractors (Jenkins, Lavie, & Driver, 2003; Lavie, 2003). In this study, subjects had to categorise celebrities printed target names centrally presented while attempting to ignore a peripheral famous face distractor image that could be congruent or incongruent with the target name. Highly familiar faces could not easily be ignored when presented as flankers and interfered with a central name categorization task²

In a similar vein, Jackson and Raymond (2006) showed that familiarity representations could vary in the extent of their robustness. Using an attentional blink (AB) task, familiarity levels were tested by comparing face recognition performance

² Note that this study was only performed with highly familiar faces; consequently there is no direct comparison of performance between familiar and unfamiliar faces. The design of these experiments does not permit to perform the same task with unfamiliar faces; therefore it is unclear whether the effects in this study are due to all faces or just familiar ones.

for British celebrities face images contrasting British and non-British participants. AB effects were used as an index of the attentional resources needed to identify a highly familiar or somewhat familiar face image. Results showed that AB effects were present for the non-British participants, indicating that attentional resources were scarce to identify a somewhat familiar face. Interestingly, AB effects were absent for the British participants. In line with the efficient visual code hypothesis, highly robust representations of familiar stimuli need less attentional resources to be processed, thus escaping the AB effect.

Benefits of robust representations of familiar faces also enhance visual working memory (WM) capacity relative to unfamiliar faces (Jackson & Raymond, 2008). In this study, visual WM capacity was measured using a standard visual change-detection task (Luck & Vogel, 1997) with concurrent verbal suppression. To measure WM capacity the number of faces to be remembered (face load) varied between loads. Concurrent verbal suppression was accomplished by presenting some digits (two digints in Experiment 1 and between two to five digits in Experiment 2). at the beginning of a trial and participants had to recall those digits at the end of the trial. In between the digit rehearsal task, a memory array with different face loads (1, 2, 3, 4, 5, 6, 8 and 10) was presented and after a 900 ms interval the memory array appeared again. Participants had to state whether the array had changed or not. Visual WM performance for familiar faces was higher than unfamiliar regardless of the low (Experiment 1) or high (Experiment 2) verbal WM load. The authors interpreted their results as WM capacity combining previously learned information (already stored in LTM) with currently available sensory information (Baddeley,

2000), that is, when the storage of stimuli is well established in LTM this enhances the storage capacity in visual WM.

The above studies imply that the information provided by familiarity is used to guide selective attention. Familiarity aids attentional selection by providing a competitive advantage over unfamiliar stimuli. Stimuli with robust representation in LTM might be provided with robust visual codes. When the stimuli is competing for attentional selection, robust visual codes results in facilitation in their processing.

Attention and emotion

Selective attention and the emotional system are two important brain systems that serve to carry out the processing of information necessary to guide human action. The *selective attention system* facilitates the limited sources of attention towards task relevant stimuli while inhibiting task irrelevant stimuli. The selection allows the cortical sensory sites to cope with their processing task. The *emotional system* interprets information in terms of the consequences of current and future goals.

Several studies have addressed how visual stimuli with emotional content are prioritised for detection. However, the results have yielded a myriad of information. For example, it has been widely reported that accuracy and speed of responding is biased in favour to stimuli that are negatively valenced compared to positive or neutral stimuli (Dijksterhuis & Aarts, 2003; Eastwood, Smilek, & Merikle, 2001; Fenske & Eastwood, 2003; Öhman, Flykt, & Esteves, 2001; Vuilleumier, Armony, Driver, & Dolan, 2001). Some studies have addressed the hypothesis of a bias in the processing of threatening stimuli to apply to all individuals in the population, whereas

other studies have suggested that this bias is mainly present in highly anxious individuals (Bishop, Jenkins, & Lawrence, 2006; Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Georgiou, 2005). However, other studies have provided differences as to whether positive stimuli capture attention most effectively than negative or neutral stimuli (Gallegos & Tranel, 2005; Leppänen & Hietanen, 2004; Russell, 1994; Tipples, Atkinson, & Young, 2002) even in highly anxious individuals (Juth, Lundqvist, Karlsson, & Öhman, 2005). Other studies have reported that emotional stimuli (either positively or negatively valenced) are prioritised in attentional processing more than neutral stimuli (Calvo & Esteves, 2005; Vuilleumier & Schwartz, 2001).

It is possible that the diversity of evidence as to which facial expression captures attention results from the variety of tasks employed and the nature of the stimuli used. I will now discuss factors related to emotional stimuli that could possibly confound the interpretation of results in emotion research. This is relevant since it reveals the need to control for such shortcomings. This thesis addresses a possible solution in Chapters 2 and 4.

Stimulus salience/arousal

Emotional stimuli as opposed to no-emotional stimuli are composed of two main dimensions. These dimensions have been conceptualised as valence (positive or negative) and arousal (high or low intensity) (Russell, 1980). According to the circumplex model of affect (Posner, Russell, & Peterson, 2005; Russell, 1980, 2003), each affective experience is a combination of these two dimensions, therefore an emotion is either positively or negatively valenced with different levels of arousal (see Figure 1.3). In addition, the neural representations for encoding those dimensions are

different, with the amygdala being in charge of arousal and the OFC representing the valence dimension of the stimulus (Anderson, Christoff, Stappen, Panitz, Ghahremani, Glover et al., 2003; Small, Gregory, Mak, Gitelman, Mesulam, & Parrish, 2003).

Typically, studies using emotional stimuli are not pre-tested to determine whether such stimuli vary in their intensity (but see Chapter 2 and 4 of this thesis). This poses a significant challenge to studies employing different images of the same category such as facial expression databases (i.e. angry facial expression images among different individuals). This suggests that stimuli can be perceived as sufficiently emotional but vary in its arousal. Different levels of arousal determine how salient a stimulus is. Anderson (2005) showed that arousal was the critical dimension that provided the special attentional status to emotional stimuli. When positive and negative words were equated in their arousal level, attentional bias was seen for both valenced dimensions when compared to neutral stimuli. Future research showing valenced effects should consider whether the differences might be influenced by the arousal dimension in the stimuli set.

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Figure 1.3. A representation of the dimensions of valence (horizontal axis) and arousal (vertical axis) according to the circumplex model of affect (Posner, Russell, & Peterson, 2005).

Subjective relevance

The emotional value of stimuli can vary among perceivers. For example, some studies have addressed the possible exiting biases of subjects' anxiety on the detection of fearful faces (Fox, et al., 2001; 2005). These studies suggest that highly anxious individuals are more sensitive to the perception of fearful faces than low anxiety individuals. However, other studies have not controlled for that and they report their results with perhaps a mix of high and low anxiety individuals (Pourtois, Grandjean, Sander, & Vuilleumier, 2004; Pessoa, Japee, Sturman, & Ungerleider, 2006). Thus, studies with emotional content can make priori assumptions about the emotional value of such stimuli to the subject.

If the biological and motivational relevance of a stimulus vary between participants then it is necessary to control the subjective relevance of a stimulus. One way to achieve this is by assigning emotional content to stimuli through learning and conditioning (see Chapter 5 of this thesis). For example, a neutral stimulus can acquire affective properties by pairing it with an aversive stimulus (Pavlov, 1927). In a typical fear conditioning paradigm, a neutral stimuli, such as a tone, is presented. The tone has no emotional association to the animal. Conditioning occurs when the tone is presented along with a mild shock (the unconditioned stimulus, US). The mild shock naturally elicits a fear response (the unconditioned response UCS). Through repeated associations, the rat learns that the tone predicts the shock and eventually the tone, by itself, will elicit the same fear conditioned response (CR). Therefore, conditioning provides a tool as to control the subjects' emotional relevance to a set of stimuli.

Stimuli properties

The low-level featural properties can make stimuli visually more distinctive. If an emotional stimuli has a visual feature more distinct than another set of stimuli then this confound would make it hard to differentiate whether performance was related to differences due to emotional factors or to visual properties. A good case for this was the angry superiority effect claimed by Hansen & Hansen (1988). In this study, participants had to detect an angry face among happy distractor faces or an angry face among neutral distractor faces, in a visual search task. The results suggested that angry faces were found more efficiently than happy and neutral faces. Reexamination of the stimuli used in this experiment showed that the effect was attributable to an artefact arising from facilitated recognition of a single feature present only in the angry condition and absent in the happy and neutral conditions (Purcell, Stewart, & Skov, 1996).

Schematic faces have been used as an attempt to control for the visual properties in emotional facial expressions (e.g. Fox et al, 2001, Eastwood, et al., 2001). These stimuli, which its ecological validity might be questioned, have also provided inconsistent results regarding the valence of the stimuli (negative expressions found better than positive and neutral faces, Eastwood, et al., 2001; positive expressions recognized better than negative ones, (Leppänen & Hietanen, 2004), raising once more the possibility of a natural perceptual bias even in schematic facial expression stimuli (Horstmann, 2002; 2007; Horstmann, et al., 2006). Further studies using a connectionist model to tease apart feature from emotional factors in emotionally expressive face images observed that there exists a perceptual bias intrinsic to the expressions of happy, angry, and neutral faces, which according to the stimuli set used favours the recognition of one facial expression over another (Mermiliod, Vermeulen, Lundqvist, & Niedenthal, 2009). This bias could provide a parsimonious explanation for the contradictory results in the above studies.

Emotion and attention interactions

The research literature concerned with the interaction between attention and emotion can be divided into two branches: top-down processes in how attention influences emotional responses; and bottom-up processes in how emotion captures attention. This evidence suggests that the relationship between attention and emotion is bi-directional. Relevant for this thesis are the effects of attention on subsequent emotional evaluations (i.e. liking, preference). This attention-affect relationship has implications for the formation of attitudes and therefore for behaviour. Two theories have attempted to explain how attention influences emotional evaluations that are reviewed as follows:

Mere exposure effect

The effect of attention on emotion has consistently been demonstrated in mere exposure studies. Zajonc (1968) observed that prior exposure to a stimulus results in positive affective evaluation, independent of conscious perception. The exposure effect has proven to be a robust, reliable phenomenon; more than 200 research articles have been published on the topic, and they have yielded strong results for a variety of stimuli and a variety of rating procedures (Bornstein, 1989). The basic design of most studies on the mere exposure effect involves presenting a neutral visual stimulus in a varied number of exposures, followed by some dependent measure of affect on each stimulus presented. In Zajonc's study, participants were presented with a series of nonsense words (Experiment 1), Chinese ideographs (Experiment 2), and faces (Experiment 3) at frequencies ranging from 0 to 25 exposures³. Participants were then asked to make liking ratings of each stimulus. The results showed a correlation between affective connotation of the stimuli and the frequency of exposure. Frequently exposed stimuli received higher liking ratings than infrequently exposed stimuli. This finding stimulated decades of research on the relation between cognition and affect.

³ The mere exposure effect reflects some degree of familiarity with the stimuli since familiarity connotes some degree of recognition and perceptual fluency. However, as the number of exposures to the stimuli is low, its representation in LTM is not robust (see attention and familiarity section in this chapter).

The mere exposure effect can be obtained by stimuli that are neither recalled nor recognized by subjects (Bornstein, 1989; Bornstein & D'Agostino, 1992, Bornstein, Leone, & Galley, 1987; Kunt-Wilson & Zajonc, 1980; Mandler, Nakamura, & Zandt, 1987). Indeed, exposure effects are more pronounced when obtained under subliminal conditions than when participants are aware of the repeated exposures. This suggests that awareness of stimuli is not required for the production of mere exposure effects; the effects might involve implicit, unconscious learning. A great deal of learning may take place without conscious awareness, deliberate effort, or higher level of cognitive processing.

The literature on the mere exposure effect reports that several exposures of the stimuli are needed for the mere exposure to enhance positive affect. Monahan, Murphy, and Zajonc (2000) subliminally presented Chinese ideographs to two groups of participants. The first group was exposed to 25 different ideographs, each shown once. The second group was exposed to 5 ideographs, each shown five times. The results showed that participants in the repeated-exposure condition were in more positive moods than the participants who were exposed to a single exposure of 25 different ideographs.

To explain the mere exposure effect, two accounts were introduced. Zajonc (2001) argued that the resulting preference is caused by classical conditioning. In the mere exposure effect, the repeatedly exposed stimulus acts as a conditioned stimulus (CS). Repeated exposure of the stimulus is followed by the absence of aversive consequences. Hence, the absence of an aversive consequence acts as an unconditioned stimulus (US). Consequently, the repeated exposure of a stimulus (CS) is paired with the absence of aversive consequences (US), causing the

conditioned response (CR) to become attached to the CS. Thus, a benevolent experience of repetition can in itself enhance positive affect.

Another account for enhancement of liking in the mere exposure effect has been introduced by the perceptual fluency theory. This theory proposes that repeated exposure to a stimulus results in a representation of the stimulus in the implicit memory (Bornstein & D'Agostino, 1992; Janiszewski & Meyvis, 2001). When the stimulus is encountered at a later time, the memory representation facilitates the encoding and processing of the stimulus. This fluency in processing results in a misattribution of liking or acceptability. Hence, repeated passive perceptual encoding experience enhances liking when the same stimulus is re-presented because it is more easily processed.

As reviewed above, the mere exposure effect and its accounts propose that, irrespective of the occupation of a stimulus in an experimental paradigm, prior exposure to that stimulus should enhance liking. However, the devaluation effect posits that stimuli presented as distractors will be more devaluated than novel and target stimuli (Raymond et al., 2003).

The devaluation effect

Evidence that attention can drive emotional responses has recently been investigated. Raymond, et al., (2003) combined a simple visual task with an emotional evaluation task. Participants were required to locate a target (whether on the right hand side or the left hand side of a fixation point) in a visual search task. After this selective attention task, a single image was centrally presented, called the *test stimulus*. This test stimulus could be a novel or the previous target or distractor stimuli. Participants evaluated the cheerfulness or dreariness of the test stimulus. The results showed that images seen as a distractor in the search task were rated more negatively than novel images or targets. The authors called this effect the *devaluation effect*. To explain the results, the authors suggested an inhibition account of the influence of attention on emotion. The central idea is that attentional inhibition directed to a stimuli, as opposed to attending, may be subsequently used to reduce the emotional salience of the distracting stimuli.

The evidence presented by the devaluation effect contradicts the mere exposure account. The idea behind this account, as explained above, is that the mere exposure of stimuli leads to positive evaluation due to familiarity effects. However, Raymond's et al., (2003) results are not in line with this account; their results suggest that the exposure of stimuli to be ignored or inhibited leads to the stimulus being devaluated.

Other studies have further researched the inhibitory effects of the devaluation effect. Fenske, Raymond, & Kunar (2004) used a more complex visual search task, which is temporally segmented: a preview-search task. A preview-search task consists of presenting a subset of distracting stimuli prior to the onset of a search array containing another set of distractors and a target. Only some of the trials presented the preview distracting stimuli. The authors reasoned that the preview effect might result in inhibitory processes applied to the previewed distractors. This inhibition would also cause an emotional devaluation of these stimuli. As expected, the results showed a devaluation of previewed distractor stimuli in contrast to nonpreviewed distractor stimuli. The authors support Raymond's et al., (2003) explanations of the devaluation effects in that selective attentional inhibition leads to devaluation and supports an account for top-down inhibitory processes in emotional evaluation.

Reward, Motivation, and Learning.

General ideas of reward function

Rewards are objects or events that make as come back for more (if positive) or avoid (if negative)(Murray, 2007; Schultz, 2007). Learning about rewards is important, since the information they convey guides behaviour between different courses of action. Rewards have several functions, such as inducing subjective feelings of pleasure and taste (hedonia) and positive emotional states (but see Berridge & Robinson, 1998); eliciting exploratory or approach behaviour, and increasing the frequency and intensity of behaviours that lead to rewards (Schultz, 2000; Schultz, Tremblay, & Hollerman, 1998). Rewards can be vegetative in nature (e.g., food, liquid, and sex) or non-vegetative (e.g., money, challenge, beauty and power). Humans are motivated to seek rewards both vegetative and non-vegetative.

Rewards have sensory, affective and motivational properties and induce changes in behaviour by increasing the frequency of behaviour that results in rewards or decreasing the frequency of behaviour that results in punishment. Reward functions define the good and bad events for an individual in an immediate sense. When reward events are accumulated they become value functions. Values are predictions of reward, in other words, values accumulate the total amount of reward an individual can expect in the future. Value functions indicate what is good or bad in the long run.
Outcomes can vary in their magnitude (i.e., amount of juice received), motivational valence (reward, punishment) and motivational salience (i.e. the probability of getting an outcome). Valence refers to the direction of value assignment (either positive or negative).

The link between learning and motivation

Motivation is described as the driving force acting on an organism to initiate and direct behaviour. It is used to explain differences in the *intensity* and *persistence* of behaviour (Petri & Govern, 2004). Motives are classified into two categories: primary and secondary motives. The main feature of primary or basic motives is that they are unlearned. They include hunger, thirst, sex and avoidance of pain (also called primary reinforcers in learning theory). Primary motives are common to both animals and humans beings. Conversely, secondary motives are mainly characterised as being learned and they differ from individual to individual (and are associated with secondary reinforcers in learning theory). Primary motives are out of the scope of this thesis but an introduction of how motives are learned is provided here.

Learning research has contributed to the understanding of motivation by emphasising the ability of individuals to learn to acquire new motives. New motives may be acquired as a result of several types of learning, such as conditioning. Conditioning is the process of changing behaviour as a function of prior experience. In a typical conditioning procedure the experimental subject experiences two events (i.e., the presentation of a stimuli and an outcome) in close temporal proximity so that an association between them is established. Given appropriate experience with the contingencies, when the first of these stimuli are re-encountered again, behaviour will change either to approach or avoid it according to the outcome associated with the previous events. Theories in motivation assume that motivation is involved in the performance of all learned responses, so that a learned behaviour will not occur unless it is energised by a motivation to acquire/avoid an outcome.

Traditionally, the main approach to understand of motivated behaviour has been studied through Pavlovian or classical conditioning (Pavlov, 1927) and operant, instrumental conditioning or reinforcement learning (Skinner, 1935). The main difference between classical and instrumental conditioning is that in classical conditioning the outcome does not depend on the individual's actions, whereas in instrumental conditioning it does. In addition, classical conditioning produces outcomes predictions and establishes conditioned incentives whereas in instrumental conditioning rewards come to serve as goals of behaviour.

Reinforcement learning.

A widely held account of the reinforcement learning was first put forward by Thorndike (1911) and is called the "*Law of Effect*". According to this law, with reinforcement learning animals acquire stimulus-response (S-R) associations. When the animal is presented with a situation or stimulus (S), the animal tries a response (R). If the outcome is rewarding, the connection between S and R is strengthened; if the outcome is not rewarding, the connection is weakened.

The capacity of learning (associability) is linked to three factors: contiguity, contingency, and predictor error (Schultz, 2006). Contiguity refers to the time delay between a R elicited by a stimulus and an outcome; this delay needs to be as brief as

possible to allow S-R association (Shanks, Pearson, & Dickinson, 1989). If rewards are presented before the stimulus or response, learning does not occur. When a outcome is contingent on an stimulus, it means that the outcome is reliably signalled by the presence of the stimulus. In order to establish contingencies, rewards should occur more frequently in the presence of the stimulus than in its absence. Contingency thus reflects how well a stimulus predicts a reward given the appropriate response. Prediction error (PE) is the difference between predicted and actual reward. When we receive an unexpected reward after an action this would signal a positive prediction error. Using PE we learn overtime the relationship between the action and the reward. With subsequent repetitions of that action and the obtained reward the relationship is learned. Then the prediction error goes back to zero as no new information about the S-R relationship is learned. However, if an expected reward does not occur as previously established with an action, then prediction error becomes negative and leads to extinction of the behaviour. Prediction error is the teaching signal that indicates to the individual that there was difference in a reward occurring or not. Learning does not occur when a reward is fully predicted.

Optimal learning is achieved with a balance between exploration and exploitation of choices presented in a learning task (March, 1991; Sutton & Barton, 1998). Exploration enables the individual to experience the outcome of numerous choices; it involves search, risk taking, experimentation, and discovery. In contrast, exploitation is directed at choosing the option that gives the highest value; it involves refinement and efficiency. Maximal reward is achieved if individuals exploit what they already know about reward but only if they initially had explored which would be the best action selection in the future. If individuals engage in exploration to the exclusion of exploitation, then, they are likely to fail to engage in selecting the optimal choice. Conversely, if individuals engage in exploitation to the exclusion of exploration, then, they are likely to engage in suboptimal repetitive choices.

Adaptive behaviours require a combination of reward evaluation, association learning, and the ability to develop appropriate actions plans and inhibit inappropriate choices on the basis of earlier experience.

Neural Substrates of the Reward Circuit.

As well as understanding how reward impacts goal-directed behaviour, here I review how rewards affect neural processes, which in turn lead to changes in behaviour. Studies from both humans and animals have suggested that value prediction codes involve a dopaminergic circuit that involves the ventral striatum, the OFC, the amygdala and the dopaminergic midbrain (Haber, 2008; Haber & Knutson, 2010; O' Doherty, 2004). These regions are highly interconnected and together form an integrated reward circuit. Each region in the reward circuit mediates different aspects of reward functions that are reviewed as follows:

Midbrain Dopamine Neurons

At the core of the reward circuit is the dopamine neurons in the midbrain⁴. Dopamine neurons are located primarily in substantia nigra (SN) and ventral tegmental area (VTA). Dopamine neurons have been associated with reward related processing (Schultz, 2004; Schultz, Dayan, Montague, 1997; Schultz & Dickinson,

⁴ The Midbrain (or Mesencephalon) is composed by the Tectum (Superior and inferior coliculus and Ventral tecmental area VTA) and the Tegmentum (Substantia Nigra (SN).

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2000). The way that dopamine neurons acquire such information is by coding an error in the prediction of reward. Dopamine neurons seem to be sensitive and flexible detectors of such difference/errors in reward prediction. Therefore they signal that an outcome is different than predicted. For that reason, dopamine neurons response has the characteristic of *teaching signals* i.e. their firing rate increases with unpredicted rewards. Rewards that are fully predicted do not produce any prediction error and firing is reduced when an expected reward is omitted (Schultz, 2001). Dopamine neurons respond with a phasic burst to unpredicted rewards or stimuli predicting such reward (Holleman & Schultz, 1998; Schultz & Dickinson, 2000). This initial burst is the teaching signal since as stimuli are learned, dopamine neurons cease to respond and the dopamine burst vanishes as performance is consolidated. Dopamine neurons send their axons to other brain structures involved in motivation and goal-directed behaviour, for example the striatum, nucleus accumbens, and frontal cortex (Schultz et al., 1998). Thus, dopamine neurons code the prediction error that is the teaching signal that will be used as a reinforcer of reward-directed behaviour.

Further evidence that the dopamine system mediates reward learning comes from studies using dopamine antagonists in animals. Dopamine antagonists reduces instrumental responding for rewards to the extent that when dopamine function is impaired animals fail to learn even when primary rewards (such as food) are the reinforcers (Wise, 2004). In addition, studies with dopamine related drugs have provided evidence that dopamine modulates reward prediction errors in the striatum (Pessiglione, et al., 2006).

Role of the Striatum in Value Coding

Midbrain dopaminergic neurons send their teaching signal to the striatum (Schultz & Dickinson, 2000; Hollerman & Schultz, 1998). Involvement of the striatum in reward processing has been shown in neurophysiological (Schultz & Dickinson, 2000; Hollerman & Schultz, 1998) and imaging studies (Pessiglione, Seymour, Flanding, Dolan, Frith, 2006; Valentin & O'Doherty, 2009), that reveal activity in the striatum consistent with prediction errors signal and reinforcement learning.

The striatum is the main input of the basal ganglia (Delgado, 2007) and can be further subdivided into dorsal and ventral components⁵. The dorsal and ventral striatum receive similar projections mainly to the prefrontal cortex, thalamus, and, as previously mentioned, dopaminergic input from the SN and VTA respectively (Delgado, 2007; Haber, 2008). The main difference in projections from the dorsal and ventral striatum is that the ventral striatum receives additional subcortical input from hypothalamus and limbic areas implicated in emotional processing, such as the amygdala (Groenewegen, Wright, Beijer, & Voorn, 1999). The functionality between dorsal and ventral striatum are distinct. The function of the ventral striatum has been involved in predicting potential rewards, whereas the dorsal striatum has been shown to be involved in learning and updating actions that lead to reward (O'Doherty et al., 2004). Thus, striatal neurons mainly code the expectations of rewards in a particular behavioural situation (Schultz et al., 1998).

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⁵ The dorsal area consists of the caudate nucleus and putamen, whereas the ventral area consists of the nucleus accumbens (Nacc) and olfactory tubercle.

Role of the Prefrontal cortex

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Whereas dopamine neurons do not differentiate between different rewards (Schultz et al., 1998), the prefrontal cortex, especially the OFC, is thought to encode details concerning the representation and identity of reward (O'Doherty, 2004; for reviews see Rolls, 2000; 2004; Rushworth & Behrens, 2008). To implement this, the OFC has the necessary structures and connections with other brains areas. The OFC is highly interconnected with the amygdala, ventral striatum and other parts of the PFC implying that it might share common functions with these structures (O'Doherty, 2007). Representations of all the different sensory modalities are found in the OFC. The secondary taste and secondary olfactory cortex are located in the OFC. It also has direct visual input from the inferior temporal cortex, auditory inputs from the superior temporal cortex and somatosensory inputs from the somatosensory cortical areas (Rolls, 2004). This gives plausibility for the involvement of the OFC in associating stimuli with primary reinforcers signalling via taste, touch and odor. Single unit recording (Critchley & Rolls, 1996; Rolls, Sienkiewicz & Yaxley, 1989) and imaging studies (Anderson, Christoff, Stappen, et al., 2003; O'Doherty, Kringelbach, Rolls, Hornak & Andrews, 2001) have shown that neurons in the OFC respond to a particular reward stimulus and when the value of an outcome is reduced by satiety. the neuron response decreases. A correlation between neural response and the value of stimuli has been shown in all the different sensory modalities (O'Doherty, 2007). In addition, the OFC also responds to abstract rewards (such as money) that are not associated to a particular sensory modality (O'Doherty et al., 2001). Neurons in the OFC respond to value for both gains and losses (Hosokawa, Kato, Inoue, & Mikami, 2007).

The OFC also plays a role in the flexible control of behaviour (O'Doherty, 2004; Rolls, 2004). Some neurons in the OFC respond to non-reward, that is, they respond when an expected reward outcome has changed because the association between stimuli and reinforcers has been altered or reversed (Rolls, 2004). Damage to the OFC results in difficulties in reversing responses to stimuli associated with reward or punishment when the contingencies have changed. This implicates the OFC in maintaining flexible representations that are updated following changing contingencies.

Several imaging studies have reported increased BOLD signal for both primary and secondary rewards in the prefrontal cortex (PFC) implicating the vmPFC, dPFC and ACC in reward processing (Haber & Knutson, 2010).

Amygdala

The amygdala has also been implicated in the processing of stimulus reward value (for reviews see Baxter & Murray, 2002; Cardinal, Parkinson, Hall, & Everitt, 2002; Murray, 2007). The amygdala mediates an association between sensory inputs and their affective valence, encoding both positive and negative associations (Paton, Belova, Morrison, & Salzman, 2006). There are strong reciprocal connections between the OFC and the amygdala. The amygdala is comprised of several nucleis and is highly reciprocally connected to many parts of the cortex and sensory areas (Murray, 2007). This suggests that the amygdala has a pivotal function with different regions of the cortex.

Two amygdala nucleis mainly involved in emotional learning are the basolateral amygdala (BLA) and the central nucleus (CeA). The BLA has been

implicated in the representation stimulus-outcome associations and uses this information to control the CeA. The BLA is reciprocally connected with all sensory modalities in the neocortex and frontal lobes and projects heavily to the ventral striatum, PFC and CeA (Cardinal, et al., 2002). On the other hand, the CeA has been implicated in the modulation of arousal and attention as well as influencing conditioned response associations through the hypothalamus, midbrain and brainstem (Cardinal, et al., 2002).

The amygdala is also involved in encoding the representation and updating of visual stimulus value (Gottfried, O'Doherty, & Dolan, 2003). The updating of predictive value functions is carried out in conjunction with the OFC (Murray, 2007). Thus, the amygdala is in charge of affective value associations and can further influence attentional and executive functions through its interactions with the OFC. It thus contributes to making optimal choices based on the current values of predicted outcomes.

Interaction of motivation with cognition

An important principle of reward learning theory states that contingencies create automatic approach towards objects associated with rewards and avoidance from objects unlikely to be beneficial, i.e., we choose actions that in previous experience have resulted in a rewarding outcome and avoid actions that have resulted in punishment. Recent research, and the focus of this thesis, has addressed the question of whether this effect of reward on overt behaviour applies a similar principle in the deployment of attention in humans. Few studies have addressed this question.

Effects of reward magnitude on attention

Influence of attention to a highly rewarding stimulus

Della Libera & Chelazzi (2006) provided evidence that selective visual attention is influenced by the delivery of variable reward. In this study, participants were engaged in an attentional task using a negative priming paradigm. In two experiments, participants were presented with a prime-probe sequence within individual trials. The prime contained a target and a distractor, from which the target had to be identified and the distractor had to be ignored. Correct responses to the prime incurred high (€ 0.10) or low reward (€ 0.01). Participants were misleadingly told that high and low rewards indicated optimal and suboptimal performance, respectively, as a combination of speed and accuracy. However, the level of reward was predetermined and occurred with the same probability (50%) for all conditions. After being rewarded, a probe display (that was never rewarded) was presented. As in the prime condition, participants had to identify a target and ignore a distractor. importantly, the probe target was assigned to one of three priming conditions: (a) attended repetition, in which the probe target was also the target in the prime condition, (b) ignored repetition, in which the probe target was the distractor in the prime condition, (c) control, in which the probe target was different that both the prime target and prime distractor.

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Reward received between prime and probe displays did not affect probe RTs or accuracy in the control condition. Importantly, responses to probe displays showed a significant interaction between reward value and priming condition in both experiments. When the probe target was the distractor in the prime condition

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(ignored repetition), negative priming (longer RT compared to control RT) was observed when high rewards were delivered but was absent with low rewards. In experiment 1, low rewards produced a positive priming effect with responses to the probe target faster than the control condition (this effect was not observed in experiment 2). The results demonstrated that reward influenced visual selective attention. The authors interpreted their results as showing that in every selection and reward feedback, a memory trace is stored and the strength of that trace is modulated by the amount of reward received. Highly rewarded attentional selection would leave stronger and long-lasting traces reflected in greater inhibition being applied to the distractor, as observed in the higher negative priming effect of the high (but not low) rewards. However, this shows the study of the interaction of attention and reward while learning. The effects probe to be sequential effects to what happen in a trial to the next while participants are being rewarded. Whether the stimuli acquired value codes or not was further explored in another study, which tested whether the above reward effects are still present after a delayed period of time.

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In a further study, Della Libera and Chelazzi (2009) explored how durable the effects of reward were in the immediate deployment of visual selective attention and whether the reward effects could generalise across different attentional paradigms. To test this, they presented an experimental paradigm made of two phases: the training phase, in which participants were delivered with rewards for good performance and a delayed test phase, in which the effects of reward from the previous training phase were tested a few days later (in the absence of ongoing rewards). The training phase involved a task in which some stimuli had to be attended or ignored. Similar to their previous work (Della Libera and Chelazzi, 2006),

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correct performance was then delivered with high ($\in 0.10$) and low ($\in 0.01$) monetary outcomes and occurred in 50% of the trials. Some critical stimuli were biased as targets or distractors during training. In addition, the probability of being rewarded was manipulated in the biased stimuli (target/distractor) so that a group of target stimuli received 80% probability of being highly rewarded and 20% of being poorly rewarded (T+) or with 20% probability of being highly rewarded and 80% of being poorly rewarded (T-). There was a similar manipulation with distracting stimuli: some stimuli were rewarded 80% of the times with a high reward and the 20% left with a low reward (D+) and others with a 20% probability of receiving a high reward and the 80% left with a low reward (D-). If these stimuli were presented in the role that was not associated with a bias in the reward schedule (e.g. T+ presented as distractor or D+ presented as target) then high and low rewards had an equal probability of occurrence. Participants completed three training sessions on consecutive days before performing the delayed test session. The results showed that the speed of selecting a target (Experiment 2) or a distractor (Experiment 1) in the test phase was affected by the reward contingencies during training. When an item served as a target selection with high reward (T+) or served as a distractor with low reward (D-) in the training phase, RTs were slower when those stimuli were presented as distractors in the test phase (Experiment 1) and faster when presented as targets (Experiment 2) than (T-) and (D+). Target selection with low reward (T-) was easier to reject when presented as distractors (Experiment 1) and more difficult to select when presented as targets (Experiment 2). These results indicate that selective attention states i.e. selecting and ignoring items, is influenced by the rewarding consequences of prior attentional state of stimuli when re-encountered again. The authors

interpreted their results as suggesting that in every attentional selection there is a memory trace involving information about the specific stimuli, the attentional process previously applied to them and the outcome value associated with it. Therefore, reward can affect the later consequences of selective attentional processing and they are durable when subsequently presented.

In a similar vein, Kristjánsson, Sigurjónsdóttir, and Driver (2010) used points as motivational incentives to targets in a visual search task. Participants were presented with a search display containing three diamond shapes. The task was to respond as quickly as possible whether the target singleton colour (either red or green) had a notch at the top or the bottom. High (10 points) and low (1 point) rewards were assigned to a target colour (red or green) and were counterbalanced across participants. The probability of outcome was also manipulated so that high rewards were obtained in 75% of such trials and the 25% left yield a low reward. The same principle was applied to target colour assigned with low rewards, 75% yield a low reward and the 25% left yield a high reward. Rewards were delivered after correct responses. Participants were instructed that they would be rewarded for fast correct responses but they were not told about the magnitude of values of rewards of As expected, highly rewarded targets showed better specific target colours. performance than low rewarded targets. Interestingly, the benefit of priming of popout effect, i.e. faster RTs when the target's colour is the same in successive trials, was larger for highly rewarded targets than low rewarded targets. In addition, the priming of pop-out effect was further explored from the preceding to the current trial according to the probability of outcome of reward magnitude within conditions. In the

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highly rewarded condition, repetition target trials that had an actual high reward outcome (75% of such trials) were separated from repetition trials that had an actual low reward outcome (25%). The same principle was applied to the low reward condition, repetition targets trials that had an actual low reward outcome (75%) were separated from trials with actual high reward outcome (25%). Results showed that target repetition effects were influenced by the reward level actually received. Priming effects were larger for the high reward condition when the preceding trial had a high outcome (75%) than when it was preceded by a low reward (25%) and were smallest in the low reward condition when the preceding trial had low reward outcome (75%) than when it was preceded by a high reward outcome (25%)(Experiment 1). The modulation effects of reward level on both repetition trials and the actual reward outcome received were also present when the contingencies reversed within a trial block (Experiment 2). This study supports previous findings that targets associated with high reward result in better performance in a visual search task.

Electrophysiological markers of selective attention and reward

Previous studies have identified that detection of targets in visual search tasks might be reflected by systematic modulations of event-related brain potentials (ERPs). If reward influences attention, then we might expect to see differences in the magnitude of these ERP markers on attention elicited by high or low reward magnitudes.

Kiss, Driver, and Eimer (2009) recently reported that search was faster for pop-out targets associated with high rewards. This study used ERP signatures related to visual selection to explore the effects of reward in a visual search task for

colour singletons. Singletons were presented within a circular array of 12 diamonds, each with a notch at its top or bottom. Each array contained one unique coloured target diamond (among 11 grey diamonds) that in half of the trials was red and the other half was green. The array was briefly presented for 150 ms and participants had to report the location of the notch in the target. The critical manipulation was the reward level for red and green targets. Participants were instructed that they could earn a bonus payment by accumulating fast and correct responses. Note, the task did not involve learning since participants were told in advance that fast correct responses to any target of one colour (say red) would give them large rewards (5 points) whereas the other colour (say green) would give them small rewards (1 point) (reward colour was counterbalanced across participants). Moreover, feedback was provided at the end of each block with the total number of bonus points earned in that block. Bonus points for each block were calculated for trials that had both a correct response and a RT faster than the median RT for all correct responses for that block. interestingly in the design of this experiment is that target salience, in terms of bottom-up physical salience, was equated; they differed only in the reward level, therefore, any differences in target selection or response would be expected to be related to reward prioritization.

To examine the time course in which reward can influence target selection, two ERP components were analysed. The N2pc component was used as a marker of visual target selection and it was measured in an early time window (180 to 220 ms). A later ERP component, the sustained posterior contralateral negativity component (SPCN), was used to examine postselection processing. The SPCN is thought to reflect additional processing of target stimuli after attentional selection. This

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component emerges between 350 to 400 ms after display onset. Results showed that processing of visual stimuli was modulated by reward. The N2pc emerged earlier and had larger amplitude for high than for low rewards. This result suggests that reward value influences the efficiency of target selection in early stages of processing. In addition, the SPCN amplitudes were larger for targets with high reward than for targets with low reward suggesting that the influence of reward on visual search extends to post perceptual processing and maintenance in visual short-term memory. However, these results are potentially related to the effects of reward on visual search since the task did not involved learning (participants were told about the stimuli's contingencies) and rewards were not delivered immediately after participants' response, leaving an unclear association of causal effect of reward contingencies on targets. This experiment cannot interpret the SPCN here since is not clear if it reflects expectation of reward or it is related to the motivational value associated with the stimuli.

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In summary, the experiments reviewed above show evidence that the reward magnitude applied to targets enhance performance. However, none of the above studies explored the 'intrinsic' properties of stimuli. By 'intrinsic' I mean a stimulus characteristic indicating a value prediction. This is intrinsic to the stimuli in the same way that an angry face has the 'intrinsic' property of anger. The studies reported above do not provide such characteristics. Instead, the effects reported above explored the interaction of selective attention with a rewarded stimulus in consecutive trials or in a related task. Moreover, reward was only explored regarding its magnitude and none of the above studies explored the effects of valence (reward vs. punishment) or the probability of outcome (vs. no outcome).

In the studies report below, I explore the role of value learning and selective attention using a two-phase strategy. In phase I, stimuli were imbued with a stable value code by participants playing a simple choice game with modest monetary or points outcomes. This method allowed measurement of value prediction codes for each stimulus and each participant by looking at their choice performance during the game task. During the game task, the magnitude of the reward was kept constant, but its valence (win, loss) and its predictability (.80 or .20 probability of outcome vs. no outcome) were manipulated. Crucially and as different from the previous reviewed studies, a few minutes after finishing the game task participants engaged in another task to measure visual attention selection for all these stimuli.

Effects of valence and predictability on attention

Raymond and O'Brien (2009) explored how the effect of value prediction might influence visual cognition under an AB task. The experiment involved two phases. In the first part, participants learned the expected values of a set of neutral novel faces. These values were monetary gain and losses (valence), which varied in the probability of occurrence (predictability). Stimuli were always presented in pairs. Within a stimuli pair, valence was kept constant but the probability of outcome varied. One stimulus had a high probability of outcome whereas its mate had a low probability of outcome. Participants were instructed to maximise earnings but they were not told about the stimuli's contingencies. This procedure aimed to establish in each participant 'intrinsic' value prediction codes for a set of otherwise neutral-value

faces. After completion of the instrumental learning task, these faces were then presented with other novel faces as T2 targets in the attentional blink paradigm (Raymond et al., 1992). Participants viewed a rapid sequence of images with an abstract image (T1) and a face (T2) embedded. T1 targets were abstract visual stimuli requiring a perceptual response (constructed of circles or squares) and T2 stimuli were faces requiring a recognition response (new or old face). Unlike in the learning task, monetary outcomes were not provided. Two interesting effects were found. AB effects were absent for faces associated with gain regardless of its predictability association, whereas faces associated with loss showed AB effects. This indicates that less attentional resources were needed to process gain associated faces, thus escaping the AB effect. In addition, when full attentional resources were present (long lag after the effects of the AB) performance was better for faces associated with high probability of outcome than for low probability of outcome, regardless of valence of that outcome. Using the same reinforcementlearning paradigm, Rutherford, O'Brien & Raymond (2010) explored the effect of value associated irrelevant cues in a spatial orienting task. Cues were associated with gain, losses or no-outcomes and were presented before a target in either cue and uncued locations. The results showed a valence effect on rapid visual orienting. Target RT were slower when the preceding cue presented at the same target location was associated with gain. To account for the results, the authors suggested that when the cue and target are presented in the same location, the cue gains access to processing. Gain associated stimuli gained more access thus slowing target response. This effect was not observed with cues associated with losses in that their gained access to processing did not slow RT to targets.

Top-down influences in face perception

Cognitive and neural models of face perception have suggested that the face perception system represent both the invariant aspects of faces that specify identity together with the changeable aspects of faces that underlies the information that facilitates social communications. These two aspects are believed to work at unison but relatively independently from each other (Bruce & Young, 1986; Haxby, Hoffman & Gobbini, 2000; 2002). Visual analysis and perception of faces is performed in a distributed neural system comprised of multiple bilateral regions. The lateral fusiform gyrus (including the fusiform face area, FFA; Kanwisher, McDermott, & Chun, 1997) is believed to perform the processing of identity, whereas the changeable aspects of faces are mediated by the superior temporal sulcus (STS; Haxby, et al., 2000). Since additional information can be gathered to process the significance of information conveyed from the face, additional regions in other parts of the brain also participate in face perception. For example, parietal regions associated with spatial attention are activated with the perception of eye gaze direction (Hoffman & Haxby, 2000). Moreover, the perception and recognition of facial expressions involves limbic areas that are associated with emotional processing (Adolphs, 2002a,b; Vuilleumier, 2005). Similarly, information about faces is also represented in the OFC. Neurons in the OFC convey information about which face identity is being seen as evidence by different neural responses to different faces. The OFC links sensory representations of faces with their motivational value (Singer, Kiebel, Winston, et al., 2004; Rolls, 2000). The OFC face responsive neurons respond with longer latencies than temporal lobe neurons (130-220 ms. typically, compared with 80-100 ms.). Taken together, activity of additional brain regions in face perception suggests that distinct

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neural circuits might influence the perception of faces. This strongly suggests that face perception is subject to top-down mechanisms. Accordingly, top-down processes may interact with bottom-up sensory analysis to guide face recognition and evaluation.

Imaging studies on fusiform cortex have suggested that FFA activity might not only dependent on bottom-up processing of the physical stimuli but also on top-down Righart, Andersson, Schwartz, Mayer and Vuilleumier (2009) processing. investigated whether top-down influences in face perception is present in patients with face-recognition impairments, a disorder termed prosopagnosia⁶. The authors questioned evidence from previous studies whether FFA activation during standard functional fMRI in developmental prosopagnosic patients could be a bias due to anticipation of face stimuli. If residual activity in FFA were due to anticipation or imagery of face stimuli this would indicate top-down influences in face processing. Righart and colleagues' study tested modulation of preserved top-down biases in FFA activity by instructing participants to detect a face or a house in ambiguous stimuli. They presented pictures of houses and faces with different amounts of noise in three conditions: low noise -where the stimuli was highly visible, high noise where the stimuli was mildly visible, or noise only - no stimuli present at all. Bottomup effects were expected in the high and low noise conditions. Based on the

⁶ Prosopagnosic patients typically fail at recognising faces of familiar individuals and often use nonfacial cues like clothes, hair, and voice to identify others (Bruce & Young, 1986). However, the ability to recognise other nonface objects might be relatively intact (Farah, 2004). Prosopagnosia can result from brain damage, especially in the fusiform gyrus. Another type, developmental or congenital prosopagnosia is present form early childhood in the absence of any neurological basis and the presence of intact sensory and cognitive function.

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expectation of a particular stimulus category, top-down effects were only expected in the only noise condition. This was tested in both healthy participants and a prosopagnosic patient. Of relevance in this thesis, FFA activity was present in the only noise images condition in both controls and patient when instructed to detect a face and absent when instructed to detect a house. The authors concluded that topdown signals might act on the visual cortex and modulate face-specific areas despite severe deficits in face recognition. In addition, FFA activity not only code for bottomup signal but also generates internal representations based on guidelines from higher-level areas when a face is anticipated. Thus, this study provides evidence for top-down modulation in face perception.

However, top-down processing also engages the subject's prior knowledge, sets up expectancies or context and imposes modifications in the processing of incoming face stimuli. For example, top-down processing in face perception also affects social cognition judgements about faces. Previous imaging studies have showed modulation of brain activity in judgements to unfamiliar faces regarding race (Hart, Whalen, Shin, et al., 2000), attractiveness (O'Doherty, Winston, Critchley, et al., 2003), and trustworthiness (Winston, Strange, O'Doherty, & Dolan, 2002). Relevant for this thesis is how top-down signals of prior learned associations modulate face perception. In an imagine study, Singer et al., (2004) investigated the processing of socially relevant cues that acquired their significance through a learning task that involved an interactive Prisoner's dilemma game. Some face stimuli were associated as co-operators, others as defectors and another set of face stimuli were associated with neutral behavioural status (control condition). The results showed that associated learning of social perception and the processing of social perception and the processing of social perceptions and the processing of social perceptions and the processing of social perceptions are perceptioned and the processing of social perceptions and the processing of social perceptions are perceptioned and the processing of social perceptions and the perception of the perception of

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for faces associated with co-operators when compared to the neutral condition. Of relevance here, saliency enhanced brain activity in face processing areas (fusiform gyrus and STS) as well as in emotional (amygdala) and motivational (OFC and striatum) areas. This study shows that prior experience with a face influence brain activity that assists in the processing of such faces as well as in areas that guide behaviour through emotional and motivational associations.

Top-down processing might also modulate the perception of facial expressions. Halberstadt, Winkielman, Niedenthal, Dalle (2009) exposed participants to ambiguous facial expressions (blends of 50% happy and 50% angry). These faces were presented with concepts that either supported processing of the current emotional percept ("angry", "happy"), were relevant (equally valenced) to the emotional percept ("messy", "reliable") or, as a control, were irrelevant to the perception and interpretation of the facial expression images (Chinese ideographs). After exposure, participants performed a memory task in which they were presented with morph movies from which the facial expression images were generated and Sec. were requested to set the movie to the exact image seen at encoding by using a sliding scale. The results showed that concepts with which target faces were encoded influenced how they were encoded and later remembered. Ambiguous facial expressions were seen to be happier when encoded with a "happy" concept and angrier when encoded with an "angry concept". No memory bias was observed in the Chinese ideographs and emotional relevant concept conditions. This suggest that top-down processing can influence the perception of facial expression.

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Overview

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As reviewed in this introduction, when the visual information enters the retina, a series of mechanisms enter into action to facilitate information processing. Re-entry loops originate the mechanisms of bottom-up and top-down processing that initiates three distinct phases in perception: activate (feedforward sweep), predict (feedback sweep) and confirm (stable state of resonance). Selective attention depends on both excitatory and inhibitory mechanisms and these mechanisms are responsive to the state of activation of the perceptual representations on which they act. Top-down signals to targets results in facilitation, whereas top-down signals to distractors results in interference. Examples of top-down signals are familiarity, emotion, and motivation.

The experiments that are introduced in this thesis have two aims. The first aim contributes to knowledge regarding how top-down processing may influence selective attention and social cognition in faces. The effects of top-down processing will be explored in two ways. Chapter 3 investigates how prior attentional states affect the subsequent perception of facial expression under the devaluation effect. Particularly, I will explore how attentional inhibition associated to distracting non-expressive face stimuli affects their subsequent facial expression perception. This will be explored for angry, happy and fearful facial expressions. To preview the findings of Chapter 3, previous attentional states to non-expressive faces interacted with the subsequent perception of facial expressions (Chapter 5) and the effects of visual search (Chapter 6). Firstly, Chapter 4 introduces a value learning task used to

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associate reward value (gain and losses) to face stimuli. This chapter also aims to compare different methodology in the value learning task by comparing data I collected in the laboratory. To preview results from Chapter 5 and 6, prior associated knowledge with a face modulated their subsequent facial expression. Gain associated faces stimuli were seen more expressive in the angry and happy facial expressions. Loss associated face stimuli were seen more expressive in the angry facial expression. In addition, Chapter 6 shows that in a visual search task faster detection were prioritised for faces associated with high predictability of outcome. These studies support for top-down modulation in face and attentional processes.

The second aim of this thesis is to contribute to the methodology in experimental psychology. As reviewed in this introduction attentional effect on facial expression recognition might provide noise in the data that could mislead in the interpretation of such studies. I identify possible sources of noise: Stimulus salience or arousal, subjective relevance, and stimuli properties. A method to control stimuli salience or arousal is provided in Chapter 2. This chapter introduces a method to control and equate for the variability in the facial expression intensity between face identities and facial expressions. An iso-expressive set of faces were created that will be used as controlled stimuli in Chapters 3 and 5. Chapter 4 introduces a value learning task that as well as being used as a method to associate value to face stimuli, provides a method to control the three sources of possible noise.

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Part 2

ATTENTION AND FACE EXPRESSION

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Chapter 2

Creating an "Iso-expressive" face set.

This chapter describes the methodology used to create an iso-expressive set of face images. To do that, psychometric measurements of face expression perception were made using face morphs (e.g., angry-neutral; fearful-neutral; happyneutral) of the same individuals expressing different expressions. Participants judged faces with a range of morph values as neutral versus expressive. The resultant psychometric curves (percent "expressive" response plotted as a function of percent face expression intensity) were used to select approximately equivalently intense expressions for each face and expression dimension in the stimulus set. The new sets of angry, happy and fearful iso-intense face images were then used in the main experiments presented in Chapter 3 and Chapter 5 of this thesis. Facial expressions are considered a core element of the perception and experience of emotions (Ekman, 1993). Emotionally expressive face images have been used as sources of emotional stimuli in a variety of experimental tasks. Studies on emotional research have used different sets of facial expressions images. For example, the most widely used sets are the Ekman and Friesen series (1976), the Japanese and Caucasian Facial Expression of Emotion (JACFEE) and Neutral faces (JACNeuf) set by Matsumoto and Ekman (1988), the Montreal set of Facial Displays of Emotion (MSFDE) by Beaupré, Cheung, and Hess (2000) and the Karolinska Directed Emotional Face database (KDEF) designed by Lundqvist, Flykt, and Öhman (1998). However, these stimuli have never been standardised (but see Goeleven, De Raedt, Leyman & Verschuere, 2008).

As reviewed in Chapter 1, previous studies on emotion have suggested that emotionally expressive face images capture attention more than neutral (nonemotional) face images. However, differences as to which expressions capture attention most effectively have been reported for positive and negative facial expression (angry better than happy: Hansen & Hansen, 1988; happy better than angry or fearful: Juth, Lundqvist, Karlsson, & Öman, 2005; happy and angry better than neutral: Vuilleumier & Schwartz, 2001; angry and happy better than sad and fearful: Williams, Moss, Bradshaw, & Mattingley, 2005). One possible explanation of the contradictory results in the above studies is that they only took into account the valence of the stimuli without controlling the intensity of the stimuli. Therefore, it is unclear whether the above results are an effect of attentional capture among the emotionally expressive face images or whether different emotional intensity in the facial expression face images account for the results (Anderson, 2005; Arnell, Killman, & Fijavz, 2007). Intensity differences could account for what the above studies have reported as an emotional effect.

Here we measured differences in expression intensity across face image identities and facial expression. The primary aim of this study was to standardise a set of face images in their expression intensity across a set of different face identities and facial expressions images.

Methods

Participants

Five students (four female, mean age 19.4) from Bangor University with normal or corrected to normal vision participated in this study. Participants were recruited through SONA and received 1 course credit and £2 in print credits in exchange of participation. Informed consents were obtained prior to participation.

Apparatus

Stimuli were displayed a 22-inch Mitsubishi DiamondPro 2060u monitor of a Pentium 4 computer through the E-prime software (Version 1.5). Participants delivered their responses by pressing the appropriate key on a standard keyboard. The experiment was conducted in a quiet environment in a small room with low ambient illumination, and the participant was left undisturbed to complete the experiment. Displays were viewed at an average distance of 60 cm.

Stimuli

Fourteen individuals (seven males, seven females) were taken from Karolinska Directed Emotional Faces set (KDEF, Lundqvist, D., Flykt, A. & Öhman, A.; Dept. of Neurosciences, Karolinska Hospital, Stockholm, Sweden, 1998). Using Photoshop 7.0, all faces were enclosed in a rectangular frame excluding most of the hair and non-facial contours and converted into greyscale. Each image subtended approximately 4.3° by 5.7° in visual angle (see Figure 2a for an example).



Figure 2.1. Panel a. Example stimuli. Six levels of morph continuum from neutral to angry, neutral to happy, and neutral to fearful for the same identity face where created to obtain average expressive rating in each morph before interpolating the standard z-score value so that expression perception of face images were equated in their intensity. Panel b. Example of a trial.

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For each identity, the neutral face was morphed (using Morpher 3.1) with its corresponding angry, happy and fearful face to generate a continuum of morphs that represented gradual transitions from the original neutral face to the expressive face of the same identity. Six morphs were chosen for each facial expression and for each identity (144 face images) in the transition zone between low expression intensity (10% morph) to high expression intensity (80% morph).

Procedure

The psychophysical method of constant stimuli was used to equate a set of faces in the expression intensity. On each trial, a fixation cross appeared at the centre of the screen for 500 ms. The fixation was followed by a morph which was also presented in the centre of the screen for 300ms (no mask followed the stimulus display). A white screen with a question mark in the centre was then presented until response (See Figure 1b). Morphs intensity and identity were presented randomly across trials on each block. Participants judged each face as "expressive" or "non-expressive" in a two-alternative forced choice (2AFC) technique. Blocks had only one emotional expression (happy, fearful or angry morphs) but presented fourteen different identities. Participants performed four blocks for the angry, four for the happy, and four more for the happy conditions with 168 trials on each. Each morph was rated eight times for each morph face identity, resulting in 2016 trials in total. Before starting the experimental trials, observers performed three practice blocks (one for each emotion and with six practice trials on each), which were identical to the experimental trials.

Data analysis- Responses that were faster than 200 ms were removed from the data analysis. Mean RT for each face and for each emotion (angry, fearful, and happy) was calculated. Responses that were 3 SD faster or/and slower than the mean for a given face and emotion were also excluded from the data analysis. This excluded 8% of trials.

Creating an "iso-expressive" face set

We z-transformed the group mean (see Tables 1.1 and 1.2 for angry, Table 2.1 and 2.2 for happy, Table 3.1 and 3.2 for fearful for a group means per face image identity) probability of an "expressive" judgement for each % morph and plotted them as a function of % morph value. Using a least squares methods, we interpolated the % morph values needed for each face and expression to yield five different response probabilities (expressed as z-scores of -1, -0.5, 0, 0.5, and 1) (See Figure 2). The interpolated morph values were used to create a set of 210 new expression morphs. Thus a 0 z-score face has an expression intensity that should yield 50% 'expressive' judgements, (i.e., guessing, or point of subjective equality) in a two-alternative forced choice expressive/non-expressive task; negative z-scores indicate a face that will be judged more often to be inexpressive than expressive; positive values indicate a face that will be judged more often to be expressive than inexpressive. Thus faces with the same z-score are approximately iso-intense across different face identities and facial expressions. The new sets of angry, happy and fearful iso-intense faces were then created and used in the following chapters as part of the main experiment (see Appendix A for an example of the resulting iso-expressive images).



Figure 2.2. Example of the interpolation process for three different identities in the happy condition. Note, the happy face images on the figure are the original images before equating them for iso-expressioness. This figure plots the *z*-transformation of the probability of reporting a face as "expressive" as a function of morph intensity. Dashed vertical coloured lines indicates the morph value necessary to equate face images to 0 *z*-score in "expressiveness" (horizontal dashed lines). These values (A face image = 39%, B face image = 33%, C face image = 27%) where then used to created the new set of iso-expressive faces.

Discussion

In this study, 14 face image identities with three emotional expressions (angry happy, fearful) from the Karolinska Directed Emotional Faces database (Lundqvist et al., 1998) were equated in their intensity across five different z-score values (-1, -0.5, 0, 0.5, 1). The main finding from this study is that expression intensity of emotionally

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expressive faces varies within and across different emotional expressions and face identities images. Although this thesis does not attempt to answer whether the contradictory results in the emotion research is due to the lack of control in the intensity of the facial expression stimuli, the importance of controlling for this emotional dimension is clear. In this study the iso-intense face images set will be used as controlled stimuli in the following Chapter 3 and 5.

Group Means Tables

Table 1.1 Female Angry - Group mean of proportion of "expressive" response (p) and corresponding z-scores (z) per each % morph in the angry facial expression condition by each face image identity. These group means were used to create the iso-expressive face set. For example in the first face image, group mean for expressiveness are shown when this face was 21% (n = .28), 28% (n = .28), 42% (n = .38), 57% (n = .50), 71% (n = .75) and 78% (n = .68) morphed for expressiveness. To generate the iso-expressive face set, these values where then transformed into z-scores (which corresponding values are shown under the z column). Known z-scores were located in y axis and the morph intensity values in the x axis so that a new y z score (-1, -0.5, 0, 0.5, 1) were then used to interpolate the new morph value needed in the x axis (See Figure 2.2 for an illustration).

	Stimuli Intensity (\phi)											
	21%		28%		42%		57%		71%		78%	
Face	р	z	р	z	р	z	р	z	р	z	р	z
(IE)	.28	-0.60	.28	-0.60	.38	-0.32	.50	0.00	.75	0.67	.68	0.45
3	.33	-0.45	.44	-0.15	.75	0.67	.88	1.15	.88	1.15	.83	0.93
11 A	.35	-0.39	.40	-0.25	.40	-0.25	.55	0.13	.68	0.45	.75	0.67
	.30	-0 52	45	-0.13	.43	-0.19	.68	0.45	.90	1.28	.85	1.04
	.38	-0.32	.35	-0.39	.50	0.00	.68	0.45	.85	1.04	.88	1.15
	.20	-0.84	.38	-0.32	.53	0.06	.78	0.76	.75	0.67	.83	0.93
	.30	-0.52	.25	-0.67	.19	-0.87	.30	-0.51	.48	-0.06	.78	0.76

	Stimuli Intensity (\u00f6)											
	21%		28%		42%		57%		71%		78%	
Face	р	z	р	z	р	Z	р	z	р	z	р	z
CAN IN	.27	-0.61	.47	-0.08	.63	0.32	.60	0.25	.90	1.28	.78	0.76
11	.40	-0.25	.35	-0.39	.70	0.52	.80	0.84	.85	1.04	.85	1.04
(1ct)	.34	-0.41	.33	-0.45	.49	-0.02	.49	-0.02	.78	0.76	1.00	3.09
	.25	-0.67	.25	-0.69	.50	0.00	.61	0.28	.73	0.60	.78	0.76
1 st	.43	-0.19	.85	1.04	.85	1.04	.98	1.96	.98	1.96	.98	1.96
(It a	.33	-0.45	.35	-0.39	.38	-0.32	.50	0.00	.75	0.67	.73	0.60
· ·	.40	-0.26	.35	-0.39	.73	0.60	.90	1.28	.98	1.96	.93	1.44

Table 1.2 Male Angry - Group mean of proportion of "expressive" response (p) and corresponding z-scores (z) per each % morph in the angry facial expression condition by each face image identity.

Table 2.1 Female Happy - Group mean of proportion of "expressive" response (p) and corresponding z-scores (z) per each % morph in the angry facial expression condition by each face image identity.

	Stimuli Intensity (ø)											
_	21%		28%		42%		49%		57%		64%	
Face	Р	z	Р	z	Р	z	Р	z	Ρ	z	Ρ	z
(Ca	.33	-0.45	.47	-0.08	.95	1.64	.93	1.44	.92	1.39	1.00	3.09
	.45	-0.13	.38	-0.32	.81	0.89	.98	1.96	.95	1.64	.94	1.53
(U.)	.28	-0.59	.20	-0.84	.70	0.52	.68	0.45	.88	1.15	.95	1.64
B	.23	-0.76	.43	-0.19	.74	0.64	.90	1.28	.95	1.61	.90	1.28
	.40	-0.26	.50	0.00	.97	1.90	.88	1.15	.98	1.96	.98	1.96
(E .	.43	-0.19	.55	0.13	.81	0.39	.95	1.61	.90	1.28	.98	1.96
	.40	-0.25	.70	0.52	.89	1.20	.93	1.44	.95	1.64	1.00	3.09
Table 2.2 Male Happy - Group mean of proportion of "expressive" response (p) and corresponding z-scores (z) per each % morph in the angry facial expression condition by each face image identity.

	Stimuli Intensity(φ)											
-	21%		28	28% 42%		%	49%		57%		64%	
Face	р	z	р	z	р	z	р	z	р	z	р	Z
Con Con	.25	-0.67	.43	-0.19	.93	1.44	.78	0.76	.95	1.64	.95	1.64
10	.20	-0.84	.25	-0.67	.78	0.76	.93	1.44	.88	1.15	.88	1.15
(1) B	.18	-0.93	.20	-0.84	.62	0.30	.75	0.67	.95	1.64	.85	1.04
B	.45	-0.13	.43	-0.19	.84	1.01	.81	0.89	.88	1.15	.93	1.44
11.3	.38	-0.32	.48	-0.06	.80	0.84	.95	1.64	.97	1.86	.98	1.96
	.13	-1.15	.36	-0.35	.92	1.41	.98	1.96	.95	1.64	.98	1.96
	.13	-1.15	.43	-0.17	.65	0.39	.88	1.15	.90	1.28	.90	1.28

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Table 3.1 Female Fearful - Group mean of proportion of "expressive" response (p) and corresponding z-scores (z) per each % morph in the fearful facial expression condition by each face image identity.

	Stimuli Intensity (ø)														
	28%		28%		42%		57	57%		64%		71%		78%	
Face	Р	Z	Р	z	Р	z	Р	z	Р	z	Р	z			
(C.8)	.35	-0.39	.45	-0.13	.73	0.60	.85	1.04	.78	0.76	.90	1.28			
Pal	.55	0.13	.85	1.04	.90	1.28	.90	1.28	.85	1.04	1.00	3.09			
18 18	.40	-0.25	.75	0.67	.90	1.28	.98	1.96	.90	1.28	.93	1.44			
T	.50	0.00	.70	0.52	.80	0.84	.90	1.28	.80	0.84	.90	1.28			
	.28	-0.59	.40	-0.25	.88	1.15	.93	1.44	.93	1.44	.93	1.44			
	.32	-0.46	.40	-0.25	.60	0 25	.65	0.39	.70	0.52	.75	0.67			
(II)	.35	-0.39	.45	-0.13	.68	0.45	.73	0.60	.73	0.60	.85	1.04			

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Table 3.2 Male Fearful - Group mean of proportion of "expressive" response (p) and corresponding z-scores (z) per each % morph in the fearful facial expression condition by each face image identity.

<u> </u>	Stimuli Intensity (ø)														
	28%		28%		42	42%		57%		64%		71%		78%	
Face	р	z	р	z	р	z	р	z	р	z	р	z			
E.	.48	-0.06	.80	0.84	.93	1.44	1.00	3.09	.95	1.64	.98	1.96			
-	.55	0.13	.85	1.04	.95	1.64	.90	1.28	1.00	3.09	.95	1.64			
610	.28	-0.60	1.00	3.09	1.00	3.09	1.00	3.09	.98	1.96	1.00	3.09			
11-11	.28	-0.60	.40	-0.25	.78	0.76	.83	0.93	.83	0.93	.85	1.04			
6.10	.13	-0.93	.33	-0.45	.65	0.39	.85	1.04	.75	0.67	.85	1.04			
114	.28	-0.60	.32	-0.46	.45	-0.13	.60	0.25	.66	0.40	.78	0.76			
6-T()	.28	-0.60	.35	-0.39	.70	0.52	.80	0.84	.83	0.93	.85	1.04			

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Chapter 3

Attentional effects on face expression perception^{3.1}.

Previous studies have shown that selective attention modulates affective responding (Raymond et al., 2003). The attentional state (attending versus ignoring) that is applied when initially exposed to a stimulus can determine later how that stimulus will be evaluated. Specifically, stimuli that are ignored in an attention task are later devaluated than attended stimuli. A possible explanation for attentional modulation of affective appraisal of stimuli is that prior active ignoring subtly alters subsequent sensitivity to face expression. In this study, participants engaged in a simple but demanding visual search task (to control their attention state) using neutral faces only. Immediately after each search trial, they made a facial expression judgement (using the iso-expressive faces created in Chapter 2) on a face that was either a prior target or distractor. The post-search psychometric functions were then used to reveal whether prior attention modulated the slope or shifted the expression sensitivity functions laterally. The former indicates sensitivity change whereas the later reflects a biasing mechanism. Results for happy, angry and fearful expression will be discussed in terms of attentional modulation of perception in other stimulus domains.

^{3.1} Experiment 3 and 4 in this chapter was presented as a poster at the Vision Science Society (VSS) conference. Gómez-Cuerva, J., & Raymond, J.E. (2007) [Abstract] Attentional modulation of face expression perception. *Journal of Vision, 7* (9):940

Raymond and colleagues (Raymond et al., 2003) report that ignoring produces affective devaluation of stimuli. In their study participants were presented with a two sequential task. The first task involved an attentional task in which participants performed a simple two-item array (one target, one distractor) target-localisation task. This was immediately followed by an evaluation task in which participants evaluated abstract visual patterns (i.e., Mondrians) that were either one of the following conditions: the prior target, the prior distractor, or a novel item (not shown in the attention task), that served as a control condition. The results showed that previously ignored stimuli received more negative evaluations that either the previous target or novel item (which evaluations were not different from each other). This suggested that it was the act of ignoring rather than attending that had clear affective consequences. The authors called this the *devaluation effect* and it was interpreted due to neural inhibition being applied to the representation of the ignored stimulus.

Here we ask whether such inhibition would be applied to face expression analysis mechanisms. If so, then, one would predict that an ignored face might also appear as less expressive. A less expressive face would be affectively less salient and less likely to attract attention. If we found less sensitivity to previously ignored faces, this would demonstrate top-down influences on face expression perception.

To investigate this, I report three experiments exploring whether the inhibitory mechanism applied to distractor faces in a two-item target localisation task have consequences for their subsequent facial expression perception. The basic procedure was the same as used in Raymond et al. (2003). A trial was composed of two sequential tasks: an attentional task inmediately followed by a expression judgement task. In the attentional task, two tinted non-expresive faces (one male,

one female) or places (house, building; for the control codition) were presented. Participants perfomed a gender task and reported the tinted colour of the target face. Inmediately after the attentional task, participants made a face expression judgement (using the iso-expressive face created in Chapter 2). The faces in the expression judgement task was either the previous attended face or the previous ignored face. Attentional modulation of attending or ignoring a face in a visual search task was assessed using a psychometric function. If prior attention enhances facial perception, then we expect to see a left shift in the psychometric curve compared to baseline. If prior ignoring reduces sensitivity to facial perception expression, then we expect to see a right shift in the psychometric curve compared to baseline.

Methods

Participants

Forty-eight students (16 participants for each Experiment) from Bangor University with normal or corrected to normal vision participated in exchange for course and printer credits. Informed consent was obtained prior to participation.

Apparatus

Apparatus was identical to that used in Experiment 5.

Stimuli

Faces used in the attention task were 0 % morphs (i.e. neutral in expression) whereas faces used in the expression judgment task were the iso-expressive faces described in Chapter 2. There were a total of 180 images used: 12 individuals (6 male, 6 female), three expressions (happy, angry, fearful) and 5 morphs for each.

Each face, regardless of the task in which it was used, was enclosed in a rectangular frame (excluding most of the hair and non-facial contours), converted into greyscale, and then resized to 175 x 240 pixels (see Figure 1, panel A). For the baseline condition, an additional set of place images (six houses, six buildings) were used. These were cropped into a squared frame, converted to greyscale, and resized to 200 x 200 pixel array. All stimuli for the attention task, i.e. the places images and the neutral faces, were colourized using JASC Image Robot software. Transparent colour overlays of vellow (hue = 40, saturation = 75), blue (hue = 150, saturation = 50), and green (hue = 70, saturation = 50) were applied to each stimulus. When presented on the screen during the experiment, each images subtended 5.84° x 7.99° of visual angle. For the attention task, images were presented in pairs on the horizontal meridian with the centre point of each 4.83° to the left and right of a central fixation spot. For the expression judgement task, images were always presented in greyscale, alone and centrally, with each image having the same size as the images in the attention task Alphanumeric stimuli (i.e., "+", "Colour?" and "?") appeared in 18point Courier-New font.



Figure 3.1. Panel A. Example of the stimuli used in the two-sequential tasks. As illustrated in Task 1, there were four different kinds of search types used in the experiment: the baseline condition used the house/building search types and the target and distractor conditions used the neutral coloured male/female faces search types. Also, depicts an example of one identity face presented iso-expressive among three facial expressions (Angry, Happy, and Fearful) used during Task 2. Panel B. Example of a schematic illustration of the trial sequence used in the experiment. Trials were started with an attentional task looking for a specific gender face (or house/building in the baseline condition) and report the colour of this face (Blue, Yellow, or Green). Note that in the attention task faces were always neutral. Immediately followed the emotional face expression task were participants judged the expressiveness of a face.

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In the *expression judgement task* participants judged each morph as "expressive" vs. "non-expressive" as a 2AFC. Faces in this later task were presented in three conditions: (1) faces were seen before as targets, or (2) as distractors, or (3) in a baseline (judge a face that has not been seen in the previous attention task) all presented as a within subjects design. Facial expression (angry in Experiment 2, happy in Experiment 3, and fearful in Experiment 4) was presented as a between subjects design.

On each trial, participants performed two sequential tasks: first an *attention task* and then an *expression judgment task*. (see Figure 3.1 panel B). Each trial began with the presentation of a central fixation cross for 1000 ms, followed by a twoitem search array for 200 ms. The search array comprised of two different-category items (i.e., a male and female face; or, on other trials, a house and building), each presented with a different colour overlay to the left or right of a fixation cross. The target category was pre-specified for each block of trials. The task was to report the target's colour (blue, yellow or green). This response was prompted by the presentation of "Colour?" on the screen at the search array offset (and remained there until response). Participants were told to respond via the keyboard using the keys S for blue, D for yellow, F for green with their left hand as quickly as possible.

After a 150 ms blank screen, the fixation cross reappeared for 1000 ms. Then, a single face from the iso-expressive set of faces was presented centrally (in greyscale) for 300 ms. Participants judged the face as "expressive" or "nonexpressive" as fast as possible.

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There were three main conditions: Baseline, Previous Target, and Previous Distractor. In the Baseline condition, the search array always consisted of place images (a building and a house). In the Previous Target and Previous Distractor conditions, only faces were used in the search array. In the Previous Target and Previous Distractor conditions the face identity presented in the expression judgment part of the trial was the same as the target or distractor face, respectively, presented in that trial's search array.

Each face identity, expression, and morph was presented equally as often in the expression judgement task and in a pseudorandom order within each block. Similarly each identity (neutral expression) was presented equally as often as target and distractor in the search array. Half of targets appeared on the right and half on the left. A third of trials had targets in each colour and the corresponding distractors were equally as likely to be in one of the other two colours. Target location, identity and colour combinations were presented in a pseudorandom order within each block.

Experimental triais were conducted in six blocks of 180 trials, resulting in a total of 1080 trials. Different target categories were pre-specified in each block such that there were two blocks with male targets, two with female targets, one with house targets, and one with building targets. To ensure that no stimulus condition was more probable than any other, half the blocks (one male, one female, and either a house or building block) were constructed using a subset of three female and three male face identities. Remaining blocks used the remaining face identities. In this way, each face appeared as target 30 times and as distractor 30 times. Each morph of each face identity was presented four times in each condition (Target, Distractor). Collapsing across face identity, there were thus 24 exposures for each morph z value for each

condition. Baseline block presented each morph of each face four times, again yielding 24 exposures per z-value.

After receiving task instructions, participants completed four practice blocks (one for each search type (males, females, houses and buildings)) with 12 practice trials in each block.

Data analysis

Three participants from Experiment 1, three from Experiment 2 and two from Experiment 3 were excluded for further analysis because they either performed the attention task with less than 70% accuracy and/or their mean search RT was greater than 2 SD than the Experiment mean RT. Only trials in which target colour was correctly reported were analysed. This excluded 8% of the data. In the attention task, mean RT was calculated for each observer for places and faces conditions separately. Trials where the RT was faster than 200 ms or/and above 3 SD longer than the participant's condition mean were also excluded from further data analysis. The same criteria was applied in the emotional judgement task; mean RT was calculated for each observer and trials where responses were faster than 200 ms or longer than 3 SD of the mean were also excluded. This resulted in the removal of 6% of the trials.

Where appropriate, a mixed design analysis of variance (ANOVA) was conducted using attention condition (target, distractor, baseline) as a within factor and Experiment (expression judgement task involving angry facial expression Experiment 1; happy facial expression Experiment 2; or fearful facial expression, Experiment 3) as a between factor. Alpha levels were set at .05.

Results

Attention Task- The group mean RTs in the attention task when faces or places were targets is reported in Table 3.1. A mixed design ANOVA using stimulus type (faces, places) as a within factor and Experiment as a between factor showed that RT was 41 ms faster, F(1,37) = 14.74, p < .001, $\eta^2_p = .285$, for the places than faces search task. The main effect of Experiment F(1,37) = 2.27, p = .117, $\eta^2_p = .109$; and its interaction (F < 1) with stimulus type were non-significant.

		Faces	Places	
Experiment	Facial Expression	M (SD)	M (SD)	
	Angry	776 (129)	730 (92)	
2	Нарру	810 (121)	762 (136)	
3	Fearful	707(129)	676 (112)	

Table 3.1. Group mean RTs for each search type stimuli for each Experiment.

Face Expression Task- Figure 3.2 shows the group mean proportion of "expressive" responses plotted as a function of expression intensity for each attention condition and Experiment. To estimate slope and the point of subjective equality (PSE) for each participant in each condition, the probability of an 'expressive' judgement was z-transformed and then re-plotted as a function of expression intensity. Using the least squares method to fit straight lines to each function (mean r

= .97; r > .92 in all cases⁷), we interpolated the expression intensity value needed to produce a .50 probability of an "expressive" judgement, i.e., the PSE, and slope for each participant and condition.

We then analysed these data using mixed design ANOVAs. For PSE values we found a main effect on Prior Attention, F(2, 74) = 38.60, p < .001, $\eta^2_{p} = .511$. PSE's were lower in the target condition (M= 1.62, SD = 0.07) than in the Distractor (M= 1.64, SD =0.09;p < .005) and baseline (M= 1.68, SD =0.13; p < .001) conditions. PSE for the distractor condition also differed significantly than from the baseline (p <.001) (Bonferroni corrected). This indicates that sensitivity for facial expression perception was higher for faces previously seen as targets compared to baseline. Sensitivity for faces previously seen as distractors were also seen as more expressive than baseline but reduced when compared to faces previously seen as targets. The main effect of the Experiment was marginally significant F(2, 37) = 3.18, p = .053, $\eta^2_{p} = .159$. Mean PSE for the angry condition (M = 1.70, SD = 0.04) was marginally higher than for the happy (M= 1.61, SD = 0.08; p = .081). Other comparisons were non-significant. Interestingly, the interaction between Experiment and Prior Attention was significant, F(2, 38) = 2.766, p < .05, $\eta^2_{p} = .178$.

To explore this interaction in more detail, a repeated measures ANOVA was conducted on the PSE values for each Experiment separately. A significant effect on *Prior Attention* was found for all Experiments [Angry, *F* (2, 24) = 5.345, *p* < .05, η^2_p =

⁷ An ANOVA on *r* values showed a non-significant main effect of Prior attention *F* (2, 74) = 1.128, p = .329, $\eta^2_{p=} .030$; a non-significant Prior attention x Experiment interaction effect (*F* > 1). The main effect of Experiment was significant *F* (2, 37) = 7.64, p < .005, $\eta^2_{p=} .292$. Post-hoc test using Bonferroni corrections showed that the mean *r* for Angry (M= .98, SD=.01) was different than the mean *r* for Happy (*M*= 96, *SD*= .04; p < .05) and Fearful (M= 96, SD= .02); p < .005). However these differences in r value across Experiments are small in magnitude and not especially meaningful. Other comparisons were non-significant.

.380; Happy, F(2, 24) = 9.325, p < .005, $\eta_p^2 = .437$; and Fearful conditions, F(2, 26) = 32.189, p < .001, $\eta_p^2 = .712$]. The PSE thresholds (see dashed vertical lines in Figure 3.2) were lower in the target condition relative to the baseline condition (leftward shift in the psychometric function) for all three Experiments (p < .05 in all cases). This shows that observers were more sensitive to the presence of expression in faces seen previously as targets (regardless of facial expression) than they were in the baseline condition.

This enhancement of sensitivity relative to baseline is also present for faces seen previously as distractors for the Happy and Fearful Experiments (both p's < .05) but was clearly absent for the Angry Experiment (p > .10), The PSE for the distractor condition was not significantly different from that for the target condition in the Happy Experiment (p > .10). However this difference was significant in both Fearful and Angry Experiments (p < .05 both).

A mixed design ANOVA on the slope data showed neither significant main effects nor significant interaction effects (all F < 1).

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Figure 3.2. Mean probability of an "expressive" response plotted as a function of expression intensity for each facial expression (angry, happy, and fearful).

Discussion

Faces seen as prior targets were seen as more expressive than faces not previously encountered on the same trial. The main finding from this set of experiments is that the effect of prior ignoring on sensitivity to face expression varies with the expression being judged. Sensitivity to happy facial expression is enhanced by prior exposure to that face regardless of whether the face was previously the target or the distractor in an attention task. This indicates that independently of the attentional state, prior exposure to a non-expressive face enhances sensitivity to happy facial expression recognition. In contrast, sensitivity to a face's angry expression is enhanced by prior exposure to that face only when the face was attended and reduced to baseline level when the prior face was the distractor. The inhibitory effects applied to the distractor face during the search task reduced the salience of the sensitivity to angry facial expression. On the other hand, sensitivity to feartel faces was enhanced when the prior face was the target and slightly reduced when the previous face was the distractor. The inhibitory effects applied to a distractor face reduces sensitivity to fearful facial perception but this reduction is not that dramatic as the applied to angry faces.

Sensitivity to facial expression in prior targets – Benefit for expression sensitivity of prior attention is similar to the mere exposure effect (Zajonc, 2001). Mere exposure refers to development of a preference for stimuli that have previously being exposed. This preference is characterised by the familiarity that is acquired with the stimuli which results in a perceptual fluency that facilitates processing when the stimuli is later reencountered. Perhaps perceptual fluency effects might have provided facilitation in facial expression perception. As in familiarity effect, familiarity leads to fewer cues being needed to interpret expression thus requires less effort on the part of the expressor to convey emotion to close familiar members. In effect this is a top-down influence of attention on expression perception.

Sensitivity to facial expression in prior distractors – The effects of ignoring were dependent on the emotional facial expression. Sensitivity to happy facial expression was not reduced when the prior face was the distractor. In the devaluation effect, ignoring a distractor stimulus results in devaluation. The results of this set of experiments suggest that it might be harder to devalue a face that expresses positive affect, implying that the devaluation effect might not affect positive events. This extends that the theory of the mechanisms behind the devaluation effect do not always results in devaluation and it depends on the emotional value attached to the evaluated distractors.

Previous distractor faces do not gain any sensitivity in the perception of anger in facial expressions. Sensitivity loss after ignoring a face indicates that angry facial expressions do not get a boost in fluency from the mere exposure effect. Instead, it mirrors the inhibition account suggested by Raymond et al., (2003) of attentional effects on emotion. Inhibitory traits might be assigned to previous distractor faces that resulted in sensitivity loss for angry facial expressions.

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In contrast, previous distractor faces did get a boost with fearful facial expressions, although reduced when compared to previous target fearful facial expressions. This suggests that the inhibitory traits assigned to previous distractor faces were less powerful than the one assigned to angry facial expressions. Angry and fearful faces are both considered negative emotions, so it might be expected to have similar results in their sensitivity to previous distractor faces. However, angry

facial expressions convey change in behaviour whereas fearful and happy faces do not.

This study shows that facial expression sensitivity for faces previously presented as targets or distractors convey two processes working together: a familiarity/mere exposure effect and a devaluation effect. These two processes require cognition suggesting that faces are malleable to top-down processing.

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Part 3

ATTENTION AND MOTIVATIONAL SALIENCE

Chapter 4

Learned Motives

The chapter introduces how a stimulus that has neutral value can become associated with value through instrumental conditioning. I will present the learning paradigm used in the rest of this thesis so that I could investigate how value-laden stimuli affect facial expression perception (Chapter 5) and attention in a visual search task (Chapter 6). In this chapter, I introduce an instrumental learning procedure used as a preliminary task in the following chapters. Details of the methodology that does not adhere to the description below are described in each experimental section for the corresponding subsequent chapter. This procedure, termed value learning, was adapted from Pessiglione et al., (2006) and used under attentional settings in Raymond & O'Brien (2009) and Rutherford et al., (2010) studies. The learning procedure aims to imbue value to otherwise neutral stimuli. This procedure provides an objective and controlled measure of valence and salience of stimuli under laboratory settings. The following chapters aim to measure how value associated codes are processed under different attentional tasks.

The data was collected in the laboratory from a set of different experiments and collapsed together for the purpose of this chapter. Thus, part of the data belongs to the following two chapters. The learning results in the following chapters will have a section regarding the resulted learning performance, as described here but with just their respective participants.

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In this study, two value learning protocols were used. The first protocol uses monetary outcomes whereas the second protocol uses points instead. In addition, the effects of memory on learning will be evaluated by varying the memory demands of the learning task between the two protocols.

Methods: Learning Task

Learning protocol 1: Monetary outcomes (12 faces)

Participants

Seventy-two participants were recruited from Bangor University Student and Community Subject Panels, and from the University of British Columbia in exchanged for course credits or money. Each participant earned £5 or \$5 during the instrumental learning task. All reported normal to correct to normal vision and were naïve to the purpose of the experiment. Informed consent form was obtained prior to participation.

Apparatus

Stimuli were displayed using Pentium computers and generated by E-prime software (Version 1.0; Schneider, Eshman, & Zuccolotto, 2002). Participants delivered their responses by pressing the appropriate keys on a standard keyboard. The display was viewed binocularly from a distance of approximately 60 cm.

Stimuli

Twelve different faces (6 male, 6 female) face images were selected from the Karolinska Directed Emotional Faces image bank (KDEF, Lundqvist, Flykt, & Öhman, 1998). Each face displayed a neutral expression and was enclosed in a rectangular frame (excluding most of the hair and non-facial contours) and then converted into grayscale. Each image was presented against a black background and subtended 3.91° by 5.59° in visual angle (See Figure 4.1a for an example).



Figure 4.1. Panel A - These figures depict an example of gain, loss, and no-outcome stimuli pairs presented during learning protocol 1 and 2. There were six pairs of faces (three males, three females). One pair of each gender was assigned to one condition (gain, loss, and no-outcome). Probability of outcome is shown for each choice. The asterisk indicates the optimal choice (not seen by participants). Panel B shows an example of a trial for the gain condition with the total earnings made so far.

Design and Procedure

This task, a probabilistic instrumental learning task with monetary outcomes, comprised two Valence conditions (Gain, Loss) crossed with two Probability conditions (High: .8; Low: .2) plus a No-Outcome condition. On each trial two vertically arranged faces (Figure 4.1) were presented. Participants were required to choose one with the aim of maximizing earnings. Six possible pairs were used. Pairs were always matched in gender and were assigned to either one of the valence conditions (Gain, Loss,) or to the No-Outcome condition. Two face pairs were assigned to the Gain, Loss or No-Outcome conditions. In the *Gain* and *Loss* conditions one face of each pair produced an outcome (a gain or loss of 5 pens, respectively) with a probability of .8 and its mate with a probability of .2. No outcome was the default. These stimuli pairs produced five different value conditions, each composed of a different combination of Valence (gain, loss) of outcome predictability (high, low): high gain (HG), low gain (LG), high Loss (HL), low loss (LL) and no outcome. This condition served as a control for stimuli exposure. Choice was forced between pairs of faces of the same valence so that an expected value was efficiently imbued. The assignment of faces to stimuli conditions was counterbalanced across participants to avoid image effects (see Appendix B).

The sequence of trial events is illustrated in Figure 4.1b. Each trial began with 1000 ms central fixation cross, followed immediately by a randomly chosen pair of stimuli vertically arranged above and below a central fixation cross. Observers choose the upper face by pressing the 't' key in the keyboard or the lower face by pressing the 'b' key. Note, in this protocol stimuli were presented until the participant responded. After response, the display remained on the screen for 1000 ms along with the outcome and the accumulated score. The trial's outcome (Gain, Loss, or Nothing) was presented on the screen in green, red or black letters, and accompanied by a brief encouraging sound, a discouraging sound or no sound, respectively. The relative position of each face was counterbalanced across trials.

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Each pair was presented 100 times in a self-paced, random order, making 600 trials in total.

Data analysis

Learning for each pair of stimuli was quantified by calculating the percentage of the optimal choice (HG for gain pairs or LL for loss pairs) on 65% or more of the last 30 trials in each outcome pair of the learning task. If performance for a particular pair did not reach this criterion, then learning data average involving those pairs were excluded from further analyses. Additionally, participants that reached the learning criterion but did not explore the contingencies associated to each stimulus within an outcome pair were also excluded from further analysis. Such participants, hereafter called exploiters, only chose the optimal choice in the gain pairs; therefore showing no evidence of learning the contingency associated to the other stimulus.

Results

In learning protocol 1, twenty-seven participants (38%) successfully learned three of the four outcomes pairs; eleven participants (15%) successfully learned two of the four outcome pairs; one participant (1%) successfully learned one of the four outcome pairs; two participants (3%) failed to learn all outcome pairs; remaining participants (thirty-seven) succeeded on learning four pairs. In addition, thirteen exploiters (18%) that showed ceiling performance across all trials in at least one gain pair. For a summary see Table 4.1 in the discussion section.



Figure 4.2 Illustration of the summary results for learning protocol 1. Panel A depicts the probability of choosing the optimal face (HG for the gain pairs; LL for the loss pairs) as a function of 10 trial bin for the gain, loss, and no-outcome condition. Panel B shows overall mean RT participants took to respond for the gain, loss and no-outcome pairs. Error bars represent ± 1 SE of the mean.

As can be seen in Figure 4.2a, participants learned the value contingencies associated with face stimuli above 65% after 20 trial for the gain pairs and 30 trials for the loss pairs. Examination of the mean performance in the last 30 trials showed that gain pairs (M = 87%, SE = 2%) were learned better than the loss pairs (M = 78%, SE = 1%) (t(77)=5.17, p < .001). For the no-outcome condition, an arbitrary selected face in each pair was chosen on 48% (SE = 2%).

Participants choice reaction times (shown Figure 4.2b) differed significantly according to the value assigned to the face pair; F(2, 154) = 101.03, p < .001; $\eta^2_p = .567$. Gain pairs (M = 1276, SE = 73) were chosen 404 ms faster than loss pairs (M = 1680, SE = 90) (p = .001). This is consistent with previous research suggesting that approach responses to aversive stimuli are slowed (Chen & Bargh, 1999). No-

outcome pairs (M = 1559, SE = 89) were 284 ms slower than gain pairs (p = .001) but faster 120 ms than loss pairs (p = .001).

In summary, gain pairs were learned better than loss pairs and choice time differed among the three value pairs, with gain pairs choice being faster than nooutcome and loss pairs; no-outcome pairs being faster than loss pairs. In the next learning protocol, I questioned whether participants' failure to learn (57%) some contingencies associated to face pairs were due to WM might have been overloaded. WM is known to be important in associative learning and it has a limited capacity (Baddeley, 2003).

Learning protocol 2: Points outcomes and memory aid (12 faces)

Participants

One hundred and sixty-one participants were recruited from Bangor University Student and from the Community Subject Panels in exchanged for course credits or money. All reported normal to correct to normal vision and were naïve to the purpose of the experiment. Informed consent form was obtained prior to participation.

Apparatus

Apparatus was the same used as in protocol 1.

Stimuli

Stimuli were the same used as protocol 1.

Design and Procedure

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The design and procedure for the learning task was exactly as in protocol 1 except in the following: The instrumental learning task had points outcomes (instead of money) but the outcome magnitude was kept constant (\pm 5 points in this protocol and \pm 5 pence in protocol 1).





In order to aid memory encoding participants viewed the outcome of their choices along with the stimuli pair used in that trial (See Figure 4.3). In other words, after response, the face display remained on the screen for 1000 ms along with the outcome and the accumulated points made so far. In protocol 1 the stimuli display disappeared and only the outcome and the accumulated earnings were presented for 1000 ms. The rest of the procedure was identical than protocol 1.

Results

From the total number of participants, thirty-eight participants (24%) successfully learned three of the four outcomes pairs; twenty participants (12%) successfully learned two of the four outcome pairs; eight participants (5%) successfully learned one of the four outcome pairs and six participants (4%) failed to learn all outcome pairs; remaining participants (eighty-nine) succeeded on learning four pairs. There were twenty-six participants (16%) showed exploiting behaviour in at least one gain pair. For a summary, see Table 4.1 in the conclusion section.



Figure 4.4. Illustration of the results obtained in the learning protocol 2. Panel a depicts the probability of choosing the optimal face (HG for the gain pairs; LL for the loss pairs) as a function of 10 trial bin for the gain, loss, and no-outcome condition. Panel b shows overall mean RT participants took to respond for the gain, loss and no-outcome pairs. Error bars represent ±1 SE of the mean.

As can be seen in Figure 4.4a, participants learned the value contingencies associated with face stimuli above 65% in less than 20 trials for the gain pairs and 30 trials for the loss pairs. Examination of the mean performance in the last 30 trials showed that gain pairs (M = 88%, SE = 1%) were learned better than the loss pairs (M = 77%, SE = 1%) (t(160)=11.53, p < .001). For the no-outcome condition, an arbitrary selected face in each pair was chosen on 52% (SE = 1%).

As in protocol 1, reaction times (shown in Figure 4.4b) data differed significantly according to the value assigned to the face pair; F(2, 320) = 155.71, p < .001; $\eta^2_p = .493$. Gain pairs (M = 1124, SE = 21) were chosen 312 ms faster than loss pairs (M = 1436, SE = 32) (p = .001). No-outcome pairs (M = 1316, SE = 28) were 192 ms slower than gain pairs (p = .001) but 120 ms faster than loss pairs (p = .001).

Like in protocol 1, gain pairs were learned better than loss pairs and choice time differed among the three value pairs, with faster choice responses to gain pairs than no-outcome and loss pairs; no-outcome pairs being faster than loss pairs.

Comparisons between the two protocols -

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The two learning protocols in this chapter show that participants can learn the outcomes associations to face stimuli. Overall, gain outcomes are learned better than loss outcomes, although this different was small (10%). Response time was faster for gain pairs and slower for loss pairs, when compared to no-outcome pairs. This is in line with previous studies than showed that automatic evaluation (either good or bad) aids behavioural predispositions toward the stimulus. Positive evaluations produce approach tendencies and negative evaluations produce immediate avoidance tendencies (Chen & Bargh, 1999). The pattern of results in the learning protocols supports this automatic evaluation with positive evaluations in gain pairs resulting in faster RTs and negative evaluations in the loss pairs with slower RTs.

Comparison between the two protocols shows that memory aid applied in protocol 2 reduced the percentage of participants (45% compared to 57% in protocol

1) that failed to learn the contingencies associated to face stimuli. Table 4.1 shows the percent of successful learning pair per pairs and protocol. To further examine, if differences in learning rate between protocol 1 and 2 were significant a 3 x 10 x 2 mixed analysis of variance (ANOVA), with learning value type (gain, loss, no-outcome) and trial bins presented as within-subjects variables; learning protocol type (protocol 1 and protocol 2) presented as between subjects variables, was run on the data from both protocols. Of interest here was the main effect of learning protocol type was non-significant *F* (1, 237) = 2.60, *p* > .10, η^2_p = .011; neither its interaction nor triple interaction were significant (all *F*s < 1). Although the memory aid applied in the design procedure in this learning protocol helped to increase learning, this difference did not reached statistical significance. Interestingly, participants were able to learn the value contingencies associated to face stimuli equally regardless whether the outcomes were money or points.

Successful learned pairs										
	Full	3 pairs	2 pairs	1 pair	Fail	Exploiters				
Protocol 1	0.51	0.38	0.15	0.01	0.03	0.18				
Protocol 2	0.55	0.24	0.12	0.05	0.04	0.16				

Table 4.1. Percent proportion of successful learned pairs and exploiters per each learning protocol. Protocol 1 and 2 had four outcome pairs (two gain pairs, two loss pairs).

I further explored the mean RTs between protocols. Table 4.2 shows the mean RTs per condition and protocol. A 3 x 2 Mixed ANOVA, with learning pairs (gain, loss, no-outcome) presented as within subject and protocol type (protocol 1 and protocol

2) presented as between subjects variable showed a main effect of learning pairs; *F* (2, 474) = 248.566, p < .000, $\eta^2_p = .877$. Faster responses to gain pairs and slower responses to loss pairs when compared to no-outcome pairs were consistent in both protocols (see Table 4.2 for a mean RT summary per condition and protocol). Overall, RT responses were faster in protocol 2 (M = 1505, SE = 56) than in protocol 1 (M = 1291, SE = 38); *F* (1, 237) = 1.683, p > .000, $\eta^2_p = .512$. However, the RT magnitude was smaller in the gain pairs (151 ms) than in the loss (244 ms) and no-outcome pairs (244 ms); *F* (2, 474) = 5.319, p > .05, $\eta^2_p = .022$. Changes in the design between protocols aimed to improve WM capacity might have aided learning in protocol 2 as suggested by overall faster RTs. The benefit in RTs was bigger in the loss and no-outcome pairs than in the gain pairs suggesting that gain pairs did not benefit from the memory aid as the loss and no-outcome pairs.

; ; ;	Learning pair							
	Gain	Loss	No-outcome	Ν				
Protocol 1	1276 (650)	1680 (798)	1560 (784)	78				
Protocol 2	1124 (267)	1436 (407)	1316 (575)	161				

Table 4.2 Mean	RTs for successful	learned pairs fo	or each condition	and protocol
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Conclusions and hypothesis

Participants were able to learn the value contingencies associated to stimuli well above criterion (65%). Across the two learning protocols, performance in the last

30 trials was better for the gain pairs than for the loss pairs. Reaction time data was fastest for gain pairs, followed for the no-outcome pairs and slowest for the loss pairs.

Four hypotheses will be tested in the following chapters regarding how imbued value laden stimuli affects their subsequent perception when presented in a different context task: choice, valence, predictability, value.

Hypothesis 1: Choice

Performance will be affected by the choice in the learning task. To achieve the learning criterion, participants will choose the optimal choice (HG, LL) to maximise payoffs, therefore it is possible that the stimuli chosen most often during the learning task will affect performance when reencountered again in a different context task.

Hypothesis 2: Valence

Performance will be affected by the valence (gain, loss) associated to stimuli. If valence drives performance, differences in stimuli associated with gain and lose (regardless of their probability of outcome) will be observed.

Hypothesis 3: Predictability

Performance will be affected by differences in the associated predictability of an outcome (high, low). If predictability drives performance then differences between stimuli associated with high or low probability of outcome (regardless of valence) will be observed.

Hypothesis 4: Value

Performance will be affected by any stimuli associated with an outcome when compared to a no-outcome stimulus.

In the following chapters, I presented experiments that investigated how learned value can affect subsequent facial expression perception, spatial attention task.

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Chapter 5

Reward effects on face expression perception.

Chapter 3, I provided some evidence for top-down effects in facial expression perception according to the previous attentional state to these faces. In this chapter I further explore how prior associative history with a face affects their subsequent facial expression perception. To test this, I present one experiment with a two-phase design. In phase I, participants engaged in an instrumental learning task aiming to imbue different values to non-expressive faces (Chapter 4). Phase II was initiated just immediately after the learning task was completed. Participants were repeatedly presented with a horizontal two-face array. Faces were different two identities but matched in their emotional intensity (Chapter 2). Crucially, each face had a different associated value. Participants task was to state which face (left, right) was more expressive. The results showed that faces associated with gain boosted their facial expression perception.

Facial expressions are widely acknowledged as a means of communicating emotion and the behavioural intentions of an individual. They are essential for interpersonal communication, thus constituting a powerful tool in social cognition. Two major views give explanations of how facial expressions are processed and perceived. The discrete-category view (Ekman, 1992) posits that there are six basic facial expressions of emotion that are universal (anger, happiness, fear, surprise, disgust, and sadness). Accordingly, facial expressions of emotion are easily categorized and are interpreted as a signal with accurate information. In the extreme formulation of this view, facial expression processing is purely in a bottom-up fashion and cannot be affected by their context (Ekman & O'Sullivan, 1988). The dimensional view of emotions stands in contrast to theories of basic emotions (Russell, 1980; Posner, Russell, & Peterson, 2005). Facial expressions are not categorised directly into specific emotion categories, but rather emotions arise from a complex interaction between cognitions and two neurophysiological systems, one related to valence and the other to arousal. In addition, emotions are believed to be organised and summarised into a cognitive structure, which would assists to resolve the perception and interpretation of a specific event. Therefore, according to the dimensional view, emotions are the result of activations of these two neurophysiological systems, together with cognitive interpretations and their corresponding labelling. This view allows for some top-down information from the perceiver to interpret and disambiguate emotional expressions.

Here, like in Chapter 3, I would like to further explore the effects of top-down processing in facial expression perception. In the previous Chapter, I explored the immediate role of prior attention on sensitivity to facial expression perception; here I
examine how acquired value in a face might influence the interpretation of facial expression. If facial expressions are subject to top-down processing then prior affective associations with a face might alter facial expression interpretation.

Through our experience with the environment, human beings build affective evaluations to others. For example, a specific identity may predict positive or negative values based on previous associations with that individual. The brain has a neural circuit that continually updates our evaluation of certain individuals according to our experience with them (Gottfried and Dolan, 2004). The neuronal mechanism by which these evaluations are constructed might be coded by the amygdala and the fusiform gyrus (Petrovic, Kalisch, Pessioglione, Singer, & Dolan, 2008). In Petrovic et al., (2008) study, face evaluations were altered by pairing faces with shocks (except a control condition in which faces received no shocks), while brain activity was recorded using fMRI. As a behavioural measure, participants rated how sympathetic they perceived the faces before and after conditioning. The results showed that affective value to faces changed after conditioning. Faces paired with shock were rated as less sympathetic whereas faces paired with no shock were rated as more sympathetic. The effect of conditioning was further assessed with skin conductance response (SCR) by comparing the first and second interval response. Skin conductance response was larger for faces associated with shock than for faces associated with no shock in the second block and than in the first block, supporting a learning effect in the affective value of faces. Interestingly, the change in face value, measured in a Q learning model, was correlated with activity in the amygdala and the fusiform gyrus. As subjective value to faces associated with shock was decreasing activity in these regions increased, suggesting that learning emotional evaluations

about faces was supported by both the amygdala and fusiform activity. This study provides evidence that affective ratings to a neutral face can change after being associated with an outcome.

Here I report one experiment exploring whether changing the affective values to a face would change their subsequent facial expression perception. To investigate this, we used a two-phase approach similar to the one used in Raymond and O'Brien (2009). Phase I comprised an instrumental learning task with outcomes (described in Chapter 4, Experiment 1, protocol 1). During this phase, face stimuli were imbued with different value expectations: gain, losses with different probability of outcome (.8 and .2) and a control condition that always produced no-outcomes. Note, faces during the learning task were always presented with a neutral expression.

In Phase II, participants were presented with a horizontal two-face display with different identifies but equated in their expression intensity. These faces were the same identity faces presented during the learning task but expressing angry or happy facial expressions. The two-face display were always matched in the facial expression but differed in the value assigned. Participants were asked to report which face (left or right) was seen as more expressive.

Within this task, there are two processes that can drive performance: the impact of the emotional valence of the facial expressions (happy, angry) and the value associated to them (valence, predictability). On this basis I make the following predictions: If the emotional valence of facial expressions impacts performance, I then predict that happy faces will be perceived more expressive than angry faces. Happy faces have previously been reported to act as social primary reinforcers (Averbeck & Duchaine, 2009; Shore & Heery, in press) whereas communicating

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anger is likely to be punishing (not rewarding). If associated value to faces and facial expression interact then I predict an asymmetrical effect with happy faces perceived as more expressive when associated with gain rather than loss outcomes and the angry faces perceived more expressive when associated with loss rather than gain outcomes. If value associations have a dominant role in perceiving facial expression, then I predict that faces associated with gain will be perceived as more expressive regardless of facial expression.

Methods

Participants

Twenty four adults (21 females; mean age 21 years) recruited through Bangor University participated in exchanged for course credits. In addition, participants earned 25 during the learning task. All reported normal to corrected to normal vision and were naïve to the purpose of the experiment. Informed consent form was obtained prior to participation.

Apparatus

Stimuli were displayed a 22-inch Mitsubishi DiamondPro 2060u monitor (32-bit true colour; resolution 1280 x 1024 pixels) and generated by E-prime software (Version 1.0; Schneider, Eshman, & Zuccolotto, 2002) using a Dell computer. Participants delivered their responses by pressing the appropriate keys on a standard keyboard. The display was viewed binocularly without head support from a distance of approximately 60 cm.

Stimuli

Stimuli in the learning task was the same as used in Experiment 5 protocol 1.

Stimuli used in the emotional judgement task, were the iso-expressive faces created in Chapter 2.



Figure 5.1. Stimuli used in the experiment. Panel A. Example of the stimuli used in the Learning task which was always presented with a neutral facial expression. Panel B. Example of the iso-expressive stimuli used for the happy and angry conditions in the Emotional Judgement task along with its z-score value.

Design and Procedure

Phase I – Instrumental learning task.

The procedure was identical to that used in Experiment 5, protocol 1.

Phase II – Emotional Judgement Task

This task was initiated after participants completed the learning task. As illustrated in Figure 5.2, a trial began with a fixation cross presented for 1000 ms followed by a 600 ms horizontal two-face array with faces arranged on either side of

a fixation cross against a black background. After offset, a black screen with a "?" appeared and remained until response. The task was to indicate which face (left, right) was more expressive. The "n" key (for left) and the "m" key (for right) were used to report choice. Face images were always two different face identities with the same facial expression (both angry or both happy) equated in expression intensity (i.e., were iso-intense morphs). However, each differed in its just previously learned valence and predictability association.

Three kinds of stimulus pairs were presented. Standard pairs comprised one face with a Neutral valence association and the other with a value association, thus making four types of Standard pairs (HG versus N, LG versus N, HL versus N, LL versus N). The location of the neutral face was counterbalanced across trials. The probability of choosing the value associated face for each facial expression and intensity combination was calculated for each type of standard pair. Competition pairs had faces with the same Predictability associations but different Valence associations: i.e., HG versus HL and LG versus LL. The location of the Gain face was counterbalanced across trials. The probability of choosing the gain associated face for each facial expression and intensity combination was calculated for each type of competition pair. For Standard and Competition pair types, an equal number of trials presented faces at each of the five expression intensity levels. Filler pairs, the third pair type, comprised faces not matched in expression intensity although matched for gender. In these pairs, a maximally expressive face image was paired with a second to lowest intensity face image. The probability of choosing the face with the higher zscore label was calculated and used as an index of good performance. Filler trials were used to encourage the participant and to index engagement in the task but were not further analysed.

There were in total 672 experimental trials, 320 Standard pairs, 160 for the Competition pairs and 192 Filler trials, presented in two blocks of 336. Half the trials had angry expressions and the rest had happy expressions. The presentation order of Pair type expression, and expression intensity was pseudorandomized for each participant for each block. In total, each face was presented 20 times in the whole experiment. The experimental session was preceded by 12 practice trials.



Figure 5.2. Example of a trial in the emotional judgement task. After a fixation cross, participants were presented with two paired faces that were matched in emotional intensity expression and facial expression. Face images differed in identity and value-laden associations. Participants were required to state which face (left or right) was perceived as more expressive.

Data Analysis

From the Expression judgement phase, data from three participants were excluded since their mean probability of correctly choosing the highest expressive face in the Filler type trials was lower than < 60%. Overall, participants were 79% correct. The mean RT was calculated for each participant. Trials with anticipation responses (RTs < 200 ms) and slow responses (3 SD above the mean RT per subject) were excluded from the data analysis. This accounted for 2% of the data.

The resultant selected trials from the expression judgement phase were used in the subsequent analysis of variance (ANOVAs) if participant demonstrated learning. For the learning phase, the mean proportion of trials in which the optimal choice (high probability of gaining and low probability of losing) was chosen during the last 30 trials was calculated for each participant and face pair. Learning was achieved if this value was 65% or greater. If this criterion was met for both gains pairs and both lose pairs, then data from the expression judgement task from each pair were averaged; if only one pair was learned to criteria, there only data from the successfully learned pair was used. Repeated measures ANOVA with the proportion of choosing a value laden face as being more expressive used valence (gain/loss) and motivational salience (high/low) as factors. Single group t-test was used to compare if the means per each condition were different from chance (.50). Additional corresponding ANOVAs using facial expression (happy, angry) and intensity (-1, -0.5, 0, 0.5,1) were also conducted. Alpha levels were set at .05. Within-subject SE was calculated using the methods of Cousineau (2005).

Results

Value Learning.

Twenty-four participants demonstrated learning. Learning performance showed that the outcome contingencies for gain pairs were learned better than those for loss pairs, F(1, 20) = 39.19, p < .001, $\eta^2_{p} = .662$. For the gain pairs, faces highly predictive of outcomes were chosen on average on 91% (SE = 1%) of the last 30 trials; for the loss pairs, the less predictive faces was chosen on 80% (SE = 1%) of the last 30 trials; for the Neutral condition, an arbitrarily selected face was chosen on 51% (SE = 0.1%) of the last 30 trials.

Face expression task.

We first analysed expression intensity choices obtained with the Standard pairs (where a value learned face was paired with a no-outcome face, here after called neutral). Figure 5.3 shows the group mean probability of choosing the face with non-neutral value associations for each value association condition. Repeated measures ANOVA was performed on the probability of choosing the non-neutral face using Facial Expression (Angry, Happy), Valence association (Gain, Loss), Predictability association (High, Low) and Expression Intensity (z-scores of -1.0, -0.5, 0.0, 0.5, 1.0) as factors. A main effect of Valence [F(1, 23) = 16.295, p < .005, $\eta^2_{p} = .415$] indicated that participants were more likely (M = 0.60, SD = 0.16) to choose a face associated with gain (over a neutral face) than they were to choose a face associated with loss (over a neutral face). For the other trial types performance was at chance (M = 0.51, SD = 0.16). Other main effects and interactions were not

different (all p's > .12), except for a marginal significant Predictability x Intensity interaction, F(4, 92) = 2.110, p = .086, $\eta^2_p = .084$, which revealed that the effect of predictability varied with the expression intensity of the stimuli. The choice for high predictability of outcome stimuli grew stronger as the emotional intensity of faces increased. Choices made when the value laden faces were the lowest intensity of facial expression (morphs with *z*-score values of -1.0) were not different than chance (M = 0.52, SD = 0.08; (t (23) = 1.06, p > .05) regardless of predictability association. This suggests that participants were uncertain to state if a face was more expressive than another if there was not a clear intensity in the faces. Data from the lowest expression intensity point (-1 *z*-score) was therefore removed. This and all subsequent analyses were collapsed across the significant intensity points.

An ANOVA on Facial Expression (happy, angry), Valence (gain, loss) and predictability (high, low) revealed a main effect of Valence. Although the main effect of Facial Expression was non-significant (F < 1), its interaction with Predictability association was marginally significant, F(1, 23) = 3.20, p = .087, $\eta^2_p = .122$. To examine these effects, separate repeated measures ANOVAs using Valence (Gain/Loss) and Predictability (high/low) as within factors were conducted for each Facial Expression (See Figure 5.3). For the Happy condition, we found a main effect of Valence, F(1, 23) = 13.55, p < .005, $\eta^2_p = .417$. Faces with gain associations were more likely to be chosen as the more expressive face (versus a Neutral face) (M = .61, SE = .02) than faces with loss associations (M = .53, SE = .02). Single groups t-test revealed that choice for gain associated stimuli, independently of the associated predictability, were better than chance level (HG = 0.63, SD= 0.19, (t(23) = 3.45, p < .05); LG = 0.59 SD= 0.17 (t(23) = 2.75, p < .05), whereas choice for loss associated

stimuli remained at chance level (both p > .05). Neither the main effect of Predictability nor its interaction with Valence were significant, (both *F* 's < 1).



Predictability of Outcome

Figure 5.3. Mean probability of choosing a value-laden face versus a non-value laden face for happy (above) and angry (below) facial expression. Standard pair condition involved pairing a value-learned face (valence and predictability of outcome) with a No-outcome face. Conditions that reached significant level above chance are indicted with an asterisk. The horizontal dashed line indicates 50% chance. Error bars represent ±1 within subjects SE.

A similar analysis of data obtained in the Angry condition also showed a main effect of Valence F(1, 23) = 8.738, p < .05, $\eta^2_p = .275$. In contrast from the Happy condition, choice involving Angry faces resulted in a main effect on Predictability, F(1, 23) = 5.55, p < .05, $\eta^2_p = .194$. Single group *t*-test revealed that only the performance on the HG condition was above chance level (M = 0.66, SD = 0.12, (t(23) = 6.64, p < .05). The Valence x Predictability interaction was non-significant, F(1, 23) = 1.43, p = .24, $\eta^2_p = .058$.



Figure 5.4. Mean probability of choosing the "gain" face for each facial expression, collapsed across predictability (High, Low) and emotional intensity. The competition condition comprised two paired faces that matched in probability of outcome associated to a stimulus of but differed in valence (HG vs. HL; LG vs. LL). The horizontal dashed line indicates 50% chance. Conditions that reached significant level above chance are indicted with an asterisk. Error bars represent ±1 within-subjects SE.

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For the data obtained with Competition pairs⁸ (HG vs. HL; LG vs. LL), we calculated the probability of choosing the gain associated face as more expressive than the loss associated face for each facial expression. A 2 (Facial Expression: angry, happy) x 2 (Predictability of outcome: high, low) repeated measures ANOVA showed a marginal main effect of Facial Expression F(1, 21) = 3.481, p = .08, $\eta^2_p = .142$. As illustrated in Figure 5.4, the probability of choosing the gain associated face was significantly above chance for both happy (t(21) = 2.85, p < .05) and angry (t(21) = 2.09, p < .05) conditions, but it was higher in the happy condition (M = .60, SD = .17) than in the angry condition (M = .56, SD = .14). Neither the main effect of Predictability (F < 1) nor the Facial Expression x Predictability interaction (F < 1) were significant.

Discussion

In this study, participant learned the value association of valence (gain, loss), predictability (high, low), or no-outcome with non-expressive faces. These faces were immediately presented to participants in a two expressive face-array and state which face was more expressive (left, right). Faces were two different identities from the previous learning task that matched in their expression intensity and facial expression but differed in the value associated to them. The results show that facial expression perception is malieable by prior associations with a face. Overall, there was a special bias towards faces associated with gain outcomes to appear "more expressive" when compared to faces associated with no-outcome or loss outcomes,

⁸ Two participants more were removed in the competition conditions as there was not enough data from them.

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regardless of their facial expressions. There was a conjoint bias with gain associations enhancing facial expression in the happy condition. This is in line with previous studies that showed that participants have a preference to choose happy faces relative to angry faces even when the financial feedback was unfavourable (Averbeck & Duchaine, 2009). In their study participants learned which of two faces was associated with a higher probability of reward. One face was associated with a .60 probability and its mate with .40 probability of outcome so that the best optimal choice was the face associated with highest probability of outcome. Both faces were the same identity face but differed in their facial expression: one face had a happy expression and the other had an angry expression. The association of high reward and low reward with the happy and angry face was counterbalanced across participants. The results showed that participants preferred to choose the happy face to the angry face even in the conditions were the happy face was not associated with the optimal choice. This mirrors previous conceptions about social cues that state that smiles carry reward value. Smiles are often associated with positive outcomes whereas expressions of anger are not.

The present study extends these findings in the following ways. The impact of emotional valence of the faces did not affect performance, as happy faces were not seen more expressive than angry faces. The results of the present study might be related to the function of approach (present in the happy and gain outcomes) versus avoidance (present in the angry and loss outcomes) cues. First, the results show that faces associated with gain outcomes were seen happier relative to loss and nooutcome associated faces. This resulted in a congruency effect as both gain associations and happy expression elicit an approach behaviour that resulted in

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facilitation in expression perception for the happy condition, as evidenced by both high-gain and low gain conditions being more expressive than chance (See Figure 5.3). However, there was an incongruency effect in the angry facial expression with only HG (but not LG as in the happy condition) faces seen angrier when associated to gain (instead of loss) outcomes. This suggests that the effect of avoidance associated with an angry face might be reduced by the gain contingencies associated to those faces. Perhaps the impact of gain associations to a face overcomes avoidance behaviour associated with a angry face when reencountered again for anger judgement that results in perceiving an angry face angrier when associated with gain outcomes. In addition, in the angry condition there was a predictability effect, suggesting that faces associated with HL were seen angrier, however this effect did not reach significance from 50% chance performance.

Dominance of approach behaviour elicited by gain associations was further supported by the results obtained in the competition condition (when the comparisons were between a gain versus a loss associated face with the same probability of outcome). Faces associated with gains were seen as more expressive that faces associated with losses, regardless of facial expression but the effects were larger in the happy (conjoint bias) than in the angry facial expression.

This study shows that facial expressions are susceptible to top-down influences from associated outcomes to those faces. The value associated with a face had an effect on participants' facial expression perception. This is in line with the dimensional view of emotions (Russell, 1980; Posner, Russell, & Peterson, 2005) in which state that some cognition interacts in the perception of emotion.

Chapter 6

The effects of reward in visual search⁹

This chapter explores how previously acquired value codes to face stimuli affects visual search. Previous research has shown that learned reward and loss value of stimuli can yield a selection advantage even in tasks where these contingencies are contextually absent. This was tested in two experiments that had a two-phase experimental design. In Phase I, participants learned to associate faces with gain, loss, and no outcome (Chapter 4). In phase II, learned faces were presented as targets in multi-item arrays. During the task, all stimuli had equal task relevance but differed in their associated reward value. In the search task, participants searched for a face defined by gender and reported whether a line of dots (present on each face) was on the left or right. In a second experiment we explored how the reward signal influenced bottom-up and top-down processing. The results showed that target faces associated with high probability of outcome, regardless of valence were detected faster than faces associated with a low probability of outcome.

⁹ Experiment 8 in Chapter 6 was presented as a poster at the Vision Science Society (VSS) conference. Gomez-Cuerva, J., Enns, J. & Raymond, J. (2009) Expected value of stimuli enhances visual search but does not affect rapid resumption. *Journal of Vision, 9* (8), 1178.

In this Chapter, I aim to explore how the reward signal affects the different stages of attentional visual processing. Bottom-up and top-down processing has been widely investigated in the visual search paradigm. During visual search, bottom-up processing is automatic and involves early preattentive processing whereas top-down control of target detection is exerted by the defining properties of the target, which favours competition for further processing. As reviewed in Chapter 1, top-down signals generate hypothesis-testing that when corroborated with low-level signals produce a response. One way to investigate the facilitation of top-down processing in hypothesis-testing is by interrupting exposure to the visual search array and then measuring the response time to detect a target after the interruption (Lleras & Enns, 2005).

Interrupted visual search

In a visual search task, target detection is achieved using iterative loops of bottom-up and top-down signals. Interrupted visual search has been used as a technique to explore and separate such signals (Lieras, Rensink, & Enns, 2005). In a typical design of an interrupted visual search task participants are presented with repeated search displays, each 100 ms ("look" episode) that are interrupted by blank displays, each 900 ms ("blank" episode). Look and blank displays are presented successively until the observer responds (See Figure 6.2b for an example of the procedure). Consequently, in a tipical trial participants are exposed to brief glimpses of alternate search arrays and blank displays. To evaluate participants ability to respond in this interrupted visual search task, Lieras et al., (2005) used the term *epoch* to refer to the time between the onset of the visual array plus a blank display (100 ms search display + 900 ms blank display = 1000 ms epoch). The term epoch 1

refers to reponses made in just one single glance of the visual array, epoch 2 refers to reponses made with two views of the visual array and so on for each successive cycle of visual array and blank display. Several types of responses were observed with interrupted visual search. First, a low percent of responses were made with just one single look and were initiated after 500 ms. The authors interpreted this results as the time needed to initiate visual search. Second, in the successive displays after epoch 1, reponses ocurred within 500ms (as well as after 500ms). This propensity of unusual fast responses after display interrumptions are called *rapid resumption* and are used as an index of benefit of having begun the search prior to its interrumption. Figure 6.1 shows an example of RT distributions for epoch 1 and for collapsed subsequent epochs.



Figure 6.1. RT distributions of correct responses in a interrupted search task. Panel A shows RT distributions for epoch 1. Note that responses are initiated after 500 ms after display array onset. Panel B presents the RT distributions following all subsequent presentations. This graph shows a binominal distribution with unusual RT made in less than 500 ms. Adapted from Lleras et al (2005).

As Figure 6.1 B shows, not all responses following interruption were fast. There were two phases in responding: an early phase within 500 ms window with rapid resumption response and a later phase with responses made after 500 ms

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indicating a <u>normal search</u> response. This ability to rapidly resume a search may reflect the use of a perceptual prediction mechanism by feedforward and recurrent processing in attentive vision (DiLollo, Enns, & Rensink, 2000). The general idea is that if a perceptual hypothesis is formed about a search array, removal of the array does not terminate the generation of the feedback signal associated with that array. If the array is then re-presented after a short interval, the perceptual hypothesis is still available and can be used to speed target detection. In the first feedforward sweep information about the target is extracted implicitly. This information becomes explicit once a perceptual hypothesis is formed, then confirmed with low-level areas, and finally producing a response. Therefore, the interrupted visual search design provides a tool to selectively disrupt the processing loop and test the stage of processing at which top-down signals enhance target detection.

The interrupted search task is a convenient way to test for the presence, and relative contributions, of the potential influences of reward learning on search. This is because it offers several measures of the search process that differentiate those influenced by bottom-up and top-down contributions to display salience. If reward affects stimulus salience to the extent as to affect bottom-up processing then this process should be evident in responses with a single glance (epoch 1). If reward enhances top-down influences in the formation of hypothesis testing, then we should observe differences in the rate of rapid resumption responses among targets associated with reward outcomes versus targets associated with no-outcomes.

In the present study we explored the influence of recently learned rewardassociations on the efficiency with which items could be identified in a visual search task. The specific focus of the current study was to explore whether changing the strength in top-down signals affects the speed of target detection.

Experiment 7 uses a standard visual search task to establish whether value associated codes to faces affects visual search. Experiment 8 uses an interrupted visual search task to explore in which stage value codes aids processing.

Experiment 7 – Visual Search

5.1

Experiment 7 aimed to evaluate whether associated reward values for a target modulate search times in visual search. Several lines of evidence support the idea that the attentional competition between objects in a scene is biased by top-down signals that include associations to long term memory (familiarity, reviewed in Chapter 1), instructions (goals), and motivation (reward, reviewed in Chapter 1). For example, it seems that, in general, familiar objects hold a competitive advantage over unfamiliar objects in the control of atientional selection (Jackson & Raymond, 2003). This competitive advantage in processing has also been reported for stimuli associated with reward (Kiss et al., 2009; Raymond & O'Brien, 2009). Raymond & O'Brien (2009) presented stimuli associated with outcomes as T2 targets in an AB task. Face images were associated with gain or losses with a different probability of outcomes (high, low). In addition, there was a control condition for exposure in which: the face stimuli always received no outcomes. The later study showed that T2 target recognition was better for faces associated with high probability of outcome regardless of valence (gain, loss) and attentional demands. Note, that all faces in this study, regardless of their prior value association, were equally task relevant in the

recognition task, and therefore should have engaged top-down processing similarly (Desimone & Duncan, 1995).

In the experiments I report here, I use a similar approach as in the Raymond & O' Brien (2009) study. In phase I, face stimuli were imbued with different associated values as reported in Chapter 4. In Phase II, initiated immediately after the learning task was finished, participants engaged in a visual search task were these stimuli were used as targets. Participants searched for a gender singleton and report the side (left, right) of a dot strip of the target (which were also present in all the distractors). To measure the effects of familiarity, novel faces (i.e. not seen in the previous learning task) were also included as targets. Distractors were always novel. All targets had the same task relevance but differed in expected value (except the novel condition). Any target detection differential effect on response time indicates differences in how the top-down mechanisms influenced visual search. Based on the results of the above studies and in animal learning literature (Mackintosh, 1973), 1 predict that stimuli associated with high probability of outcome (regardless of valence) might facilitate target detection in a visual search task.

Methods

Participants

Forty-nine students (25 females; mean age 20 years) from Bangor University participated in exchanged for course credits. All reported normal to corrected to normal vision and were naïve to the purpose of the experiment. Informed consent forms were obtained prior to participation.

Apparatus

Stimuli were displayed using Pentium computers and generated by E-prime software (Version 1.0; Schneider, Eshman, & Zuccolotto, 2002). Participants delivered their responses by pressing the appropriate keys on a standard keyboard. The display was viewed binocularly from a distance of approximately 60 cm.

Stimuli

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Faces used in both phases of the experiment were selected from the Karolinska Directed Emotional Faces image bank (KDEF, Lundqvist, Flykt, & Öhman, 1998). Each face displayed a neutral expression and was enclosed in a rectangular frame (excluding most of the hair and non-facial contours) and then converted to grayscale. Each image was presented against a black background and subtended 3.91° by 5.59° in visual angle (See Figure 4.1 in Chapter 4 for an example). Twelve different faces (6 male, 6 female) were used in the learning task, an additional 56 faces (28 males, 28 females) were used as novel faces in the visual search task. When presented in the visual search task, a thin vertical strip (19° x 59° in visual angle) of fine white random dots was superimposed on the left or right side of the face covering its full vertical length. (See Figure 6.2 for an example). The visual search display always consisted of 10 face images (target plus nine distractors).

Wait

A- Experiment 7: Visual Search



B- Experiment 8: Interrupted Visual Search



Look 200ms

Figure 6.2. Procedure for Experiment 7 (A) and Experiment 8 (B). In both experiments, participants performed a gender singleton search task and report the side (left or right) of the line of dots in the target. Gender singleton task was presented in blocks. In this example observers had to search for a male face among female faces. In Experiment 7 the display was presented until response. Experiment 8 visual search was interrupted. The cycle search which begins with a search arrays ("looks") presented for 200 ms and interrupted by blank displays ("wait") for 1000 ms. This cycle was repeated 16 times or until the subject responded.

Design and Procedure

Phase I - Instrumental Learning Task.

The learning procedure was identical to that used in Experiment 5, protocol 2.

Phase II - Visual Search Task

After completion of the instrumental learning task participants performed the visual search task. A trial (see Figure 6.2 A) began with a fixation cross in the centre of the display for 500 ms followed by an array of ten face images (the target and nine distractors). The display remained present until response. The target was identifiable as being the gender singleton in the display. The task was to report the location (left, right) of the dot strip on the target face as rapidly and accurately as possible. Successive trials were self-paced. Targets were male in three blocks (56 trials each) and female in three other similar blocks. Male-target and female-target blocks were alternated within an experimental session and counterbalanced across participants. For different trials within each block, the target was one of the six different value-learned taces from the prior learning task or a novel face (i.e., not seen in the previous learning task). Two different faces for each value condition and two different novel faces were used equally often as targets. Distractors were always novel and were never used as targets. Different faces were used in the novel condition for different participants to avoid image effects.

There was a total of 336 trials with 12 repetitions of each combination of Target strip Side x Target Gender x target Value Type (high-gain, low-gain, high-loss, low-loss, no-outcome, and novel). The percentage of correct responses was displayed on the screen at the end of each block to provide performance feedback. The experimental session was preceded by two blocks (one with male targets, another with female targets) of 12 practice trials each.

Data analysis

Learning. Participants were considered to have learned the value of the faces in the learning task if they chose the optimal face for each pair on more than 65% of the last 30 trials for that pair. If performance for a particular pair did not reach this criterion, then RT data obtained when either face in that pair was presented as a target were excluded from further analyses. When participants learned both gain or both loss pairs, then RT data obtained when these stimuli were presented as targets were averaged.

Visual Search. Only RT data from correct trials were analyzed. Anticipation errors (with RTs < 200 ms) and slow responses (> 3000 ms) were also excluded. Mean RT for each participant and value condition combination was then calculated and any RT greater than three SD above the mean was removed iteratively until no outliers remained. This excluded 13% of the data. Three repeated measures analysis of variance (ANOVA) tests were conducted on the mean RTs. The first one-way ANOVA used two value conditions (no-outcome, novel) as a within factor. The second one-way ANOVA used five target value types (high-loss, low-loss, nooutcome, low-gain, high-gain) as within factor. The third, a two-way ANOVA used valence (gain, loss) and predictability (high, low) as within subject factors. Planned comparisons of condition means were tested using t-tests. Alpha levels were set at .05.

Results and Discussion

Value Learning

Thirty of the 49 participants succeeded in learning all four outcome pairs to criterion in the learning task. The remaining 19 participants successfully learned at least three of the four outcomes pairs. Gain pairs (M = 91%, SE = 1%) were learned better than the loss pairs (M = 79%, SE = 1%) (t(48) = 12.96, p < .05). For the no-outcome condition, an arbitrarily selected face in each pair was chosen on 53% (SE = 3%) of the last 30 trials.

Visual Search

The mean accuracy of search was very high (98% correct). However, more errors were made to Novel target faces (3%) than to value learned faces (2%); [*F* (5, 240)= 2.573, p < .05, η^2_{p} = .051]. Error rates did not vary according to the Value conditions associated to the target [*F* <1].

Figure 6.3 shows the mean correct RT for target identification as a function of the six conditions in the experiment. A first analysis, comparing the novel with the no-outcome conditions, was an index of the influence of familiarity on visual search. It showed a 55 ms advantage for those faces that had been presented 100 times in the learning phase (M = 1649, SD = 130) over completely novel faces (M = 1704, SE = 163), F(1, 48) = 5.32, p < .05, $\eta^2_{p} = .100$). This showed that familiarity aided visual search.

A second analysis compared the five conditions in which all faces had been seen equally often, but some had been associated with differential gains and losses and probabilities (high-loss, low-loss, no-outcome, low-gain, high-gain), as an index of the influence of reward on search. It revealed a significant main effect of condition $[F(4, 192) = 2.966, p < .05, \eta^2_p = .058]$. Planned comparisons showed that mean RTs for both high-gain (M = 1582, SD = 143) and high-loss (M = 1601, SD = 168) were significantly faster than RT for the no-outcome condition (M = 1649, SD = 130) (t (48) = 2.190, p < .05; t (48) = 3.351, p < .005, respectively). Other comparisons were not significant.

Finally, the relations between the reward dimensions of valence (gain, loss) and predictability (high, low) were examined in a 2 x 2 ANOVA involving only the first four conditions in Figure 6.3. This analysis showed that mean RT was 37 ms shorter when the predictability of outcome was high (M= 1592, SD= 130) than when it was low (M= 1629, SD= 130) [F (1, 48) = 6.075, p < .05, η^2_p = .112]. Neither the main effect of valence (F < 1) nor its interaction with predictability was significant [F (1, 48) = 1.559, p = .218, η^2_p = .031]. Lack of an interaction was indicative that prior responding to the optimal stimuli in the learning task (i.e. high gain, low lose) did not exert any observable effect on subsequent visual search behaviour.

This finding indicates that the predictability dimension of reward is more important that the valence dimension in establishing the salience of a target item in visual search. As such, it is consistent with findings from animal learning (Mackintosh, 1975) that predict greater processing of stimuli that have been highly predictive of outcomes in the past.



Figure 6.3 . Target detection mean RTs as a function of value condition.

Experiment 8 – Interrupted Visual Search

Experiment 7 showed that target faces associated with a high probability of outcome resulted in a search speed advantage over target faces associated with a low probability of reward. This suggests that faces associated with high probability of outcome provided some salience to these stimuli, therefore, they were detected more rapidly. In the present study, we aim to measure and quantify this salience. There are at least two ways this could have come about: (1) Associated outcomes could be triggered on the feed-forward sweep of processing that commences when the display first appears, or at least when the participant's gaze falls sufficiently close to the face to permit bottom-up activation. (2) Alternatively, these associated outcomes could

activate hypothesis-testing mechanisms for one face over another, meaning that the associated outcomes will have a top-down (goal-directed) influence on search.

The interrupted search offers several measures of the search process that differentiates the influence by bottom-up and top-down contributions to display salience. First, it provides an overall measure of search efficiency, as in Experiment 7, which will be measured from the display onset until participants respond. Second, it provides a measure of stimuli salience in a bottom-up fashion, which would be measured in responses at identifying a target in just one single glance at a new search display. Thus, the proportion of all correct responses that occur in Epoch 1 (as opposed to Epochs 2-16) can be used as an index of whether bottom-up salience of faces is driven by the previous associated outcomes. Third, a final measure is the advantage that associated outcomes may provide in forming hypothesis testing. These are measured in the rapid resumption responses that occur only in Epochs 2 and on. Rapid resumption responses (all correct responses made within 500 ms of a display onset in Epoch 2-16) will therefore be used to index the reward influences on top-down activation of target hypotheses. If probability of outcome has an influence on the hypothesis-activation aspect of visual search, then these rapid responses should be more likely for targets associated with a high predictability of outcome.

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As reviewed in Chapter 1, there is evidence that activations in the OFC sent as feedback can modulate early visual processing via reentrant loops. Such pathways afford an opportunity for value codes to modulate perception.

Methods

Participants

Forty-one student (34 females; mean age 23.1 years) from the University of British Columbia participated in exchanged for course credits. Each also earned \$5 during the instrumental learning task. All reported normal to corrected to normal vision and were naïve to the purpose of the experiment. Informed consent forms were obtained prior to participation.

Apparatus

Stimuli were displayed using Pentium computers and generated by E-prime software (Version 1.0; Schneider, Eshman, & Zuccolotto, 2002). Participants delivered their responses by pressing the appropriate keys on a standard keyboard. The display was viewed binocularly from a distance of approximately 3.81°.

Stimuli

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Stimuli were the same as in Experiment 5.

Design and Procedure

Phase I - Instrumental Learning Task

The learning procedure was identical to that used in Experiment 5, protocol 1.

Phase II - Visual Search Task

After completion of the instrumental learning task participants performed the interrupted visual search task. The procedure of the search task was the same as in

Chapter 6 – Interrupted search 132

Experiment 7 with the following exceptions. A trial (see Figure 6.2b) began with a fixation cross in the centre of the display for 500 ms followed by a series of search cycles. Each cycle comprised the search display presented for 200 ms (*Look*) and an interruption of a blank display for 1000 ms (*Wait*). The epoch (i.e., one Look plus one Wait) had a total duration of 1200 ms. The search cycle was repeated 16 times in succession or until the participant responded, whichever occurred first.

Data analysis

Learning data was treated as for Experiment 7. As before, RT data from trials in which the target was from an unsuccessfully learned pair of faces were excluded from further analyses. RT data from correct trials only were analyzed; 5% of the data were thus excluded. All the data from two participants were excluded from the data analysis because their search accuracy fell below 70% correct.

In the interrupted search task data, for each participant the absolute frequency of responses made within each 100 ms bin was calculated for each target value type X epoch combination. These RT distributions were then normalized so that the proportion of responses distributed across bins within each epoch summed to 1.0. A total mean proportion of total correct response for each bin was then calculated per condition and participant. In line with Lleras et al., (2005), the RR rate was defined as the proportion of responses from epochs 2-16 made within 500 ms. Normal Search rate was defined as the proportion of responses that occurred later than 500 ms.

Normalized RT proportions were computed by dividing the proportion of total correct responses by the total frequency of responses for each subject, per condition

(high-loss, low-loss, no-outcome, low-gain, high-gain and Novel). This was done separately for epoch 1 data and then once again collapsing all remaining from epochs (2 - 16).

Results and Discussion

Value Learning

Thirty-five of the 41 participants demonstrated learning in at least one pair of faces for gain and at least one pair of faces for the loss. Of these, eleven participants learned all pairs, nine learned one loss pair and both gain pairs and fifteen learned one gain pair and both loss pairs. Gain pairs (M = 88%, SE = 1%) were learned better than the loss pairs (M = 79%, SE = 1%); the magnitude of this effect (9%) was small, but significant (p < .05). For the no-outcome condition, an arbitrary selected face in each pair was chosen on 51% (SE = 2%) of the trials.

Interrupted Visual Search Task

Overall, percentage of errors in this task was very low (5%) and was unaffected by Value condition and Novel, F(5, 170) = 1.581, p = .168, $\eta^2_p = .004$.

Figure 3 shows the mean correct RT (i.e., the interval between the onset of the first presentation of the search array and response, in real time) as a function of the six conditions in the experiment. Overall, these data followed the same pattern as in Experiment 7, though the same specific comparisons were not always statistically significant. A first analysis, comparing the novel with the no-outcome conditions, pointed to a 213 ms advantage for those faces that had been seen in the learning phase but were not associated with any reward outcome (M = 4519, SE = 155) over novel faces (M = 4732, SE = 182). However, this difference was not statistically

significant, [*F*(1, 32) = 1.45, p > .10, $\eta^2_p = .043$], likely as a consequence of the large variability that surrounds mean correct RT in an interrupted search task that can extend as long as 10 seconds or more.

A second analysis compared the five conditions associated with differential gains and losses (high-loss, low-loss, no-outcome, low-gain, high-gain) and revealed a significant main effect of condition [F (4, 128) = 2.51, p < .05, $\eta^2_p = .073$]. Planned comparisons showed that mean RTs target faces associated with high predictable outcomes (high- gain M = 4070, SD = 168 and high-loss M = 4090, SD = 111) were found more quickly than target faces associated with no outcome (M = 4519, SD = 155) [high- gain: t(32) = 2.73, p < .05; high-loss: t(32) = 3.17, p < .05]. Similarly, target faces associated with low predictable outcomes (low- gain M = 4222, SD = 136 and low-loss M = 4177, SD = 152) were found marginally more quickly than targets associated with no outcome [low-gain: t(32) = 1.88, p = .07; low-loss: t(32) = 1.99, p = .05]. High probably targets speeded efficiency by 438 ms relative to no-outcome targets whereas low probable target speeded efficiency by only 320 ms.

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Finally, the relationship between the reward dimensions of valence and predictability were examined in a 2 x 2 ANOVA involving only the first four conditions in Figure 3. This analysis showed non-significant main effects of valence [F > 1] and predictability [F(1, 32) = 1.22, p = .278, $\eta^2_p = .037$] and a non-significant interaction [F > 1]. This ANOVA indicates that the type of outcome (high, low or gain, loss) were not different from each other in terms of influencing search efficiency.



Figure 6.4. Mean RT from stimuli onset until response per each condition.

Figure 6.5 shows the proportion of correct response made following the initial look at a new search display. In the first epoch the majority of the responses occurred 500 ms. after response onset as expected. As in the previous analyses we first tested for a familiarity effect (by comparing the novel versus no outcome conditions), before turning to the influences of reward. The two rightmost bars in Figure 4 show that a greater proportion of these correct responses occurred for novel faces (M = 0.035, SE = 0.007) than for familiar (no-outcome) faces (M = 0.017, SE = 0.007), [F(1, 32) = 10.38, p < .005, $\eta^2_p = .244$], indicating that with just one look novel target faces were detected more often that familiar (no-outcome) target faces.

A second analysis examined the five reward outcome conditions, and it showed a main effect of Value Type condition [$F(3.05, 97.73) = 6.21, p < .001, \eta^2_p = .163$]. Planned comparisons showed that when compared to the no-outcome condition (M = 0.016, SE = 0.004), performance in both the high-gain (M = 0.039, SE

= 0.007) and high-loss (M = 0.034, SE = 0.005) and low-loss (M = 0.045, SE = 0.005) conditions were all significantly different [t(32)= 3.63, p < .05; t(32)= 2.94, p < .05; t(32)= 3.81, p < .05 respectively]. Only the low-gain (M = 0.024, SE = 0.004) condition produced performance that was marginally better than that for the no-outcome condition [t(32)= 1.84, p = .075].

However, when the Valence [F(1, 32) = 2.02, p = .165, $\eta_{p}^{2} = .059$] and Predictability [F < 1, $\eta_{p}^{2} = .004$] effects were explored in a 2 x 2 ANOVA, only the interaction was significant [F(1, 32) = 10.59, p < .05, $\eta_{p}^{2} = .249$]. Simple effects showed that target detection was higher for both high-gain and low-lost conditions when compared to the low-gain condition [t(32)= 2.69, p < .05; t(32)= 3.20, p < .005respectively]. The low-loss condition was also marginally significant compared to high-loss condition [t(32)= 1.78, p = .08]. Other comparisons were not significant. This shows that responses in epoch 1 were driven by the stimuli chosen more often (i.e. high predictability of gain and low predictability of loss) during the learning task.

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Figure 6.5. Mean proportions of total correct responses as a function of Value Type condition with just a single exposure in epoch 1.

Figure 6.6 shows the mean proportion rapid resumption responses in Epochs 2-16 (for a detailed distribution per epoch and condition see Appendix D). RR rates were unaffected by familiarity with the target [F > 1, $\eta^2_p = .007$]. The mean RR rate in the no-outcome condition (M = 0.45, SE = 0.02) was nearly identical (See right side of Figure 5) to that in the Novel condition (M = 0.46, SE = 0.03).

Analysis on the five conditions associated with different levels of reward (highgain, low-gain, no-outcome, low-loss, high-loss) revealed again a significant value type condition effect on RR rates [F (4, 128) = 3.35, p < .05, $\eta_{p}^{2} = .095$]. Unexpectedly, planned comparisons showed that RR rates for target faces associated with both high-gain (M = .47, SE = .028) and high-loss (M = .46, SE =.028) were not different than RR rates for target faces associated with No-outcome (M = .45, SE = .024), [t(32) = -.76, p > .10; t(32) = -.32, p > .10; respectively]. However, the RR rate for target faces associated with low-gain (M = .41, SE = .027) and low-loss (M = .41, SE = .024) were marginally reduced when compared to RR rate for targets with no-outcome association [t(32)= 1.70, p = .09; t(32)= 1.92, p = .06; respectively].

Finally, when the data were re-analyzed for the effects of valence and predictability (excluding the no-outcome condition), a non-significant main effect of valence $[F > 1, \eta_p^2] = .008$] but a significant main effect of predictability $[F (1, 32) = 11.46, p < .005, \eta_p^2] = .264$] was found. Detection of targets in RR rates were 6 percentage points less frequent for low probable outcome stimuli (M = .40, SE = .025), regardless of valence, than they were for high probable outcome faces (M = .46, SE = .025). This effect of probability is opposite to that found with search efficiency suggesting that hypothesis testing was not formed for the low predictability of outcome stimuli.



Figure 6.6. Mean number of proportion of rapid resumption responses as a function of value type experimental conditions during epochs 2-16.
Discussion – Experiments 7 & 8

This chapter examined the effects of previously acquired value associations to a target face in a visual search task. To explore this we presented novel face stimuli in a choice game to imbue different value associations. When these stimuli were then used as targets in a visual search task then yielded the following major results:

Effects of value learning in target detection on RTs - The first question was whether value codes associated to targets would modulate visual search. In Experiment 7, target faces associated with high probability of outcome (regardless of valence) were found faster than targets associated with low predictability of outcome. indicating that stimuli associated with high probability of outcome received higher attentional priority. Thus, it appears that performance was driven by the predictability of the stimuli. This is in line with previous results that showed that associations with high probability of outcome facilitated target recognition regardless of attentional demands (Raymond & O'Brien, 2009) and with attentional theories of associative learning (Mackintosh, 1975). Such theories propose that, during learning participants pay different amounts of attention to different cues according to their probability of outcome, yet those cues are presented simultaneously. In consequence, stimuli associated with higher probability of outcome will capture more attention than those with lower probability of outcome. This attentional theory can be applied to explain the results of the present study. During learning, participants learned about the predictiveness of the cues (high, low). Any difference accomplished in the learning rate was then measured during the visual search task, which showed a benefit in target detection RT for faces associated with high probability of outcome. This suggested that top-down signals during target processing for these stimuli were more

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perceptually accessible than those associated with low probability of outcome implying that these later stimuli had weaker top-down signals. These signals were explored in Experiment 8 by interrupting visual search and showed the following:

Effects of value learning in bottom-up salience (epoch 1) – In epoch 1 participants viewed the target stimuli for 200 ms followed by a 1000 ms blank screen (responses made after this belonged to subsequent epochs). As reviewed in Chapter 1, the first feedforward sweep takes ~100 ms (Lamme & Roelfsema, 2000), suggesting that anytime beyond that has the influence of top-down signals. When I examined whether value codes signal affected search with just one glimpse of the visual array we found that performance was driven by prior choice in the learning task. Faces associated with high gain and low loss were the faces chosen repeatedly in the learning phase and these faces were more likely to provoke a response in Epoch 1. This suggests that response in epoch 1 was driven by previously learned motor responses during the learning task. Perhaps the initial recurrent processes in visual search are inclined to activate automaticity in motor response.

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Effects of value learning in the formation of hypothesis-testing (rates of RR) – Rapid resumption refers to correct RTs within 500 ms of search display onset and relies on hypothesis formation in the penultimate look. The valence of the targets (gain, loss) did not drive performance, suggesting that there are no differences in forming a perceptual hypothesis between positive and negative targets. What is surprising, RR rates were reduced in the low probability of outcome condition relative to the high predictable and no-outcome conditions. Targets associated with low probability of outcome did not keep an expectation (hypothesis formation) more active than in the other conditions. It's not clear what is driving the difference between the low predictable and the other conditions, but if predictability plays a role, low predictability of outcome was the most unreliable condition in terms of receiving an outcome. The no-outcome condition was 100% predictable of having no outcome and the high predictable condition was 80%. Perhaps, targets associated with low predictability of outcome were not predictive of attention during the learning task, therefore exclusive with regard to any advantage in any other cognitive processes.

Note, although the data does not show a benefit in the rates of RR for the high predictable conditions compared to other conditions, the RT data did showed a benefit for this condition.

Effects of familiarity – Comparisons between the no-outcome and the novel conditions were used to explore the effects of familiarity. Familiarity benefit RTs during visual search. This is in line with previous studies that showed a competitive advantage for familiar over unfamiliar stimuli when competing for attention (Buttle & Raymond, 2002, Jackson & Raymond, 2003).

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Unexpectedly, novelty showed a benefit in responses made in epoch 1 and in the rates of RR. It may be that novelty is itself rewarding (Schultz, 2004) or at least get selection priority and this may be why it also shows an advantage in both responses in epoch 1 and the same benefit as familiar stimuli in the rates of RR.

In summary, the central finding of the present experiment is that target detection was faster for faces highly predictive of outcome, regardless of valence than the low predictive associated faces. This shows that prior value learning was able to modulate perceptual detection in a subsequent unrelated task. Part 4

GENERAL DISCUSSION

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General Discussion

The objective of this thesis was to investigate how prior experience with faces affects their subsequent perception. To address this, (1) I explored how facial expression perception is influenced by both prior attentional states to those face stimuli and prior information about the face stimuli's expected value. (2) I also explored how associated values to faces influence target detection when presented in a visual search task.

Prior experience with objects is believed to influence cognition through topdown signals. When visual information reaches the visual cortex an initial feedforward sweep of information is sent to higher-level areas of processing. This higher-level area sends back a top-down signal with the aim to guide and disambiguate information from low-level signals. The interaction between connections from higher to lower-levels is repeated by recurrent processing until a percept is formed. Once the visual stimulus has been encoded, it gets access to WM. Working memory then generates attentional signals (goal-driven) to select relevant information processing, inhibit irrelevant ones and maintain representations for additional processing. Top-down signals are initiated from frontal areas in the brain (Buschman & Miller, 2007; Desimone & Duncan, 1995).

One source of top-down signal explored in this thesis is the value a stimulus acquires by interacting with it in specific ways. Learning to accurately predict outcomes is achieved by comparing predictions with actual outcomes and then using the resultant error signal to update value prediction codes associated with the specific stimuli (Paton et al., 2006). Stimuli predicting high value outcomes motivate behavioural engagement whereas those predicting low value or negative outcome do not. In this thesis I explored the effect of top-down signals in social cognition contexts and in the mechanism of attention.

Effects of prior history on the perception of facial expressions

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The experiment I reported in Chapter 3, showed how after a simple visual search task involving neutral faces, distractor devaluation effects were noticeable as changes in sensitivity to emotional facial expressions. When faces were seen as prior distractors, sensitivity to facial expression varied according to the emotion being judged. Ignoring compared to attending a neutral face reduces subsequent sensitivity to the presence of a negative expression on that face but has no effect on sensitivity to the appearance of a positive expression. However, when faces were seen as prior targets sensitivity to facial expression was enhanced relative to faces that were not seen in the prior attentional task (baseline).

Previously offered explanations of distractor devaluation proposed that selectively attending a target stimulus in the presence of a distractor causes inhibition to become associated with the relevant distractor feature. When that feature is reencountered, the associated inhibition is re-instantiated, depressing affective

appraisal (Raymond et al., 2003). However, it is unclear from these views what 'associated inhibition' means and how re-activating inhibition determines affective response under different conditions of emotional stimulation. Raymond (2009) proposed that a useful conceptual framework in which to consider this is the notion of value prediction and motivation. Suppose that in the current experiment distractor signal potential errors (implicit negative outcomes), a state that reduces their predicted value and lessens motivation to engage with them subsequently. In this way, memory for prior attentional inhibition is stored as a negative change in the distractor's predicted value. When re-presented in the expression task a few seconds later, motivation to interact with it would be depressed relative to that for a target face. Moreover, adding an emotional expression to the test face should further adjusts its motivational value. A negative facial expression should serve to further reduce the test face's predicted value, whereas a positive expression should improve it (O'Doberty et al., 2003; Custers & Aarts, 2005). The end result of such motivationally based modulation would be a decline in explicit sensitivity to negative expressions for distractors (relative to that for targets) and a nulling of any distractor 'devaluation' like-effects for distractor faces with positive expressions as seen in Chapter 3. Interestingly, the motivational based account for the results of the experiments in Chapter 3 matches with the results of the experiment reported in Chapter 5.

Chapter 5 explored how associated value codes with neutral faces changes their subsequent facial expression perception. Value codes were imbued to face stimuli through an instrumental learning task in which participants were choosing the optimal choice stimuli in order to maximise rewards. I manipulated the valence (gain,

loss), probability of outcome (high, low) and a control condition for exposure that always received no outcomes. Participants learned the contingencies through trial and error. I then presented these learned non-expressive face stimuli in a face expression task. Chapter 5 presented a horizontal two-face array and participants were asked to judge which face (left, right) was more expressive. Previous history with faces associated with gain outcomes increased their emotional salience regardless of the emotion being judged (angry, happy). This effect was more enhanced for faces with happy expression than for angry facial expressions. Rewards and punishments could be compared in the two studies (Chapter 3 and 5) as follows. According to the motivational based modulation of the devaluation effect, correctly identifying a target could be compared with a feeling of reward (implicit rewarding outcome), whereas mistakenly identifying a distractor for a target could be compared to a punishment (implicit negative outcomes). These rewards and punishments could be linked to the gain and loss associations imbued through the value learning task in the experiment in Chapter 5. In other words, I provide behavioural data that shows that faces seen as prior targets or gain associations were seen as more expressive than faces seen as prior distractors or loss associations.

The above studies provide behavioural evidence that when the same faces are encoded with different contextual history, sensitivity to facial expression changes. This is in line with the dimensional view of emotions (Russell, 1980; Posner, Russell, & Peterson, 2005). This suggests that facial expression relies on stored prior history with that face for processing. This influence appears to develop very quickly since faces in the attentional task (Chapter 3) were presented for just 200 ms. Past

experience with a face may then be integrated into social attributions that are then used in their facial expression interpretation. The processing of social attributions and face may be coded separately and the emotion perceived on the face is based on different weights given to the two dimensions (valence and arousal) of emotional processing (Russell, 1980; Posner, Russell, & Peterson, 2005). There is evidence that the temporal pole plays a role in contextual framing (Smith et al., 2004). Lesions to the temporal pole can result in the loss of recognition of famous scenes, loss of memory for events and loss of person related knowledge (Tranel et al., 1997). In fact, neurocognitive models of faces perception have attributed a role for the temporal pole in face processing (Haxby et al, 2000) and being connected to structures important in the processing of emotional and social information such as STS, amygdala, and ventral PFC (Charbardes et al., 2002). Thus, the temporal pole might interact with the STS to use contextual information to modulate social attributions. The STS has a particular role in the perception of changeable aspects of the face such as facial expressions (Haxby et al., 2000). It is likely that these regions are further influenced by top-down signals from the OFC where learned associations with faces are stored (Rolls, 2000).

In summary, the meaning attributed to facial expression is context-dependent, thus facial expressions perception is malleable by prior history with that face. Future research could address the malleability of facial expression with different previous context. In the studies reported here, affective associations were attributed to neutral faces. Further research could explore if affective associations to actual facial expression (e.g happy expressions) change the perception of the subsequent facial expression either the same (happy) or different (angry) emotional expression.

Effects of prior history in the detection of target faces

The remaining experiments from Chapter 6 investigated the effect of value associations on the detection of faces in a visual search task. Target faces associated with high probability of outcome were found faster than faces associated with no outcome. This suggested that predictability of receiving an outcome provided a top-down signal that resulted in target detection facilitation. I then further explored the nature of this top-down signal by interrupting visual search. Top-down signals are believed to form a hypothesis testing about the percept that is being processed. By interrupting an initiated search, processing of hypothesis testing is also interrupted but held in memory. When the visual search is then resumed, hypothesis testing that were formed in the penultimate look results in very fast latencies of RT responses, therefore measuring facilitation of target detection. Choice behaviour during the learning task resulted in facilitation in target detection performance with just one look of the visual display. Hypotheses testing were less formed for target faces associated with low probability of outcome. However, overall mean RTs for faces associated with high probability of outcome were also found faster than target faces associated with no-outcome. Thus, the predictability of an outcome is more accessible and more available for processing which then results in facilitation in target face detection.

These results indicate that visual search for targets associated with high probability of outcome can lead to better overall performance. It would be interesting for future research to test the extent to which the present reward effect lead to optimal search behaviour. One possible neural source for the present effects is that faces associated with motivational salience leads to stronger (or more enduring) corresponding neural activity. This possibility might be examined by applying measures of neural activity to the new procedures I have introduced here.

Neural mechanism implications

The above experiments provide an indirect measure that the neural mechanisms thought to mediate attention, emotional evaluation, and motivation interact to determine visual selection. The OFC probably is one of the structures that play a role in integrating these mechanisms. Damage to the OFC shows impairments in WM, changes in reinforcement contingencies, and emotional changes (Rolls, 2000; 2004). Moreover, this structure has numerous reciprocal connections to visual processing areas, as well as the amygdala, temporal lobe structures, striatum, thalamus, among others (Rolls, 2000; 2004). Thus, the OFC is a good candidate for supplying an infrastructure for the reciprocal modulation between visual sensory, emotion evaluation and motivation systems. Another brain structure that might play a role in linking attention, emotion and motivation is the amygdala. Brain imaging studies have shown amygdala activation to responses to emotional stimuli that are modulated by attention (Vuilleumier, et al., 2001; Pessoa et al., 2002). The amygdala has also a well-established role in emotional learning; specifically the amygdala complex has multiple roles in associative learning and the regulation of attention (Gallagher & Holland, 1994).

In addition, the experiments reported in this thesis also suggest that the attention, emotional evaluation, and motivation mechanisms provide a top-down signal that also affects the processing of faces. This top-down signal affects both

social aspects in face perception (Chapter 3 and 5) and attentional detection (Chapter 6). This is in line with previous studies showing an interaction between these mechanisms. For example, Singer et al., (2004) showed enhanced brain activity in fusiform gyrus and posterior STS in response to socially salient faces. Streit et al., (1999) have shown an interaction between superior temporal cortex and the amygdala in the recognition of facial expression, especially fear. Furthermore, neurophysiological evidence showed that some neurons in the macaque inferior temporal visual cortex are tuned to the invariant representations of faces. These neurons provide the inputs to other brain regions such as the OFC and the amygdala believed to further process face representation in their reinforced social associations and emotional behaviour (Rolls, 2007). Thus, the OFC and the amygdala can be thought of as components of a neural system that links sensory representations of face stimuli with the social judgements we make about them on the basis of their motivational value.

Control measure for possible confounds in stimuli

In this thesis, I also introduced two methods to control for possible confounds in the emotional research addressed in Chapter 2 and 4. This confounds refer to (1) the stimulus arousal/salience, (2) subjective relevance, and (3) stimuli properties. In Chapter 2, it was shown that there are differences in the expression intensity among faces. By creating an iso-expressive set of faces, I provided a method to control and equate the natural differences in expression intensity among facial expression face images. In addition, the value learning procedure introduced in Chapter 4, allowed to control all the above mentioned confounds in the following ways. First, stimuli

acquire salience following the experience in receiving a reward (Jagadeesh, Chelazzi, Mishkin & Desimone, 2001). The arousal/salience dimension was controlled by associating stimuli with different probabilities of outcome. Second, controlled assigned expected value to face stimuli allowed to control for assumptions about the value of emotional stimuli. Before the learning procedure the stimuli had no value to the participant, through learning the contingencies the prior neutral value face was then assigned with it. Lastly, low-level visual features in the stimuli were controlled, as face stimuli were randomised across the learning conditions to avoid image effects. Moreover, participants were exposed to the same number of trials to acquire an associated value code, thus stimuli exposure was held constant across the different value conditions. Participants that did not reach a learning criterion were not included in the data analysis. For all the above reasons, the stimuli's salience, subjective relevance and stimuli properties were controlled.

Short Summary

Behavioural evidence from the experiments reported in this thesis indicates that faces associated with outcomes acquire saliency and that this saliency affect the mechanisms of attention and social judgements. Thus, internal representation of faces, acquired through experience, affect the brain's strategy for perceiving and processing such faces.

References

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- Adolphs, A (2003). Cognitive neuroscience of human social behaviour. Nature Review Neuroscience, 4 (3), 165-178.
- Anderson, A. (2005). Affective influences on the attentional dynamics supporting awareness. Journal Of Experimental Psychology General, 134 (2), 258-81.
- Anderson, A., Christoff, K., Stappen, I., Panitz, D., Ghahremani, D., Glover, G., et al. (2003). Dissociated neural representations of intensity and valence in human olfaction. Nature Neuroscience, 6 (2), 196-202.
- Arnell, K., Killman, K., & Fijavz, D. (2007). Blinded by emotion: target misses follow attention capture by arousing distractors in RSVP. Emotion , 7 (3), 465-77.
- Averbeck, B., & Duchaine, B. (2009). Integration of social and utilitarian factors in decision making. Emotion , 9 (5), 599-608.

Baddeley, A. (1992). Working memory. Sciences , 255 (5044), 556-559.

- Baddeley, A. (2000). The episodic buffer: a new component of working memory? Trends in Cognitive Sciences, 4 (11), 417-423.
- Baddeley, A. (2003). Working memory: looking back and looking forward. Nature reviews Neuroscience, 4 (10), 829-39.
 - Baxter, M., & Murray, E. (2002). The amygdala and reward. Nature reviews Neuroscience, 3 (7), 563-73.
 - Beaupré, M. G., Cheung, N., & Hess, U. (2000). The Montreal Set of Facial Displays of Emotion [Slides]. (Available from Ursula Hess, Department of Psychology, University of Quebec at Montreal, P.O. Box 8888, Station "Centre-ville," Montreal, Quebec H3C 3P8.)
 - Berridge, K., & Robinson, T. (1998). What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience? Brain research Brain research reviews , 28 (3), 309-69.

- Bishop, S., Jenkins, R., & Lawrence, A. (2006). Neural Processing of Fearful Faces: Effects of Anxiety are Gated by Perceptual Capacity Limitations. Cerebral Cortex, 17 (7), 1595-1603.
- Bornstein, R. F. (1989). "Exposure and Affect: Overview and Meta-analysis of Research, 1968-1987". Psychological Bulletin, 106 (2), 265-289.
- Bornstein, R. F., & D'Agostino, P. R. (1992). Stimulus recognition and the mere exposure effect. Journal of Personality and Social Psychology, 63, 545-552.
- Bornstein, R. F., Leone, D. R., & Galley, D. J. (1987). The generalizability of subliminal mere exposure effects: Influence of stimuli perceived without awareness on social behavior. Journal of Personality and Social Psychology, 53, 1070-1079.
- Bruce, V. & Young, A. W. (1986). Understanding face recognition. British Journal of Psychology, 77, 305-327.
- Bullier, J. (2001). Integrated model of visual processing. Brain research Brain research reviews , 36 (2-3) 96-107.

- Bundesen, C. (1990). A Theory of Visual Attention. Psychological review, 97 (4), 523-547.
- Buttle, H., & Raymond, J. (2003). High familiarity enhances visual change detection for face stimuli. Perception & Psychophysics , 65 (8), 1296-306.
- Calvo, M., & Esteves, F. (2005). Detection of emotional faces: Low perceptual threshold and wide attentional span. Visual Cognition , 12 (1), 13-27.
- Cardinal, R., Parkinson, J., Hall, J., & Everitt, B. (2002). Emotion and motivation: the role of the amygdala, ventral striatum, and prefrontal cortex. Neuroscience And Biobehavioral Reviews, 26 (3), 321-52.
- Clark, J. M. (1996). Contributions of inhibitory mechanisms to unified theory in neuroscience and psychology. Brain and Cognition, 30, 127–152

- Chen, M., & Bargh, J. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. Personality and social pychology bulletin, 25 (2), 215-224.
- Cousineau, D. (2005, Jan 1). Confidence intervals in within-subject designs: A simpler solution to Loftus and Masson's method. Tutorial in Quantitative Methods for Psychology.
- Critchley, I., & Rolls, E. (1996). Hunger and Satiety Modify the Responses of Olfactory and Visual Neurons in the Primate Orbitofkontal Cortex . Journal of neurophysiology , 4 (75), 1673-1685.
- Curtis, C., & D'Esposito, M. (2003). Persistent activity in the prefrontal cortex during working memory. Trends in cognitive sciences, 7 (9), 415-423.
- Custers, R. & Aarts. H. (2005). Positive affect as implicit motivator: On the nonconscious operation of behavioral goals, Journal of Personality and Social Psychology, 89, 129–142.
- Dalyrymple-Alford, E.C., & Budayr, B. (1966). Examination of some aspects of the Stroop colour-word test. Perceptual and Motor Skills, 23, 1211–1214.

10 .

- Deigado, M. (2007). Reward-related responses in the human striatum. Annals of the New York Academy of Sciences, 1104, 70-88.
- Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. Annual review of neuroscience, 18, 193-222.
- Di Lollo, V., Enns, J., & Rensick, R. (2000). Competition for consciousness among visual events: The psychophysics of reentrant visual processes. Journal of Experimental Psychology: General , 129 (4), 481-507.
- Dijksterhuis, A., & Aarts, H. (2003, Jan 1). On wildebeests and humans: the preferential detection of negative stimuli. Psychological Science .

- Eastwood, J., Smilek, D., & Merikle, P. (2001). Differential attentional guidance by unattended faces expressing positive and negative emotion. Perception & Psychophysics , 63 (6), 1004-13.
- Egeth, H., & Yantis, S. (1997). Visual attention: control, representation, and time course. Annual review of psychology , 48, 269-97.
- Ekman, P. (1993). Facial Expression and Emotion. American Psychologist , 48, 384-392. Ekman and Friesen, 1976 P.
- Ekman and W. Friesen, Pictures of facial affect, Consulting Psychologists Press, Palo Alto, CA (1976).
- Ekman, P., & O'Sullivan, M. (1988). The role of context in interpreting facial expression: comment on Russell and Fehr (1987). Journal Of Experimental Psychology General , 117 (1), 86-90.
- Eriksen, C., & James, J. (1986). Visual Attention within and around the field of focal attention: A zoom lens model. Perception & Psychophysics , 40 (4), 225-240.
- Eriksen, C., & Yeh, Y. (1985). Allocation of Attention in the Visual Field. Journal of Experimental Psychology: Human Perception and Performance, 11 (5), 583-597
- Felleman, D., & Essen, D. (1991). Distributed Hierarchical Processing in the Pimate Cerebral Cortex. Cerebral Cortex, 1, 1-47.
- Felleman, D., & Van Essen, D. (1991). Distributed hierarchical processing in the primate cerebral cortex. Cerebral cortex (New York, NY : 1991) . 1 (1), 1-47.
- Fenske, M., & Eastwood, J. (2003). Modulation of Focused Attention by Faces Expressing Emotion: Evidence From Flanker Tasks. Emotion, 3 (4), 327-343.
- Fenske, M., Raymond, J., & Kunar, M. (2004). The affective consequences of visual attention in preview search. Psychonomic bulletin & review , 11 (6), 1055-61.

- Folk, C., Remington, R., & Johnston, J. (1992). Involuntary covert orienting is contingent on attentional control settings. Journal of Experimental Psychology: Human Perception and Performance, 18 (4), 1030-44.
- Fox, E., Russo, R., & Georgiou, G. (2005, Jan 1). Anxiety Modulates the Degree of Attentive Resources Required to Process Emotional Faces. Cognitive .
- Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? Journal Of Experimental Psychology General, 130 (4), 681-700.
- Gallagher, M. & Holland, P.C. (1994). The amygdala complex: Multiple roles in associative learning and attention. PNAS, 91, 11771-11776.
- Gallegos, D., & Tranel, D. (2005). Positive facial affect facilitates the identification of famous faces. Brain and Language , 93 (3), 338-348.
- Gilbert, C., & Sigman, M. (2007). Brain states: top-down influences in sensory processing. Neuron , 54 (5), 677-96.
- Goeleven, E, Raedt, R., Leyman, L., & Verschuere, B. (2008). The Karolinska Directed Emotional Faces: A validation study. Cognition & Emotion, 22 (6), 1094-1118.
 - Gomez-Cuerva, J., Enns, J., Raymond, J. (2009). [Abstract] Expected value of stimuli enhances visual search but does not affect rapid resumption. *Journal of Vision*, 9 (8) article 1178
 - Gottfried, J.A., Dolan, R.J., 2004. Human orbitofrontal cortex mediates extinction learning while accessing conditioned representations of value. Nat. Neurosci. 7, 1145–1153.
 - Gottfried, J., O'doherty, J., & Dolan, R. (2003). Encoding predictive reward value in human amygdala and orbitofrontal cortex. Science , 301 (5636), 1104-7.

- Groenewegen, H., Wright, C., Beijer, A., & Voorn, P. (1999). Convergence and segregation of ventral striatal inputs and outputs. Annals of the New York Academy of Sciences, 877, 49-63.
- Haber, S. (2008). Parallel and integrative processing through the Basal Ganglia reward circuit: lessons from addiction. Biological Psychiatry , 64 (3), 173-4.
- Haber, S., & Knutson, B. (2009). The Reward Circuit: Linking Primate Anatomy and Human Imaging. Neuropsychopharmacology , 35 (1), 4-26.
- Halberstadt, J., Winkielman, P., Niedenthal, P., & Dalle, N. (2009). Emotional Conception: How Embodied Emotion Concepts Guide Perception and Facial Action. Psychological Science, 20 (10), 1254-1261.
- Hansen, C., & Hansen, R. (1988). Finding the face in the crowd: an anger superiority effect. Journal of personality and social psychology , 54 (6), 917-24.
- Haxby, J.V., Hoffman, E. A., & Gobbini, M.I. (2000). The distributed human neural system for face perception. Trends in Cognitive Sciences, 4, 223-233. Haxby, J.V., Hoffman, E. A., & Gobbini, M.I. (2002).
- Psychiatry, 51, 59-67.
 - Hoffman, E. A., & Haxby, J. V. (2000). Distinct representations of eye gaze and identity in the distributed human neural system for face perception. Nature Neuroscience, 3, 80-84.
 - Hollerman, J., & Schultz, W. (1998). Dopamine neurons report an error in the temporal prediction of reward during learning. Nature Neuroscience, 1 (4), 304-9.
 - Horowitz, T., & Wolfe, J. (1998). Visual search has no memory. Nature, 394 (6693), 575-7. Horstmann, G. (2002, Jan 1). Evidence for Attentional Capture by a Surprising Color Singleton in Visual Search. Psychological Science.

- Horstmann, G. (2007). Preattentive face processing: What do visual search experiments with schematic faces tell us? Visual Cognition , 15 (7), 700-833.
- Horstmann, G., Borgstedt, K., & Heumann, M. (2006). Flanker effects with faces may depend on perceptual as well as emotional differences. Emotion , 6 (1), 28-39.
- Hosokawa, T., Kato, K., Inoue, M., & Mikami, A. (2007). Neurons in the macaque orbitofrontal cortex code relative preference of both rewarding and aversive outcomes. Neuroscience research , 57 (3), 434-45.
- Houghton, G., & Tipper, S. P. (1994). A model of inhibitory mechanisms in selective attention. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory Processes in Attention, Memory, and Language* (pp. 53-112). London: Academic Press.
- Houghton, G., Tipper, S. P., Weaver, B., & Shore, D. I. (1996). Inhibition and interference in selective attention: Some tests of a neural network model. *Visual Cognition*, *3*(2), 119-164.
- Jackson, M., & Raymond, J. (2006). The role of attention and familiarity in face identification. Perception & Psychophysics , 68 (4), 543-57.
- Jackson, M., & Raycond, J. (2008). Familiarity enhances visual working memory for
 faces. Journal of Experimental Psychology: Human Perception and
 Performance, 34 (3), 556-568.
 - Janiszewski, C., & Meyvis, T. (2001). Effects of brand logo complexity, repetition, and spacing on processing fluency and judgment. Journal of Consumer Research, 28, 18-32.
 - Jenkins, R., Lavie, N., & Driver, J. (2003). Ignoring famous faces: category-specific dilution of distractor interference. Perception & Psychophysics , 65 (2), 298-309.
 - Juth, P., Lundqvist, D., Karlsson, A., & Öhman, A. (2005). Looking for Foes and Friends: Perceptual and Emotional Factors When Finding a Face in the Crowd. Emotion , 5 (4), 379-395.

- Keysers, C. & Perrett, D.I. (2002). Visual masking and RSVP reveal neural competition. Trends in Cognitive Sciences, 6 (3), 120-125.
- Kiss, M., Driver, J., & Eimer, M. (2009). Reward priority of visual target singletons modulates event-related potential signatures of attentional selection. Psychological science : a journal of the American Psychological Society / APS , 20 (2), 245-51.
- Kristjansson, A., Sigurjonsdottir, O., & Driver, J. (2010). Fortune and reversals of fortune in visual search: Reward contingencies for pop-out targets affect search efficiency and target repetition effects. Attention, Perception & Psychophysics , 72 (5), 1229-1236.
- Kunst-Wilson W. R., Zajonc R.B. (1980). Affective discrimination of stimuli that cannot be recognized. Science, 207. 557-558.
- LaBerge, D. (1983). Spatial Extent of Attention to Letters and Words. Journal of Experimental Psychology: Human Perception and Performance, 9 (3), 371-379.
- LaBerge, D., & Brown, V. (1989). Theory of Attentional Operations in Shape Identification. Psychological review, 96 (1), 101-124.
- Lamme, V. (2004). Separate neural definitions of visual consciousness and visual attention; a case for phenomenal awareness. Neural networks : the official journal of the International Neural Network Society , 17 (5-6), 861-72.
- Lamme, V. (2006). Towards a true neural stance on consciousness. Trends in cognitive sciences, 10 (11), 494-501.
- Lamme, V., & Roelfsema, P. (2000). The distinct modes of vision offered by
 feedforward and recurrent processing. Trends in neurosciences , 23 (11), 5719.

- Leppänen, J., & Hietanen, J. (2004). Positive facial expressions are recognized faster than negative facial expressions, but why? Psychological Research , 69 (1-2), 22-9.
- Libera, C., & Chelazzi, L. (2006). Visual Selective Attention and the Effects of Monetary Rewards. Psychological Science .
- Libera, C., & Chelazzi, L. (2009). Learning to Attend and to Ignore Is a Matter of Gains and Losses. Psychological science : a journal of the American Psychological Society / APS .
- Liu, J., Harris, A. & Kanwisher, N. (2002). Stages of processing in face perception: an MEG study. *Nature Neurosci.* **5**, 910–916.
- Lleras, A., Rensink, R., & Enns, J. (2005). New Insights on the Interaction Between Vision and Memory. Psychological Science .
- Luck, S., & Vogel, E. (1997). The capacity of visual working memory for features and conjunctions. Nature , 390 (6657), 279-81.
- Lundqvist. D., Flykt, A., Öhman, A. (1998). The Karolinska Directed Emotional Faces—KDEF [CD-ROM]. Department of Clinical Neuroscience, Psychology section, Karolinska Institutet, Stockholm, Sweden. MacDonald P.A. &
 - Joordens S. (2000) Investigation a memory-based account of negative priming: support for selection-feature mismatch. Journal of Experimental Psychology: Human Perception Performance, 26, 1478-1496.
 - Mackintosh, N. (1975). A Theory of Attention: Variations in the Associability of Stimuli with Reinforcement. 82 (4), 276-298.
 - Mandler, G., Nakamura, Y., & Van Zandt, B. J. S. (1987). Nonspecific effects of exposure on stimuli that cannot be recognized. Journal of Experimental Psychology: Learning, Memory, and Cognition, 13, 646-648.
 - March, J. (1991). Exploration and exploitation in organizational learning. Organization Science, 2 (1), 71-87.

- Matsumoto, D., & Ekman, P. (1988). Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and Neutral Faces (JACNeuF). Slides. San Francisco, CA: Department of Psycology, San Francisco State University.
- Maunsell, J., Nealey, T., & DePriest, D. (1990). Magnocellular and parvocellular contributions to responses in the middle temporal visual area (MT) of the macaque monkey. The Journal of neuroscience : the official journal of the Society for Neuroscience , 10 (10), 3323-34.
- McLeod CM. (1998). Directed forgetting. In: Golding JM, MacLeod CM, editors. Intentional forgetting: interdisciplinary approaches. Mahwah (NJ): Lawrence Erlbaum. 453-481.
- Mermillod, M., Vermeulen, N., Lundqvist, D., & Niedenthal, P. (2009, Jan 5). Neural computation as a tool to differentiate perceptual from emotional processes: The case of anger superiority effect. Cognition , 1-12.
- Miller, B., & D'Esposito, M. (2005). Searching for "the top" in top-down control. Neuron , 48 (4), 535-8.
- Miller, E., & Cohen, J. (2001). An integrative theory of prefrontal cortex function. Annual review of neuroscience , 24, 167-202.
- Monahan, J. L., Murphy, S. T. & Zajonc, R. B. (2000). Subliminal Mere Exposure: Specific, General and Diffuse Effects. Psychological Science, 11, 462-467.
- Moore, T., & Armstrong, K. (2003). Selective gating of visual signals by microstimulation of frontal cortex. Nature , 421 (6921), 370-3.
- Murray, E. (2007). The amygdala, reward and emotion. Trends in Cognitive Sciences , 11 (11), 489-97.
- Neill, W.T., Valdes, L.A., Terry, K.M., & Corfein, D.S. (1992). Persistence of negative priming: II. Evidence for episodic trace retrieval. Journal of Experimental Psychology: Learning, Memory and Cognition, 18, 993-1000.

- O'doherty, J. (2007). Lights, camembert, action! The role of human orbitofrontal cortex in encoding stimuli, rewards, and choices. Annals of the New York Academy of Sciences , 1121, 254-72.
- O'doherty, J. (2004). Reward representations and reward-related learning in the human brain: insights from neuroimaging. Current Opinion in Neurobiology, 14 (6), 769-776.
- O'doherty, J., Dayan, P., Schultz, J., Deichmann, R., Friston, K., & Dolan, R. (2004). Dissociable roles of ventral and dorsal striatum in instrumental conditioning. Science, 304 (5669), 452-4.
- O'Doherty, J., Kringelbach, M., Rolls, E., Hornak, J., & Andrews, C. (2001). Abstract reward and punishment representations in the human orbitofrontal cortex. Nature Neuroscience , 4 (1), 95-102.
- Ohman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: detecting the snake in the grass. Journal Of Experimental Psychology General, 130 (3), 466-78.
- Paten J. J., Belova, M. E., Morrison, S. E. & Salzman, C. D. (2006). The primate amygdala represents the positive and negative value of visual stimuli during learning. Nature, 439, 865-870.
 - Pavlov, I. P. (1927). Conditioned Reflexes: An Investigation of the Physiological Activity of the Cerebral Cortex. Translated and Edited by G. V. Anrep. London: Oxford University Press.
 - Pearce, J., & Hall, G. (1980). A model for Pavlovian learning: variations in the effectiveness of conditioned but not of unconditioned stimuli. Psychological review, 87 (6), 532-52.
 - Pessiglione, M., Seymour, B., Flandin, G., Dolan, R., & Frith, C. (2006). Dopaminedependent prediction errors underpin reward-seeking behaviour in humans. Nature , 442 (7106), 1042-1045.

- Pessoa, L., Japee, S., Sturman, D., & Ungerleider, L. (2006). Target visibility and visual awareness modulate amygdala responses to fearful faces. Cerebral cortex (New York, NY : 1991), 16 (3), 366-75.
- Pessoa, L., McKenna, M., Gutierrez, E. & Ungerleider, L. G. (2002). Neural processing of emotional faces requires attention. Proc. Nat. Acad. Sci., 99(17), pp. 11458-11463
- Petri, H., & Govern, J. (2004). Motivation: Theory, research, and applications (5th ed.). Belmont, CA: Wadsworth/Thomson Learning.
- Petrovic, P., Kalisch, R., Pessiglione, M., Singer, T., & Dolan, R. (2008). Learning affective values for faces is expressed in amygdala and fusiform gyrus. Social Cognitive and Affective Neuroscience, 3 (2), 109-118.
- Posner, J., Russell, J., & Peterson, B. (2005). The circumplex model of affect: an integrative approach to affective neuroscience, cognitive development, and psychopathology. Development and psychopathology , 17 (3), 715-34.
- Posner, M. (1980). Orienting of attention. The Quartely Journal of Experimental Psychology , 32, 3-25.
- Posner, M. & Cohen, Y.A. (1984). Components of visual orienting. In H. Bouma &
 D.G. Bouwhuis (Eds), Attention and Performance X. Hillsdale NJ : Erlbaum.
 - Pourtois, G., Grandjean, D., Sander, D., & Vuilleumier, P. (2004). Electrophysiological correlates of rapid spatial orienting towards fearful faces. Cerebral cortex (New York, NY : 1991), 14 (6), 619-33.
 - Purcell, D., Stewart, A., & Skov, R. (1996). It takes a confounded face to pop out of a crowd. Perception , 25 (9), 1091-108.
 - Raymond, J. E. (2009). Interactions of Attention, Emotion, and Motivation. In Attention (Ed) N. Srinivasan, Progress in Brain Research Series, Elsevier, Amsterdam, pp. 293-308.

- Raymond, J., & O'Brien, J. (2009). Selective Visual Attention and Motivation: The Consequences of Value Learning in an Attentional Blink Task. Psychological science : a journal of the American Psychological Society / APS. Raymond, J.,
- Fenske, M., & Tavassoli, N. (2003). Selective attention determines emotional responses to novel visual stimuli. Psychological science : a journal of the American Psychological Society / APS , 14 (6), 537-42.
- Raymond, J., Shapiro, K., & Arnell, K. (1992). Temporary suppression of visual processing in an RSVP task: an attentional blink? Journal of Experimental Psychology: Human Perception and Performance , 18 (3), 849-60.
- Reynolds, J., & Chelazzi, L. (2004). Attentional modulation of visual processing. Annual review of neuroscience, 27, 611-47.
- Rolls, E. (2000). The orbitofrontal cortex and reward. Cerebral Cortex , 10 (2), 284-294.
- Rolls, E. (2004). The functions of the orbitofrontal cortex. Brain and Cognition , 55 (1), 11-29.
- Roils, E. (2007). The representation of information about faces in the temporal and frontal lobes. Neuropsychologia, 45, 124-143.

2.

- Rolls, E.T., Sienkiewicz, Z.J., and Yaxley, S. (1989) Hunger modulates the responses to gustatory stimuli of single neurons in the caudolateral orbitofrontal cortex of the macaque monkey. Eur. J. Neurosci., 1, 53–60.
- Rushworth, M., & Behrens, T. (2008). Choice, uncertainty and value in prefrontal and cingulate cortex. Nature Neuroscience , 11 (4), 389-97.
- Russell, J. (1980). A Circumplex Model of Affect. Journal of personality and social psychology , 39 (6), 1161-1178.
- Russell, J. (2003). Core affect and the psychological construction of emotion. Psychological review , 110 (1), 145-72.

- Russell, J. (1994). Is there universal recognition of emotion from facial expression? A review of the cross-cultural studies. Psychological bulletin, 115 (1), 102-41.
- Rutherford, H., O'brien, J., & Raymond, J. (2010). Value associations of irrelevant stimuli modify rapid visual orienting. Psychonomic Bulletin & Review , 17 (4), 536-542.
- Schneider, W., Eshman, A., & Zuccolotto, A. (2002). E-Prime: a User's Guide. Pittsburgh: Psychology Software Tools, 278 pages.
- Schultz, W., Dayan, P., Montague, P. (1997). A Neural Substrate of Prediction and Reward. Science , 275 (5306), 1593-1599.
- Schultz, W. 2000. Multiple reward signals in the brain. Nat. Rev. Neurosci. 1: 199– 207.
- Schultz, W. (2006). Behavioral Theories and the Neurophysiology of Reward. Annual Review of Psychology , 57 (1), 87-115.
- Schultz, W. (2004). Neural coding of basic reward terms of animal learning theory, game theory, microeconomics and behavioural ecology. Current Opinion in Neurobiology, 14 (2), 139-47.
- Schultz, W., & Dickinson, A. (2000). Neuronal coding of prediction errors. Annual review of neuroscience , 23, 473-500.
- Schultz, W., Tremblay, L., & Hollerman, J. (1998). Reward prediction in primate basal ganglia and frontal cortex. Neuropharmacology, 37 (4-5), 421-429.
- Shore, D., & Heerey, E. (2010). The value of genuine and polite smiles. Emotion (in press) Skinner, B. F. (1935). Two types of conditioned reflex, and a pseudo type. Journal of General Psychology, 12, 66-67.
- Small, D., Gregory, M., Mak, Y., Gitelman, D., Mesulam, M., & Parrish, T. (2003). Dissociation of neural representation of intensity and affective valuation in human gustation. Neuron , 39 (4), 701-11.

- Smith, A.P., Henson, R.N., Dolan, R.J. Rugg, M.D. (2004). fMRI correlates of the episodic retrieval of emotional contexts. Neuroimage, 22, 868-78.
- Streit, M. et al. (1999) Neurophysiological correlates of the recognition of facial expressions of emotion as revealed by magnetoencephalography. Cognit. Brain Res. 7, 481–491.
- Summerfield, C. & Egner, T. (2009). Expectation (and attention) in visual cognition. Trends in Cognitive Science, 13 (9), 403-409.
- Sutton, R. S. & Barto, A. G. 1998 Reinforcement learning: an introduction. Cambridge, MA: MIT Press.
- Tranel, D., Damasio, H., Damasio, A.R. (1997) A neural basis for the retrieval of conceptual knowledge. Neuropsychologia, 35, 1319-1327.
- Theeuwes, J. (1991). Exogenous and endogenous control of attention: the effect of visual onsets and offsets. Perception & Psychophysics , 49 (1), 83-90.
- Theeuwes, J. (1992). Perceptual selectivity for color and form. Perception & psychophysics , 51 (6), 599-606.
- Theeuwes, J. (1994). Stimulus-driven capture and attentional set: selective search for color and visual abrupt onsets. Journal of Experimental Psychology: Human Perception and Performance, 20 (4), 799-806.

Thorndike, E. L. (1911). Animal intelligence. New York: Macmillan

- Tipper, S. P. (1985). The negative priming effect: inhibitory priming by ignored objects. The Quarterly Journal of Experimental Psychology, 37 (4), 64-70.
- Tipper, S. P. (2001). Does negative priming reflect inhibitory mechanisms? A review and integration of conflicting views. The Quarterly Journal of Experimental Psychology, 54A (2), 321-343.
- Tipples, J., Atkinson, A., & Young, A. (2002). The eyebrow frown: a salient social signal. Emotion , 2 (3), 288-96.

- Tomita, H., Ohbayashi, M., Nakahara, K., Hasegawa, I., & Miyashita, Y. (1999). Topdown signal from prefrontal cortex in executive control of memory retrieval. Nature, 401 (6754), 699-703.
- Tong, F. (2003). Primary visual cortex and visual awareness. Nature reviews Neuroscience, 4 (3), 219-29.
- Tong, F., & Nakayama, K. (1999). Robust representations for faces: evidence from visual search. Journal of Experimental Psychology: Human Perception and Performance, 25 (4), 1016-35.
- Treisman, A., & Gelade, G. (1980). A feature-integration theory of attention. Cognitive psychology , 12 (1), 97-136.
- Valentin, V., & O'doherty, J. (2009). Overlapping Prediction Errors in Dorsal Striatum During Instrumental Learning With Juice and Money Reward in the Human Brain. Journal of Neurophysiology , 102 (6), 3384.
- Vuilleumier, P., & Schwartz, S. (2001). Emotional facial expressions capture attention. Neurology, 56 (2), 153-8.

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- Vuilieumier, P., Armony, J., Driver, J., & Dolan, R. (2001). Effects of attention and emotion on face processing in the human brain: an event-related fMRI study. Neuron , 30 (3), 829-41.
- Williams, M., Moss, S., Bradshaw, J., & Mattingley, J. (2005). Look at me, I'm smiling:
 Visual search for threatening and nonthreatening facial expressions. Visual
 Cognition , 12 (1), 29-50.
- Wise, R. (2004). Dopamine, learning and motivation. Nature reviews Neuroscience, 5 (6), 483-94.
- Wolfe, J. (1994). Guided Search 2.0 A revised model of visual search. Psychonomic Bulletin & Review , 1 (2), 202-238.
- Woodman, G., Vogel, E., Luck, S. (2001). Visual Search Remains Efficient when Visual Working Memory is Full. *Psychological Science*, 12 (3), 219-224

- Yantis, S. (1998). Control of visual attention. In H. Pashler (Ed.), Attention. Hove: Psychology Press, 233-256.
- Zajonc, R. (1968). "Attitudinal effects of mere exposure." Journal of Personality and Social Psychology Monographs, 9(2, Pt.2)
- Zajonc, R. (2001). Mere Exposure: A Gateway to the Subliminal. Current Directions in Psychological Science, 10, 224-228.

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Appendices

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Appendix A

	z score				
	-1	-0.5	0	0.5	1
Face 1				0.72	
Face 2	0.03	0.32	0.32	0.48	0.93
Face 3				0.72	
Face 4 Face 5	-0.05 0.09	0.25	0.48	0.72	0.98
Face 6	0.04	0.21	0.39	0.56	0.73
Face 7	0.29	0.44	0.59	0.74	0.89

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Table A.1 Females, angry condition. Interpolated faces and its corresponding interpolated threshold according to the predicted z score.

Table A.2 Males, angry condition. Interpolated faces and its corresponding interpolated threshold according to the predicted z score.

	-1	-0.5	z score 0	0.5	1
Face 1	0.08	0.24	0.20		0.71
Face 2	0,08		0,39		0,71
Face 3	-0,01	0,16	0,34	0,51	0,68
Face 4	0,29	0,36	0,43	0,50	0,57
Face 5 Face 6	0,11 -0,06	0,29 0,06	0,48 0,18	0,66 0,30 0,30	0,85 0,42
Face 7	0,05	0,27 0,20	0,49 0,32	0,70	0,92 0,55

Table A.3 Females, happy condition. Interpolated faces and its corresponding interpolated threshold according to the predicted z score.

	z score				
	-1	-0.5	0	0.5	1
Face 1	0.17		0.20	0.26	
Face 2	0.14	0,23	0.29	0,38	0,42
Face 3			0.37	0.45	0.54
Face 4		0,29	0,37	0,45	0,34
Face 5	0,16	0,24	0,33	0,41	0,50
Face 6	0,13	0,20	0,27	0,35	0,42
Face 7	0,06	0,16	0,26	0,35	0,45

Property P

Table A.4 Males, happy condition. Interpolated faces and its corresponding interpolated threshold according to the predicted z score.

		z score				
	-1	-0.5	0	0.5	1	
Face 1		6				
Face 2	0,17	0,24	0,32	0,40	0,47	
Face 3	0,21	0,28	0,36	0,44	0,51	
Face 4	0,24	0,31	0,39	0,47	0,54	
Face 5	0.04	0,16	0,28	0,39	0,51	
Face 6	0,11	0,19	0,27	0,36	0,44	
Face 7	0,21	0,27	0,33	0,39	0,45	
2.00	0,20	0,2.0	0,00	0,44	0,02	

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Table A.5 Females, fearful condition. Interpolated faces and its corresponding interpolated threshold according to the predicted z score.

	z score									
	-1	-0.5	0	0.5	1					
Face 1	0.15	0.28	0.42	0.56	0.70					
Face 2	0.22	0.29	0.37	0.44	0.52					
Face 3				8						
Face 4	0,13	0,24	0,34	0,45	0,55					
Face 5	-0,06	0,11	0,29	0,46	0,64					
Face 6	0,23	0,33	0,42	0,52	0,61					
Face 7	0,08	0,28	0,49	0,70	0,90					

Section 1.

Table A.6 Females, fearful condition. Interpolated faces and its corresponding interpolated threshold according to the predicted z score.

	z score										
	-1	-0.5	0	0.5	1						
Face 1	0.22	0.29	0.36	0.43	0.50						
Face 2	0.20	0.27	0.35	0.42	0.50						
Face 3				O,42							
Face 4	0,30	0,34	0,38	0,42	0,46						
10.10	0,19	0,32	0,45	0,57	0,70						
Face 5					Cell .						
Face 6	0,28	0,39	0,50	0,61	0,72						
Face 7	0.21	0,38	0,55	0,73	0,90						
	0,21	0,04	0,47	0,59	0,72						

6.1

Appendix B

Counterbalancing conditions in the assignment of Value to Stimuli Learning protocol 1 and 2

Table A.7. Assignment of learned value to each face images during the learning task in the phase I of learning protocol 1 and 2. These counterbalancing conditions involves 12 face images (6 pairs) and 12 value assignment conditions. Face images pairs were constant across the different counterbalancing conditions. Valence assignment to images is represented by G that stands for "gain" and L that stands for "loss". Predictability assignment is represented by H that stand for "high" probability of outcome and L that stands for "low" probability of outcome. N stands for No-Outcome.

							Learning Condition						
		1	2	3	4	5	6	7	8	9	10	11	12
Pair 1	02.0	HG	HL	Ν	HG	ĤL	Ν	LG	LL	Ν	LG	LL	Ν
		LG	LL	N	l_G	LL	Ν	HG	HL	Ν	HG	HL	Ν
Pair 2	11.00	HL	HG	HL	N	Ν	HG	LL	LG	LL	Ν	Ν	LG
		LĽ	LG	LL	N	Ν	LG	HL	HG	HL	Ν	Ν	HG
Pair 3	Call Call	Ν	Ν	HG	нL	HG	HL	Ν	Ν	LG	LL	LG	LL
	(15 4	Ν	Ν	LG	LL	LG	LL	Ν	Ν	HG	HL	HG	LG

												Appendice	35 I/O
					Learning Condition (continuation)								
17 mil 12 121		<u> </u>	2	3	4	5	6	7	8	9	10	11	12
Pair 4	T	HG	HL	Ν	HG	HL	Ν	LG	LL	Ν	LG	LL	Ν
		LG	LL	Ν	LG	LL.	Ν	HG	HL	Ν	HG	HL	Ν
Pair 5		HL	HG	HL	Ν	N	HG	LL	LG	LL	Ν	Ν	LG
	1	LL	LG	LL	N	N	LG	HL	HG	HL	Ν	Ν	HG
Pair 6		N	Ν	HG	ΗL	HG	HL	Ν	Ν	LG	LL	LG	LL
		N	Ν	LG	LL	LG	LL	Ν	Ν	HG	HL	HG	LG

Appendix C



Figure A.1 Assignment of Stimuli per experimental block in Chapter 3.



Appendix D

Figure A.3 Distribution of correct response times in Experiment 8 for each value condition. Bars in grey depict rapid resumption responses (i.e., the increased frequency of correct RTs within 500 ms of display onset in all but in the first epoch).