Upper and Lower Visual Field Differences: An Investigation of the Gaze Cascade Effect

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ABSTRACT

The purpose of the current thesis was to investigate the role of gaze direction, when making preference decisions. Previous research has reported a progressive gaze bias towards the preferred stimuli as participants near a decision, termed the gaze cascade effect (Shimojo, Simion, Shimojo & Scheir, 2003). The gaze cascade effect is strongest during the final 1500 msec prior to decision (Shimojo et al.). Previous eye-tracking research has displayed natural viewing biases towards the upper visual field. However, previous investigations have not investigated the impact of image placement on the gaze cascade effect. Study 1 investigated the impact of presenting stimuli vertically on the gaze cascade effect. Results indicated that natural scanning biases towards the upper visual field impacted the gaze cascade effect. The gaze cascade effect was reliably seen only when the preferred image was presented in the upper visual field. Using vertically paired stimuli study 2 investigated the impact of choice difficulty on the gaze cascade effect. Similar to study 1 the gaze cascade effect was only reliably seen when the preferred image was presented in the upper visual field. Additionally choice difficulty impacted the gaze cascade effect where easy decisions displayed a larger gaze cascade effect than hard decisions. Study 3 investigated if the gaze cascade effect is unique to preference decisions or present during all visual decisions. Judgments of concavity using perceptually ambiguous spheres were used and no gaze cascade effect was observed. Study 3 indicated that the gaze cascade effect is unique to preference decisions. Results of the current experiments indicate the gaze cascade effect is qualified by the spatial layout of the stimuli and choice difficulty. Results of the current experiments are consistent with previous eye-tracking research demonstrating

biases towards the upper visual field and offering support for Previc's theory on how we interact in visual space.

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CHAPTER 1
GENERAL INTRODUCTION

Everyday we are bombarded by situations that force us to make decisions or to choose one item over another. Many forced choice situations such as deciding between two similar objects or selecting which face is more attractive have been termed preference decisions. It is widely believed that preference or attractiveness decisions are highly subjective and rely strongly on personal taste (Reber, Schwarz, & Winkielman, 2004; Wolf, 1992). Self-reflection supports this hypothesis. For example, if you were asked post-hoc why you chose the item or face that you did; you would likely be able to provide multiple reasons for your choice (it was their blue eyes or they had a very distinctive nose). Past research has demonstrated that many of these choices are less subjective than originally thought and that they can be linked to factors that are appreciated cross-culturally (Jones & Hill, 1993; Rhodes et al., 2001), such as familiarity, averageness and symmetry (for a review see Thornhill & Gangestad, 1999). These patterns are particularly evident in ratings of facial attractiveness, indicating that many factors influence our personal preferences.

In addition to understanding what we like it is also important to understand how our preferences are formed. Understanding how preferences are formed is important as our preferences guide many of our actions and behaviours (Hosoda, Stone-Romero, & Coats, 2003). For instance, infants prefer and will gaze longer at faces previously rated as attractive by adults (Fantz, 1964; Langlois et al., 1987; Slater & Quinn, 2001). Thus, understanding how preferences are formed is an important part of understanding why social interactions are initiated. Further, understanding how preferences are formed could also lead to valuable information regarding how or if these preferences could be influenced.

The current thesis will review several lines of research that have attempted to describe what we prefer or how preference decisions are made including: facial attractiveness, the mere-exposure effect, associations with attractiveness and reward, and the gaze cascade effect. Visual field differences and how they relate to preference formation will also be discussed and investigated by focusing on the gaze cascade effect. The gaze cascade effect is a progressive bias of orienting behaviours such as our gaze, measured using fixations, towards the preferred stimulus as we near our decision (Shimojo, Simion, Shimojo, & Scheier, 2003). Specifically how the gaze cascade effect is impacted when stimuli are presented vertically (i.e. in the upper and lower visual fields) rather than horizontally (i.e. across the right and left visual fields) will be investigated.

Attractiveness Judgments

It is widely believed that attractiveness is individually assessed and the result of personal subjective biases. The well-known clichés 'beauty is in the eye of the beholder' and 'don't judge a book by its cover' indicate the popularity of these beliefs and the desire for everyone to be treated equally (Langlois et al., 2000). On the other hand, a large body of empirical evidence as well as our common sense tells us this is not necessarily the case. For example, runway models share many characteristics with one another and are widely thought of and described as being beautiful. You do not need to rely on your own individual experience to know that they are attractive.

Previous research has identified facial characteristics that contribute to our preferences such as averageness and symmetry. Preferences have often been related to how familiar an object is evidenced by people indicating that they prefer an object/face that they have seen before over a novel image. Therefore, theoretical models have attributed our preferences to how similar an object is to a known template for that object (Langlois et al., 1987; Linn, Reznick, Kagan & Hans, 1982), suggesting that when we assess preference for an object/face we are comparing it to a known template that we have previously stored. These templates are created by our own cumulative experiences with a specific stimulus set and separate templates would be created for each stimulus set. It has been observed that the more similar an item is to a template, the more familiar it is and the more it is preferred (Langlois & Roggman, 1990).

Faces are a stimulus set of particular interest to researchers as they are very common stimuli that we are exposed to on a regular basis. Several investigations have attempted to define the face template exploring the contributions of qualities such as averageness, symmetry and sexual dimorphism (for a review see Rhodes, 2006). Despite significant research it has been difficult to define a template that fully explains our facial preferences. Similarly preferences for average and symmetrical cars, watches and birds have also been identified (Halberstadt & Rhodes, 2003), suggesting that preferred objects across stimulus sets may share some important characteristics.

Past investigations have identified ways that attractiveness influences our behaviours. A meta-analysis of experimental studies concluded that attractive people receive better treatment (increased compensation levels) and are more likely to be hired for a job or to be perceived as having higher qualifications for a job (Hosoda et al., 2003). Explanations such as implicit personality theory (Ashmore & Turnia, 1980) and the lack of fit model (Heilman, 1983) agree that individuals are initially categorized on physical characteristics that are readily visible.

Implicit personality theory investigates the role of stereotypes and associated behaviours. Implicit personality theory posits that positive personality characteristics are associated with attractive individuals. It is defined as the inferential relations between attributes of personality

(Ashmore & Turnia, 1980). This theory has been supported when sex stereotypes have been investigated. Similarly, Heilman's (1983) lack of fit model suggests that we have a predefined expectation of what type of individual will succeed in a specific situation. Subsequently success is defined by how closely the individual fits with the predefined characteristics of the individual we had identified. According to this model one of our predefined characteristics of a successful individual will be linked to their attractiveness.

Interestingly, children rated as more attractive experience preferential treatment, demonstrated through less severe punishments and higher grades (Baugh & Parry, 1991; Grammer, Fink, Moller, & Thornhill, 2003; Langlois et al., 2000). Furthermore, positive personality traits are perceived to be associated with attractive people (Dion, Berscheid, & Walster, 1972; Kniffen & Wilson, 2004; Snyder, Tanke, & Berscheid, 1977) indicating that attractiveness advertises valuable information that relates to how we interact with one another. Due to the powerful influence attractiveness has on our behaviour it is important to understand how these preferences are formed or what causes us to prefer one object/face over another.

Attractiveness and Reward

Functional imaging evidence offers further evidence that beauty is not defined by our subjective preferences. FMRI studies demonstrate that viewing attractive faces activates anatomical correlates associated with reward. Our tendency to increase interactions with preferred images has been related to our interpreting preferred images as a reward, especially images of attractive faces. Viewing attractive faces stimulates the ventral striatum, specifically when the face is gazing at the viewer (Kampe, Frith, Dolan, & Frith, 2001). The ventral striatum has been linked to dopaminergic brain regions, which are responsible for reward prediction (Schultz, Dayan, & Montague, 1997). Similar activation patterns have been observed cross culturally providing support that attractive faces share universal qualities, such as symmetry and averageness.

Activation of dopaminergic brain regions may also offer insight into how the attractiveness of an individual shapes our behaviours towards them. Activation of our reward systems is associated with approach behaviours suggesting that we are more likely to approach an individual whom we find attractive (Schultz et al., 1997). These findings also further support the maxim that what is beautiful is good.

Kampe and colleagues (2001) demonstrated that activation patterns to attractive faces were mediated by the gaze direction of the model. Activation levels of the ventral striatum increased when the attractive face was looking at you as opposed to when it displayed an averted gaze direction. Actually, activation in the ventral striatum decreased when an attractive face was displayed with an averted gaze suggesting that we desire the attention from attractive faces and are ‘dissatisfied’ when they direct their attention away from us.

The Mere Exposure Effect

The mere exposure paradigm relates preference of an object to familiarity, or perhaps more accurately a lack of novelty. In the mere-exposure paradigm, exposure consists of simply making the stimulus accessible to an individual’s sensory receptors. The stimuli can be presented in a subliminal (flash presentations that do not allow enough time for the image to be processed at a conscious level) manner so that the participant is not even aware of the stimulus presented. The effects of repeated exposures are measured by assessing the participant’s preference for the objects after exposure (Zajonc, 2001).

Zajonc (1968) postulated that simply exposing someone to a word or symbol increases his or her liking for that object. A review of studies linking word frequency to their evaluative meanings indicated positive words are used more frequently, suggesting a link between positive affect and exposure. Extending this finding Zajonc presented nonsense syllables multiple times predicting that increasing the number of exposures would lead to more positive associations towards those nonsense syllables. The bulk of experimental evidence displayed this trend suggesting that increasing familiarity with a word/symbol creates more positive associations.

Interestingly, investigations using the mere-exposure paradigm demonstrate that participants may indicate preferences within categories of abstract objects such as octagons when they are unable to provide a subjective reason for liking the object. Although there may not be a subjective or after the fact explanation of why one octagon was selected over another there is an objective explanation. Kunst-Wilson and Zajonc (1980) observed that participants display increased preferences for objects that were previously presented even if participants were not aware of the previous presentations. In mere exposure studies there is an objective history of previous exposures that the participant is not aware of. Participant's lack of awareness of these previous exposures is indicated by their inability to remember previously viewed objects at a rate greater than chance. However, when pairs of objects are presented they will indicate a preference at greater than chance levels for the object/polygon that was previously presented. Increased preference for subliminally presented stimuli indicates that affective discriminations are possible without extensive participation of the cognitive system.

Zajonc (2001) has explained the mere exposure effect as a form of classical conditioning. The conditioned stimulus (CS) is the repeatedly exposed stimuli. The conditioned response (CR) is the indicated preference for the CS. The question that remains is what is the unconditioned stimulus (US)? Zajonc hypothesizes that the US is the absence of a noxious or aversive event, thus, the absence of a negative event results in the positive approach behaviour of participants (CS). Zajonc postulates that our natural tendency towards a new stimulus is one of tentative exploration, which elicits a combination of approach and avoidance tendencies. The repeated exposures and absence of a noxious event cause our avoidance tendencies to decrease and result in a positive affect becoming attached to the repeated stimulus.

Mandler, Nakamura and Van Zandt (1987) were interested if the mere exposure effect could be extended to other types of judgment, such as brightness and darkness, positing that affective preference judgments in the mere exposure paradigm may be mediated by a judgment of familiarity that is produced by repeated exposures. These activation effects are assumed to be context free and are simply increasing the accessibility of the activated image. Thus, the familiarity generated by prior exposures could be related to any judgment about a stimulus. Using identical methods as Kunst-Wilson and Zajonc (1980), Mandler and colleagues extended the paradigm to include judgments of brightness and darkness. They found that judgments of preference, brightness and darkness all differed significantly from chance but did not significantly differ from one another, allowing them to conclude that the resulting activation from mere exposures can be related to any relevant dimension of the stimuli.

Previous theories outlined above describe why we prefer one image to another; however, they neglect to explain how these preferences are formed. More recently how preferences are formed has been investigated using eye-tracking methods (Simion & Shimojo, 2006; Simion & Shimojo, 2006; Shimojo et al., 2003; Glaholt & Reingold, 2009). Shimojo et al. (2003) postulated that we look longer and interact more with stimuli (faces and abstract objects) that we like or prefer and that this orienting bias increases our preference for the image, termed the gaze cascade effect. The gaze cascade effect has been observed across stimulus sets though it is stronger when cognitive biases are weaker such as with abstract objects.

Gaze Cascade Effect

Shimojo and colleagues (2003) investigated how eye movements influence preference decisions. They predicted that orienting behaviour such as gaze is important in preference formation due to its relation with exposure; specifically, gaze leads to foveation of an object, which is associated with deeper sensory processing. Their findings indicate that gaze plays an active role in preference formation. The role of gaze is a two-part process. The initial process is linked to preferential looking (Birch, Shimojo, & Held, 1985) the second process is the mere exposure effect (Zajonc, 1968). Together these processes create a positive feedback loop that leads to an orienting bias. They observed that as you near the point of decision there is a progressive bias towards fixating at the to be chosen stimulus, termed the gaze cascade effect.

A series of experiments was conducted to investigate several factors such as novelty and strength of cognitive biases to demonstrate the robust nature of the gaze cascade effect methods (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2006). The gaze cascade effect was observed when viewing computer generated faces, abstract objects, and when a gaze contingent display limited the viewing window and increased task difficulty. Additionally, Shimojo et al. (2003) were able to artificially induce preferences by manipulating the viewing times for different stimuli. Finally, the effect was still present when viewing was interrupted prior to a decision being made.

In their initial experiment Shimojo and colleagues (2003) investigated gaze patterns during preference decisions. They presented pairs of computer-generated faces and allowed participants an unlimited amount of time to make a preference decision. They used two control tasks to ensure that patterns could be attributed exclusively to preference formation and not to decision-making processes: which face is rounder (roundness) and which face is less attractive (dislike). They also manipulated level of difficulty regarding the attractiveness decisions: including face pairs that either maximized (attractiveness-easy) or minimized (attractiveness-hard) the levels of attractiveness between the faces.

Shimojo and colleagues (2003) conducted a gaze likelihood analysis for each of their conditions (roundness, dislike, attractiveness-easy, attractiveness-hard). Gaze likelihood analysis creates a growth curve for each trial type that displays the percentage of time spent looking at the preferred image prior to making a decision. If no viewing bias occurs growth curves would start and end at chance levels indicating that participants were equally likely to be looking at either image. At trial onset all 4 curves (roundness, dislike, attractiveness-easy, attractiveness-hard) started at chance levels, indicating that there was no initial gaze bias towards either image. However, in the attractiveness conditions as participants neared a decision their gaze was biased towards the selected image at a level significantly higher than chance in fact during some trials up to 83% of their gaze was directed towards the selected image. This progressive bias towards the selected image was termed the gaze cascade effect and was particularly strong in the final second before the decision was made. This trend was observed for both the easy and difficult conditions, though the gaze cascade effect was larger in the difficult condition. Examination of the likelihood curves illustrated that the face roundness task and face dislike task did not display biases towards the selected image, indicating that the observed gaze bias was not the result of reaching a decision or attempting to remember which image was selected. Further, these patterns were not related to length of time to reach a decision, as there was no correlation between these two variables. The final 1.67 seconds prior to decision was used as the starting point for the gaze likelihood analysis as this represented approximately the mean decision minus one standard deviation.

The results from this study led the researchers to develop a dual-contribution model for preferential decision-making (see Figure 1-1; Shimojo et al., 2003). This model includes input from orienting behaviour structures such as gaze and from a cognitive assessment system. The cognitive systems are thought to be responsible for comparing the current stimuli to a known template. Although the model incorporates feedback from cognitive assessment systems, it is thought that one's cognitive representations are relatively stable and that short-term influences would not be substantial. According to this model, orienting behaviours also incorporate feedback, where gaze biases increase exposure and lead to increased preferences similar to the mere exposure effect. The decision module is then responsible for integrating the information from these two systems.

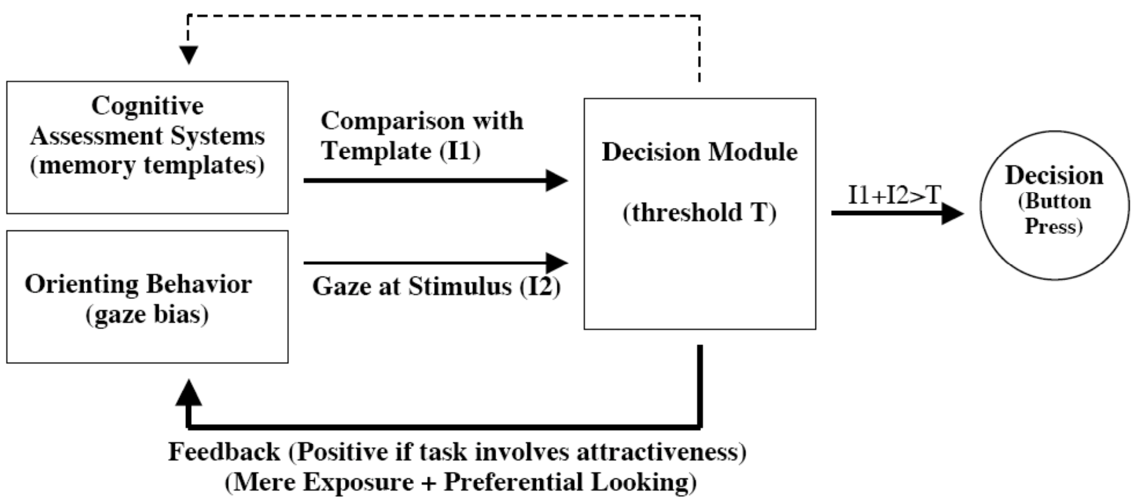

Figure 1-1. Dual contribution model of preference formation as proposed by Shimojo, Simion, Shimojo, & Scheier (2003). Block diagram of our dual contribution model. The two inputs, I1 and I2, are integrated in the decision module and compared with a "consciousness threshold" T; when T is reached the decision is made. Feedback from the decision module into the structures from which the inputs originate enhances their respective signals. When the task involves attractiveness, the feedback becomes positive, through the interaction between exposure and preferential looking. It is this positive feedback loop that makes the critical difference in gaze between preference and other tasks. The dashed feedback line into the cognitive assessment

systems illustrates the general belief that cognitive representations flexible yet stable, thus cannot be changed easily by short-term exposure.

This model explains the current data, specifically in regards to the larger gaze cascade that is observed in the difficult attractiveness decisions. When the cognitive biases for a decision are weak (i.e. difficult decisions or abstract stimuli) orienting systems will play a larger role in the decision making process. To further examine the importance of orienting behaviours Shimojo and colleagues (2003) tested the gaze cascade effect using abstract shapes. They examined preference formation for abstract shapes using a similar procedure as they used for faces. This condition produced the strongest gaze cascade effect. The gaze cascade effect for abstract objects was significantly stronger than for faces. Similar to the difficult face task this could be the result of weak cognitive biases towards the selected stimuli.

The robustness of Shimojo and colleagues (2003) dual-contribution decision model was further tested against several other factors; the first factor examined was novelty (Shimojo et al., 2003). In real world situations we are repeatedly presented with the same stimuli across multiple situations. Investigating if the gaze cascade would still be present if stimuli had been previously viewed, participants were tested on two consecutive days using identical stimulus pairs. On 23.3% of the trials participants selected the opposite face on day 2. However, the gaze cascade effect was still present on both days across all trials. Indicating that even when stimuli are no longer novel or when opposing stimuli are selected the gaze cascade is present.

An important test of this model is whether purposefully biasing a participant's gaze will influence their preferences (Shimojo et al., 2003). This effect must be observable for the dual-contribution model to be valid. To manipulate gaze duration the faces from each pair were displayed separately, presenting one face for a longer duration than the other. Multiple conditions were used so that faces were presented in the center of the screen as well as in the periphery to ensure that differences could not be explained by display properties. Faces were presented in repetitions of 2, 6 and 12 so all faces were seen the same number of times but for different durations. Additionally, to further establish whether this effect is unique to preference judgments the original control conditions of roundness and less attractive were included. Participant preferences were biased towards the face displayed longer when faces were repeated 6 or 12 times. However, when faces were presented only twice there was no selection bias towards the face that was displayed longer.

Faces can be processed holistically and can potentially be biased by unique featural details, which might result in decisions of facial attractiveness being processed differently than preferences for more abstract stimuli (Simion & Shimojo, 2006). To examine the importance of holistic processing on facial preferences a gaze contingent display was used to view faces. A gaze contingent display forces participants to assess each feature independently and to then integrate featural information to create one image; abstract objects would not contain the same level of featural data (A gaze contingent display limits the participant's view to a small peephole sized area). This technique also increased the difficulty of the decisions allowing for further evaluation of the decision model. Similar to their previous investigations a roundness control task was used.

Simion and Shimojo's (2006) results indicated that the attractiveness task was more difficult than the control task as indicated by longer average response times. Increased response times also confirmed that the use of a gaze contingent display increased task difficulty. Due to the increase in response time the last 14 seconds prior to decision were used rather than the final 2.5 seconds as in previous analyses. This increased length of analysis produced a longer gaze cascade allowing for a more detailed investigation of the role of gaze in preference decisions. Despite methodological differences a similar gaze cascade was observed, at times reaching a magnitude of 84%. However, the cascade was observed for 7.5 seconds prior to decision rather than for 800-1200 millisecond (msec) as in the full viewing condition.

The early appearance of the gaze cascade during longer trials displays further evidence that orienting systems are playing an active role in preference formation. These results confirm that the gaze cascade effect is not a result of participants focusing on their choice, as both control tasks failed to display the pattern. It is possible that the participants have made their choice prior to manually entering a decision and further sampling is only occurring to reconfirm their choice.

Simion and Shimojo (2007) tested the possibility that a decision is made unconsciously prior to a button press by examining the gaze cascade effect with interruption. Participants were instructed to make and enter their preference decision when they were ready. As a result, some decisions were made when the stimuli were present and some after they had been removed from the screen (interrupted). They hypothesized that if the gaze cascade is the result of liking the stimulus better (and not decision making) then the bias should continue to be present after the decision has been made. However, if the bias is a product of the decision making process (as they believe) it will disappear or be reduced after the participant has made their decision.

Based on their previous research they used randomly selected presentation times with a mean of 3105 msec (ranging from 800-5000 msec). The trials where participants had enough time to decide (when the images were still displayed at time of button press) displayed the expected gaze cascade effect. Interestingly, as hypothesized by the dual-contribution model for preferential decision-making, the gaze bias significantly decreased post-decision, indicating that the orienting bias cannot be attributed to a general state of liking but to the decision making process itself. In the trials where the stimuli were removed prior to the point of decision there was no obvious gaze cascade, yet, 58% of the gaze was directed to the eventual choice demonstrating a slight gaze bias that might indicate the onset of the gaze cascade. Interestingly, for a brief period of time after the stimuli were removed from the screen participants gazed at the previous location of their choice, prior to their final button press. This residual bias was interpreted as participants needing to complete the gaze cascade effect by continually looking where the preferred face was previously displayed. This series of studies indicates a strong role of orienting behaviours in the process of preference decisions.

Shimojo, Simion and colleagues (2003; 2006; 2007) have presented a case for the role of orienting biases in preference decisions, suggesting that how we interact with an object influences our preferences. They infer that how we look at an image contributes to our level of preference for an object; however, many questions regarding how preference decisions develop remain unanswered. Specifically if their effect can be replicated to other real world stimulus sets, such as, photographs?

Glaholt and Reingold (2009) used identical methods to Shimojo, Simion and colleagues (2003; 2006; 2007) replacing faces with photographs of artwork. The goal of their investigation was to further investigate the time course of the gaze cascade effect and provide further evidence that it is a process unique to preference decisions, regardless of stimuli type. The control task required participants to indicate which photo was taken most recently. They observed a similar gaze cascade pattern in all of their preference conditions (2-alternative forced choice, gaze contingent display and 8- alternative forced choice). Interestingly, they also observed the gaze cascade effect during their control task, which Simion, Shimojo and colleagues did not observe. Simion, Shimojo and colleagues provided graphical data and qualitative interpretations stating that the gaze cascade effect was not present during their control trials. Glaholt and Reingold (2009) conclude based on their results that the gaze cascade effect might be associated with visual decisions and is not unique to preference decisions.

Though both investigations used similar methodology there are several potential explanations for why different results were observed during their control trials. One possible explanation could be that the control tasks between the two investigations are qualitatively different and may be measuring different things. For example, the face roundness task used by Shimojo and colleagues (2003) would have involved an objective description of a round face that participants would need to evaluate each face against and that this evaluation would not be related to preference. Similarly the face dislike task used, though semantically similar, is known to engage different brain areas than those associated with preference. It is possible that the control task used by Glaholt and Reingold (2009), which photo was taken more recently, is more difficult to judge and possibly related to participant preferences, thus inducing a gaze cascade effect. Further research is required to investigate the presence of the gaze cascade effect in other visual decisions.

Eye-tracking and the Upper Visual Field

It is important to note that Glaholt and Reingold (2009), Shimojo and colleagues (2003), and Simion and Shimojo (2006 & 2007) presented their stimuli horizontally with one image appearing in the left visual field and one image appearing in the right visual field. Past eye-tracking and neuropsychology research has indicated that there are viewing differences in the upper and lower visual fields that may impact the gaze cascade effect. Specifically, more time is spent in the upper visual field during free-viewing tasks.

Previous investigations of the gaze cascade effect (Glaholt & Reingold, 2009; Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007) have positioned images horizontally on the screen in the left and right visual fields. However, previous studies have shown visual search differences in the upper and lower visual fields (VF) that may impact the gaze cascade effect.

Past eye-tracking studies have revealed differential viewing patterns in the upper and lower visual fields. Previc (1996) investigated the role of attentional and oculomotor influences on visual search using conjunction search tasks (CS; the target is defined as a unique combination of at least two features and the distractor shapes differ on one feature) and feature search tasks (FS; the target differs from a distractor shape by a single feature) visual search tasks. Previc observed a slight trend favouring the upper visual field. Participants spent 14% of their time looking in the upper visual field compared to 11.3% in the lower visual field when they were looking away from the horizontal meridian. A similar effect was observed favouring the left visual field (12.3%) over the right visual field (9.7%) when participants were looking away from the vertical meridian. However, neither of these trends was significant. Finally, asymmetry in the direction of the first saccade was also observed indicating the initial saccade favoured the upper hemifield.

Earlier investigations of eye-movements have revealed similar biases to the upper visual field. Gould and Schaffer (1965) using numeric stimuli sought to investigate eye-movement patterns in visual scanning when the number of positive instances of a target is varied. They observed a viewing pattern where eye-movements moved from central fixation to the upper left corner of the visual display and continued to scan from left to right. They divided the viewing area into a 3 X 3 matrix to further investigate viewing patterns. The result of their analysis indicated that that the left side of the display was under scanned (18.5%) compared to the right side (41.6%). They also found that more fixations (38.4%) fell into the upper third of the matrix than the lower third of the matrix (30.2%). No statistical interpretations of the data were provided so it is unknown if these differences reach statistical significance.

Chedru, Leblanc, and Lhermitte (1973) used eye-tracking methods to investigate visual search patterns in normal and brain-damaged subjects. They noted significant differences in which visual quadrant was explored first. During their task they found that in 35% of trials the upper left visual quadrant was first to be explored. Additionally, in 20% of trials the upper right quadrant was first to be explored. They also found that 52.5% of time was spent exploring the left hemispace. Additionally, the left upper quadrant was explored 29% of the time significantly longer than any of the other visual quadrants.

Hall (1985) investigated the efficiency of visual search patterns in hearing, deaf and learning disabled children. They found that 56% of first eye movements were directed to the top center and 27% were directed at the bottom center. They also observed a tendency for all groups to search the top hemispace first when no information on target position was provided. Additionally, investigation of search efficiency revealed that participants used efficient search strategies in the lower hemispace only 28% of the time compared to 50% of the time in the upper hemispace.

A review of past eye-tracking research indicates that more time is spent in the upper visual field. Also, the first saccade is more likely to be made to the upper visual field. These oculomotor differences have been linked to visual search patterns associated with reading. In addition to these findings neuropsychology literature provides alternate explanations linked to how we interact with objects in visual space.

Neuropsychology of Visual Field Differences

Christman and Niebauer (1997) summarize visual field differences concluding advantages in the lower visual field (LVF) in simple reaction time, global processing and near stereoscopic vision. Upper visual field (UVF) advantages have been found for local processing, stereoscopic vision, visual search and visual attention. Previc (1990) hypothesized that upper and lower visual field differences are related to how objects are processed in space predicting the LVF is more involved in near visual space relying on global processing. Additionally, the specializations of the LVF are primarily sensory in nature (i.e. low spatial/high temporal frequency analysis such as reaching or tactile manipulations), whereas, the UVF is more involved in far visual space relying on local perceptual processing (e.g. visual search tasks). The specializations of the UVF are more attentional or perceptual in nature. Previc further suggests that near space or the lower visual field has greater representation in the dorsal visual pathway whereas the upper visual field has greater representation in the ventral pathway. The following paragraphs will further explain this prediction.

Previc (1990) hypothesizes that functional specialization of visual pathways is related to the fundamental division of the primate world into near and far space that developed as a result of increasing ecological demands. Previc states that the near-far distinction can help account for why these functional differences (i.e. visual field advantages) are relative and not absolute. Additionally, the near-far dichotomy has a clear ecological basis originating from the visual experiences of primates.

Previc’s (1990) theory divides the visual pathway into two visual streams: a dorsal stream and a ventral stream. The differences between the two pathways are in regards to the processing strategies and not to the types of information that are being processed; though similar distinctions have been made previously, none account for the same amount of data as the current explanation (Previc). The differences between the two visual streams are manifested at both the subcortical (magno-cellular/parvo-cellular) and the cortical levels. The dorsal system is dominated by magno-cellular inputs that aid in the processing of transient or non-linear stimuli that are important during near space behaviours such as reaching. Conversely the ventral stream is dominated by parvo-cellular inputs that aid in processing images so that they can be retained long enough to be stored in long-term memory. Parvo-cellular inputs are important when conducting visual search tasks.

As mentioned similar divisions of the visual system into two visual streams have been made previously (Ungerleoder & Mishkin, 1982; Milner & Goodale 1993). Ungerleider and Mishkin (1982) proposed two distinct diverging cortical pathways that originate from a common origin. One multisynaptic occipitotemporal pathway responsible for object vision and one multisynaptic occiptioparietal pathway responsible for spatial vision. The information from each pathway is eventually reintegrated via interconnections between the two pathways. Milner and Goodale (1993) proposed the existence of similar cortical pathways noting one pathway is responsible for vision for perception and the other vision for action. They indicate that the difference between the two systems could best be understood in terms of the output systems each stream serves and not by the type of information serving as input. Similar to Previc differences are noted at both the cortical and sub cortical level. However, sub cortical differences noted by Previc are not as well defined as he describes.

Merigan and Maunsell (1993) review the subcortical and cortical divisions of the primate visual systems highlighting the interaction between the two systems. They highlight extensive segregation of the sub cortical (magno and parvo cellular) and cortical (dorsal & ventral streams) pathway similar to what is described by Previc. However, they do not indicate that the dorsal and ventral streams are dominated by either parvo or magno cellular inputs as indicated by Previc.

Instead it is noted that both visual streams receive input from both the parvo and magno cellular layers. Though the magno cellular layer dominates the input to the dorsal stream.

Evidence of functional specialization of the dorsal visual stream is focused on the areas of the posterior parietal cortex (7a) and middle temporal cortex (MT). Supporting the involvement of the dorsal visual stream in near space is the way that posterior parietal neurons (7a) code visual space. Many posterior parietal neurons code visual space using head-centered coordinates rather than using an animal's fixations. Previc (1990) reviews further evidence indicating the role of 7a neurons in near space describing their involvement in reaching movements, particularly when reaching movements are targeted at biologically reinforcing items such as food.

The MT neurons of the dorsal visual stream play less of a motivational role; instead they code motion cues and exhibit quick responsiveness to stimuli. The MT neurons are involved in many global aspects of motion processing that aid in reaching movements in near space. However, the neurons of the dorsal stream have poor spatial resolution (i.e. unable to provide a precise location of an object in space) rendering them ineffective in visual search tasks.

Previc (1990) also reviews extensive cortical and subcortical evidence for the role of the ventral stream in far space. Cortical evidence of the ventral stream is related to the areas V4 and inferotemproal cortex (IT), demonstrating specialization for scanning and recognition of objects. Neurons in the dorsal stream are coded using head-centered coordinates, whereas, neuronal activity in the IT area is linked to the gaze of an animal often only responding when the animal is fixating on the object. IT neurons prefer complex objects including faces and are highly sensitive to changes in the contours of objects. They also respond for longer latencies, often as long as several hundred msec, potentially indicating involvement in long-term memory encoding. Neurons in area V4 are involved in form perception and are involved in the preparation of saccades during visual search. Lesion evidence from neuropsychological findings further supports the role for the ventral visual stream in scanning and recognition of objects in extrapersonal space.

In conclusion, based on cortical and subcortical evidence Previc (1990) hypothesizes that specialization of the visual streams is based on the visual experiences of primates. As the distinction between near and far vision increased visual stream specializations developed. The dorsal stream developed specialized cells for detecting objects and how they move to allow for more accurate reaching movements. The ventral stream developed specialized cells for identifying objects and scanning the environment for objects during visual search.

Previc (1998) expanded his original model to include four brain systems that mediate how we interact in the different areas of space: peripersonal (near), focal-extrapersonal (far), action-extrapersonal and ambient extrapersonal. Peripersonal space is responsible for reaching behaviours that occur in near-body space and is located primarily in the dorsolateral cortex. The focal-extrapersonal system is involved in visual search of the environment and is located ventrolaterally in the inferior temporal and lateral frontal cortex. Previc suggests that this system is intimately tied to abstract thought processes or 'executive intelligence' in humans. The action-extrapersonal system is primarily used in navigation and is located ventromedially through the cerebral cortex to include the hippocampus and the parahippocmpal regions. The final system, ambient-extrapersonal, is focused on the orientation of the body in fixed space and is involved in postural control and locomotion. This system relies on dorsomedial visual inputs as well as vestibular and somatosensory inputs. The peripersonal and focal extrapersonal systems were described previously and the remaining two systems will be described in greater detail below.

The action-extrapersonal (AcE) system is closely linked to our memory of specific places or events. There is no lateral limit to the AcE system, which can respond to cues all around us, for example we can orient to auditory cues that originate from behind us. Similar to the focal extrapersonal system the AcE system is biased to the upper visual field. This can be seen in the work of Intraub and Richardson (1989) where participants overrepresented upper visual space when reproducing a previously seen image. Similar to focal extrapersonal space, AcE space is also gaze centered as evidenced by neuronal responses in the primate hippocampus responding to space where gaze has been fixated (Previc, 1998). Fixated information in focal extrapersonal and AcE space is primarily processed through the parvocellular layer (Previc, 1990). The principal sensory systems involved are vision and audition.

The AcE system primarily involves the medial temporal lobe and its ventromedial inputs (V3 & V4), superior temporal sulcus, inferior and ventromedial cortices and a limbic- subcortical network (Previc, 1998). The limbic-subcortical network links the hippocampus with the superior colliculus, anterior thalamus and cingulate cortex. The visual inputs stem from a second ventral pathway positioned more medially than the classic ventral pathway. This ventromedial visual system plays a larger role in scene memory as supported in topographical memory disturbances post lesion. The cortical system of the AcE system plays an important role in integrating somatosensory, proprioceptive and vestibular inputs from extrapersonal space.

The ambient extrapersonal (AmE) system ensures the proper orientation of our bodies in gravitational space (Previc, 1998). Primarily working to achieve postural control and to stabilize our perception of the world during self-motion. Stabilizing our perception of the world eases the tasks completed in other 3-dimensional (3D) systems described earlier (peripersonal, focal-extrapersonal & action-extrapersonal). Similar to peripersonal space the AmE system is biased towards the lower visual field as optical flow predominantly arises from objects along the ground plane during self-motion. The predominant sensory system used by the AmE system is vision.

The neural substrates of the AmE system are not well understood but are thought to be the least corticalized of all the 3D systems (Previc, 1998). The key structure of the AmE system is yet to be identified but there is evidence that the dorsomedial portion of the superior parietal lobe and the retroinsular cortex are critically involved in AmE functions. The primary visual pathway for the AmE system is a dorsomedial pathway projecting to the parieto-occipital area.

Previc postulated that processing differences between the upper and lower visual fields results from how a particular system is involved in distant and proximal space. Not surprisingly UVF advantages have been observed in visual search, saccadic latency, and memory guided saccades, whereas, LVF advantages have been observed in guided manual activities. Previc further asserts that biases associated with local and global processing are also related to the visual processing required for the different areas of space (Previc, 1990 & 1998). Previc links most of these patterns to the ecological realities for how we interact with objects, for example visual scanning or object recognition most often occurs in our UVF (Previc, Declerk, & Brabander, 2005).

Hagenbeek and Van Strien (2002) investigated if presenting stimuli in the different visual quadrants would add additional information regarding visual field advantages in three laterality tasks: a face-matching task, a letter-naming task, and a lexical decision task. Christman and Niebauer (1997) have suggested a systematic link between the left and lower visual fields and the right and upper visual fields. In the face matching task reaction times were shorter in the lower left and upper right fields, supporting Christman and Niebauer's (1997) suggestion. Results from the letter-naming task also supported the Christman and Niebauer's (1997) hypothesis, displaying both a right VF advantage and an upper VF advantage. There was no significant interaction between the lower-upper and the left-right visual fields in the lexical decision task. The current studies indicate that investigations of visual quadrants may be more sensitive to detecting differences than studies investigating lateral visual field differences. Hagenbeek and Van Strien (2002) suggest that scanning and attentional biases may have contributed to the upper right visual field advantages for their face-naming task.

Previc and Blume (1993) demonstrated differences in visual search performance indicating advantages in the upper right visual field. Using a 36-item conjunction search task targets were identified nearly 150 msec faster in the upper right visual field and 50 msec faster in the right visual field. As predicted by Previc (1990) this advantage might be the result of the focal extrapersonal attentional system that has been demonstrated to be biased to the upper and right visual field.

It has been questioned whether upper visual field advantages in visual search tasks are the result of attentional biases or visual processing biases. Previc (1996) conducted two experiments using a feature search task (FS; the target differs by a single feature from the distractor shapes) and a conjunction search task (CS; the target is defined as a unique combination of at least two features and presented amid targets that differ in one feature or more) to investigate if attentional biases or oculomotor biases are responsible for upper right visual field advantages during search tasks. Experiment one suggested that upper-right visual field biases are attentional in nature as the bias decreased as the distracters were added or the task difficulty increased. Experiment two directly assessed the contribution of oculomotor biases to the upper-right visual field advantage by tracking eye movements. Although, Previc reports observing slight oculomotor trends to the upper-visual field they were neither significant nor large enough to account for the reaction time and accuracy advantages found in the upper-right visual field. Thus, experiment two further supports that visual search advantages in the upper visual field are related to attentional biases of the focal-extrapersonal system.

Intraub and Richardson (1989) originally reported that visual scene memory of individuals was distorted displaying boundary extensions where the original scene appears compressed and the boundaries are extended. Intraub and Richardson specifically observed expansions of the upper visual field. This is consistent with Previc's proposed ecological linkages where scenes would be viewed and perhaps remembered as being farther away. Previc and Intraub (1997) formally examined the original data to test if a vertical bias was present in the boundary extensions. Upon closer examination a vertical shift was observed. The average vertical shift was between -9.5% (wide angle) and -15% (close-up), indicating a significant downward shift causing an expansion of the upper visual field. This supports Previc's ecological hypothesis between near and far space which predicts that given the slope they are viewed at visual scenes may be remembered as being a greater distance away and would thus increase the representation of the upper visual field.

Niebauer and Christman (1998) investigated vertical and horizontal visual field differences in categorical and coordinate judgments. Their results indicate that the previously observed differences in the left and right visual fields could be extended to the upper and lower visual fields. Left and lower visual field advantages were present for the coordinate task. Upper and right visual field advantages were present in the categorical task. These results are what Previc would predict given the lower visual fields involvement in movement and grasping and the upper visual fields involvement in visual scanning.

Christman and Niebauer (1997) suggested that upper and lower visual field differences might be systematically linked to left and right visual field differences. Hagenbeek and Van Strien

(2001) supported this link using a face-matching task. They found shorter reaction times for faces presented in the lower left and upper right VFs. They also found that fewer faces were matched correctly in the upper left quadrant than in any other quadrant. To explain this interaction they hypothesized that the interaction may be the result of how the faces were processed. The left visual field (right hemisphere) specializes in local processing and the right visual field (left hemisphere) in global processing. Local processing is biased to the upper visual field and global processing to the lower visual field. Thus, the interaction might occur as a result of differential processing strategies of the faces in the different visual fields. An upper visual field advantage is supported by evidence of an attentional bias. This bias has been widely attributed to an ecological origin, where it is advantageous to be searching for objects that are found in far space.

Although there is not consistent support for visual biases presented by Previc (1990, 1998) there is consistent evidence that there are attentional differences between the upper and lower visual fields (Christman & Niebauer, 1997; Hagenbeek & Van Strien, 2002; He, Cavanagh & Intriligator, 1997; Intraub & Richardson, 1989; Niebauer & Christman, 1998; Previc, 1996; Previc & Blume, 1993). He and colleagues observed finer attentional resolution for images presented in the lower visual field. This is potentially explained by how the visual fields are represented in the visual cortex. The lower visual field is represented in the upper portion of the primary visual cortex that projects more heavily to occipital parietal regions that are linked to spatial attention (Posner, Walker, Friedrich, & Rafal, 1987). Reviewing differences in visual search patterns between the upper and lower visual fields it is plausible that presenting stimuli across the upper and lower visual field might impact the gaze cascade effect.

What Makes a Face Attractive?

When investigating attractiveness preferences for faces it is important to have a general understanding of what makes a face attractive. Recent investigations have uncovered similarities in cross-cultural ratings of attractiveness, suggesting that attractiveness may have a biological foundation and may have an evolutionary advantage (Jones & Hill, 1993; Rhodes et al., 2001). Further evidence of an evolutionary origin comes from developmental research. It has been noted that infants (3 – 6 months of age) gaze longer at faces of those previously rated as attractive than at those rated as unattractive (Langlois et al., 1987; Rhodes, Geldes, Jeffery, Dziurawiec, & Clark, 2002; Slater et al., 1998). Indicating there may be innate mechanisms for identifying attractive faces prior to exposure and internalization of cultural norms and expectations; perhaps linked to similar reward processes as has been observed in adult population (Kampe et al., 2001). It was demonstrated that activation patterns to attractive faces were mediated by gaze direction of the model (Kampe et al., 2001). Activation levels of the ventral striatum increased when the attractive face was looking at you as opposed to when it displayed an averted gaze direction. Actually, activation in the ventral striatum decreased when an attractive face was displayed with an averted gaze; suggesting we desire the attention of the attractive faces and may be 'dissatisfied' when they direct their attention away from us. Interestingly, dynamic cues such as gaze direction can also influence attractiveness. Gaze direction is an important cue as it can invite social interactions, indicate threats, or objects of interest.

Gaze Direction

As previously mentioned, past research has shown that gaze direction can alter attractiveness ratings indicating people prefer faces that display a direct gaze (i.e. a face that is looking at them; Kampe et al., 2001). It was also demonstrated that direct gaze increases the reward value of attractive faces as demonstrated by previous investigations using fMRI. However, a recent study by Jones, DeBruine, Little, Conway, and Feinberg (2006) identified that preferences for direct gaze can be mediated by facial expressions. Groups of attractive and unattractive faces displaying either happy or neutral expressions were used. The faces either displayed direct or averted gazes. They found that direct gaze increased preference of faces that were smiling. Alternatively, averted gaze decreased preferences for smiling faces. Interestingly, when the face displayed a neutral expression gaze had no effect on attractiveness ratings.

The Power of Gaze Direction

Eyes play a significant role in directing and sharing attention. Gaze direction is the most accurate nonverbal information that others can provide to us (Hietanen, 1999). The ability to use gaze direction is a very important factor in participating in normal and successful social interactions. For example, gaze can help to identify when a person wants to initiate an interaction with you (Hietanen, 1999), wants to direct your attention to a point of interest or threat (Hietanen, 1999), or to let you know that someone is interested in you (Kleinke, 1986). Gaze can also be used to establish hierarchies or the mood of interaction. For example, the simple act of establishing eye contact can be perceived as a sign of hostility or threat (Ellsworth & Carlsmith, 1973), or mutual staring can be perceived as a sign of attraction or general interest (Kleinke, 1986).

The multitude of possible signals that eye gaze can communicate makes it reasonable to assume that sensitivity to the eye region makes evolutionary sense. Given the many important signals gaze may be communicating it is important that the observer is able to quickly detect and identify the meaning of gaze (von Grunau & Anston, 1995). Specifically as eye gaze can indicate objects of importance or threat it makes sense from a survival standpoint that there are advantages to gaze perception (Macrae, Hood, Milne, Rowe, & Mason, 2002). Given the importance of gaze direction and the need for quick detection it would be expected that reactions to gaze would be reflexive rather than voluntary. There is extensive evidence that indicates that this is in fact the case.

Gaze direction can play a fundamental role in orienting attention, and this orienting is reflexive (Friesen, Moore, & Kingstone, 2005). There are two main reasons why the orienting of attention to gaze is thought to be reflexive: the speed at which it occurs and that it occurs when the gaze stimulus is not predictive (Friesen & Kingstone, 2003). It is thought that this reflexive shift in attention is driven by one of two distinct systems: subcortical (mediated by the superior colliculus when an abrupt onset of stimuli occurs in our periphery) and cortical (mediated by the temporal and parietal lobes when a face gazes towards a particular direction). Friesen and Kingstone (2003) demonstrate that gaze direction engages a reflexive attentional system, indicating a preferential bias towards cortical mechanisms.

Further, when presented with gaze stimuli people will mimic the original person's gaze direction even when there is no instruction or advantage in doing so (Ricciardelli, Bricolo, Aglioti, & Chelazzi, 2002). This gaze following ability is thought by some to be a reflection of sharing experiences with someone (Baron-Cohen, 1995). Interestingly, Ricciardelli and colleagues (2002) found that this imitative function is unique to gaze stimuli as when they used dual arrows as a distracter cue the same reflexive action effect was not found.

Similar to the research done by Eastwood, Smilek, and Merikle (2001), von Grunau and Anston (1995) used a pop out effect to investigate gaze. Using arrays of schematic eye stimuli, realistically drawn eyes and three block control stimuli, which consisted of rightward or straight gaze. Faster reactions times were observed during trials that used realistically drawn eyes, however, a true pop out effect was not observed. As expected, faster reaction times were observed for the realistically drawn stimuli and the schematic eye stimuli indicating that an asymmetry in gaze was detected quickly during a search task. Providing further support that eyes are unique stimuli, the same search asymmetry was not observed for the block stimuli. It is possible that the difficulty of the task or the number of stimuli used is responsible for the lack of pop out effect.

There is also evidence that gaze following may be a talent specific to humans. There is evidence that chimpanzees can follow gaze (Tomasello, Call, & Hare, 1998) but there is little evidence if they understand the communicative importance of gaze following (Barth, Reaux, & Povinelli, 2005). In a study by Barth and colleagues (2005) the impact of directions on chimpanzee ability to follow gaze was investigated. They found that the subjects were not able to reliably use the pointing or glancing cues. This may indicate that the subjects are not able to understand more subtle communications that are similar to gaze.

Doherty and Anderson (2001) investigated if it is gaze that we are following or if it is head movements. They used photographs where people were asked to avert their eyes either left or right but were told to keep their head position stable. They then masked the eyes of the images and participants were instructed to indicate which direction the person was looking. They found that even under strict instructions not to shift their head direction when pictures were taken, that participants were able to identify the gaze direction at greater than chance levels when the eyes were masked. This indicates that in any gaze movement there is also a systematic slight movement of head direction, which can be detected by observers. This research presents two important points. First, head direction and gaze direction are tightly coupled and cannot be completely dissociated. Second, it may indicate that gaze direction is so important that even when the eyes are masked we have sensitive detection systems to identify it and to use its communicative intentions.

It is important to investigate the impact of gaze direction on the gaze cascade effect for two reasons. First, gaze direction is a powerful social cue that invokes reflexive shifts of attention. As a result is possible that attractive stimuli with averted gaze may display a reduced or altered gaze cascade effect. Secondly, gaze direction has been associated linked to attractiveness ratings and may impact the gaze cascade effect.

Rationale

Every day we are presented with situations that force us to make decisions, selecting one item over another. It is important to understand these preferences as they are significantly linked to our behaviours. Facial attractiveness plays an important role in mate selection and general social interactions. Previous research has outlined several static (symmetry, averageness & sexual dimorphism; Thornhill & Gangstead, 1999) and dynamic (gaze direction; Kampe et al., 2001) characteristics that influence facial attractiveness. Recent research has begun to investigate how preferences are formed and on the process of making preference decisions rather than focusing on what makes us like the image better (Shimojo et al., 2003; Simion & Shimojo, 2006, Simion & Shimojo, 2007; Glaholt & Reingold, 2009). A gradual bias towards the preferred image has been observed at the end of the trial (Shimojo et al., 2003); however, currently preference decisions have only been investigated when the images are presented horizontally on a screen.

Important visual processing differences exist between the upper and lower visual fields. These differences include how efficiently information is processed in each visual field (Hall, 1985). Study 1 investigated the impact of presenting images in the upper and lower visual field on the gaze cascade effect. Past research indicates that visual search tasks typically indicate an advantage in the upper visual field indicated by faster reaction times to detect stimuli (Previc, 1996). Faster reaction times and evidence on search patterns suggest that participants are more likely to start their search in the upper visual field (Chedru et al., 1973). This has been explained using ecological reasoning that postulates most visual search occurs in far space or in the upper visual field. As a result it was predicted that presenting images across the upper and lower visual fields would impact the gaze cascade effect. Specifically, larger biases will be observed in the upper visual field than in the lower visual field. This explanation would fit with the dual contribution model for preference decisions postulated by Shimojo and colleagues (2003). The contribution of the mere exposure effect would suggest that initially looking in the top visual field and potentially spending longer times searching the upper visual field would increase the preference for that image.

The second study further investigated the effects reported by Shimojo and colleagues (2003) that suggest the presence of larger gaze cascade effects in more difficult decisions. Images were again displayed across the upper and lower visual fields to further investigate the impact this has on the gaze cascade effect. Study 2 also investigated the effect of gaze direction on the gaze cascade effect and preference decisions. Past research has indicated that viewing a face with averted gaze will trigger a similar gaze shift in the observer (Friesen et al., 2005). Further, it has also been noted that faces displaying an averted gaze are preferred less to faces that display a direct gaze (Kampe et al., 2001). It has also been postulated that this effect interacts with the attractiveness of the face displaying the averted gaze. Study 2 compared faces that had been matched to minimize (difficult decision) or maximize (easy decision) the attractiveness differences between the two faces. Additionally, faces were matched on their gaze direction (direct, left averted and right averted).

Finally, in response to the work of Glaholt and Reingold (2009) the gaze cascade effect was investigated in a simple visual decision task. The visual decision task used perceptually ambiguous images of spheres developed by Mcmanus, Buckman, and Woolley (2004). The spheres are mirror images of one another presented in the upper and lower visual field where participants are asked to select which image is most concave. If Glaholt and Reingold are correct and the gaze cascade effect is a product of any visual decision, then the spheres task should display the gaze cascade effect. However, if Shimojo and colleagues (2003) are correct and the gaze cascade effect is unique to preference decisions then the gaze cascade effect should not be present in the spheres task. Based on the work of Shimojo and colleagues (2003) it was predicted that participants would not display the gaze cascade effect during the spheres task. This would indicate that the gaze cascade effect is not the product of a visual decision and is specific to a preference decision.

CHAPTER 2
STUDY 1

Introduction

This chapter is a manuscript in preparation and contains some repetition from the general introduction.

Every day we are bombarded by situations that force us to choose one image or object over another. These choices can be easy such as selecting which television show to watch or can be more difficult such as when picking out an expensive watch. Past investigations have focused on why we prefer one object to another linking our preferences to symmetry or averageness. However, researchers have recently begun to focus on how preferences are formed instead of what characteristics make us prefer one image or object. Focusing on how preferences are formed has revealed an orienting bias termed the gaze cascade effect (Simion & Shimojo, 2006; Simion & Shimojo, 2007; Shimojo, Simion, Shimojo, & Scheier, 2003).

Shimojo et al. (2003) used a series of experiments to investigate how unconscious orienting behaviours such as eye movements are involved in making preference decisions, postulating that gaze plays an important role in preference formation due to its relation with exposure. Specifically, gaze leads to foveation of an object, which is associated with deeper sensory processing. Their findings indicate that gaze does play an active role in preference formation, observing that as participants near their point of decision there is a progressive gaze bias towards the chosen stimulus, termed the gaze cascade effect. Shimojo et al. (2003) hypothesized that the role of gaze direction in preference decisions is a two-part process. The initial process is linked to preferential looking (Birch, Shimojo, & Held, 1985) and the second process is the mere exposure effect (Kunst Wilson & Zajonc, 1980); together these processes create a positive feedback loop that leads to an orienting bias.

A series of experiments were used to investigate several factors and demonstrate the robust nature of the gaze cascade effect: observing its presence when viewing faces (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007), abstract objects (Shimojo et al., 2003), and using a gaze contingent display (Simion & Shimojo, 2006). Additionally, they were able to artificially induce preference through biasing the viewing times of stimuli (Shimojo et al., 2003). Finally, the effect was still present when viewing was interrupted prior to a decision being made (Simion & Shimojo, 2007). Pairs of computer generated faces or abstract objects that were displayed horizontally on the screen spanning the right and left visual fields and two control tasks were used to ensure that patterns could be attributed exclusively to preference formation and not to general decision-making processes (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007).

Across multiple studies a similar gaze pattern was observed with no initial bias towards the preferred image at the start of the trial (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007). During preference conditions as participants neared their decision their gaze (specifically during the final 1.5 seconds) was biased towards the selected image at a level significantly higher than chance, in some instances up to 83% of viewing time (Shimojo et al., 2003). Examination of the likelihood curves illustrated that neither control task reached a point of saturation, indicating that the observed gaze bias was not the result of reaching a decision or attempting to remember their decision. Interestingly, trials using abstract objects displayed a larger gaze cascade effect (Shimojo et al., 2003).

The results from this study led to the development of a dual-contribution model for preferential decision-making (Shimojo et al., 2003). This model involves input from orienting behaviour structures such as gaze and from a cognitive assessment system. The cognitive systems are thought to be responsible for comparing the current stimuli to a known template. Although the model incorporates feedback from cognitive assessment systems, it is thought that our cognitive representations are relatively stable and that short-term influences would not be substantial. According to the model orienting behaviours also incorporate feedback, where gaze biases increase exposure and lead to increased preferences similar to the mere exposure effect. The decision module is then responsible for integrating the information from these two systems, when the cognitive basis for a decision is weak (i.e. difficult decisions or abstract stimuli) the orienting systems will play a larger role in the decision making process.

Glaholt and Reingold (2009) sought to further investigate the gaze cascade effect using photographs of artwork in an attempt to use more real-world stimuli rather than computer generated faces. Their purpose was to further investigate the time course of the gaze cascade effect and provide further evidence that it is a process unique to preference decisions, regardless of stimuli type. They observed a similar gaze cascade pattern in all of their preference conditions (2-alternative forced choice, gaze contingent display and 8- alternative forced choice). Interestingly, they also observed the gaze cascade effect during their control task (which photo was taken most recently), which Simion, Shimojo and colleagues did not observe. Simion, Shimojo and colleagues provided graphical data and qualitative interpretations stating that the gaze cascade effect was not present during their control trials. Glaholt and Reingold (2009) conclude based on their results that the gaze cascade effect might be associated with visual decisions and is not unique to preference decisions.

Previc (1998) has identified four brain systems that mediate how we interact in the different areas of space: peripersonal, focal-extrapersonal, action-extrapersonal and ambient extrapersonal. Specifically of interest for the current topic are peripersonal space and focal-extrapersonal space. Peripersonal space is responsible for reaching behaviours that occur in near-body space and is located primarily in the dorsolateral cortex. The focal-extrapersonal system is involved in visual search of the environment and is located ventrolaterally in the inferior temporal and lateral frontal cortex (Previc, 1998).

Previous investigations presented stimuli across the left and right visual fields. However, past neuropsychology and eye-tracking research has revealed important differences in viewing patterns across the visual fields that may impact the gaze cascade effect. Specifically, that more time is spent in the upper visual field during free-viewing tasks (Chedru, Leblanc, & Lhermitte, 1973; Gould & Schaffer, 1968; Previc, 1996). Previc (1996) investigated the role of attentional and oculomotor influences on visual search across visual fields and observed a slight trend favouring the upper visual field. Participants spent 14% of their time looking in the upper visual field compared to 11.3% in the lower visual field when they were looking away from the horizontal meridian. A similar effect was observed favouring the left visual field (12.3%) over the right visual field (9.7%) when participants were looking away from the vertical meridian. Additionally an asymmetry of the direction of the first saccade was also observed indicating the initial saccade favoured the upper hemifield.

Earlier investigations of eye-movements revealed similar oculomotor biases to the upper visual field. Gould and Schaffer (1965) using numeric stimuli found that more fixations (38.4%) fell into the upper third of the matrix than the lower third of the matrix (30.2%). Chedru et al. (1973) also noted significant differences in which visual quadrant was first explored. During their task they found that in 55% of trials the upper visual field was first to be explored. Additionally, the left upper quadrant was explored 29% of the time significantly longer than any of the other visual quadrants (Chedru et al., 1973). Hall (1985) investigated the efficiency of visual search patterns in hearing, deaf and learning disabled children. They found that 56% of first eye movements were directed to the top center and 27% were directed at the bottom center (Hall, 1985). They also observed a tendency for all groups to search the top hemispace first when no information on target position was provided (Hall, 1985).

These oculomotor differences have been linked to how we interact with objects in visual space. Christman and Niebauer (1997) summarize these differences concluding advantages in the lower visual field (LVF) in simple reaction time, global processing and near stereoscopic vision and upper visual field (UVF) advantages for local processing, stereoscopic vision, visual search and visual attention. Previc (1990) hypothesized that upper and lower visual field differences are related to how objects are processed in space. Specifically that the lower visual field is more involved in near vision as a result of biases during reaching tasks and manipulation of objects. The upper visual field is more involved in far visual space as a result of its relation to visual search and object identification (Previc, 1990). Reviewing differences in visual search patterns between the upper and lower visual fields it is plausible that presenting stimuli across the upper and lower visual might impact the gaze cascade effect.

Review of past eye tracking and visual search research indicates that participants spend greater lengths of time in the upper visual field than in the lower visual field. Given the relation between the mere exposure effect and the gaze cascade effect it is plausible that differential viewing patterns may influence the gaze cascade effect. The current study will investigate the gaze cascade effect when images are displayed vertically (i.e. across the upper and lower visual field). It is predicted that the gaze cascade effect will be present across all trials but that it will be strongest during top preferred trials. Similar to the findings of Shimojo et al. (2003), it is expected that the gaze cascade effect will be strongest during String, Geon and Greeble (see Appendix K for a description of stimulus sets) trials as they are unfamiliar stimuli and strong cognitive biases will not be associated with them.

Methods

Participants

The current study tested 29 right-handed participants (15 male). All participants were undergraduate students from the University of Saskatchewan participating for course credit in Psychology 110. All participants were naïve to the purposes of the study.

Methods

After providing informed consent participants completed a brief demographics questionnaire that included handedness and footedness questions. Next participants were centered and seated in front of a computer screen and a Remote Eye-tracking Device (RED). The RED used is the SMI iView REDII. The RED can be used to record and measure eye movement without any physical contact with the participant. The SMI iView REDII system is a two-computer system linked using a serial port to trigger stimulus presentation. Motorized focus, iris, and zoom control provide automatic or manual remote operation from a second computer. The RED was calibrated by the experimenter using a 9-point calibration grid for each participant. To maintain continuous recording of eye-movements and maintain calibration participants were asked to keep their head as still as possible. To assist participants in stabilizing their head position a chin rest was provided and adjusted to their comfort level.

Participant eye movements were recorded during two blocks of trials. Block one contained 206 trials (see Figure 2-1 for sample stimuli): 84 face trials and 122 object trials. Faces were created using the online software FaceGen, facial symmetry was manipulated (low, medium & high) to vary attractiveness. Object trials consisted of chair, Geon, Greeble or String stimuli and were provided from the Tarr Lab online database. Stimulus sets for the object trials were selected for a variety of reasons. Geon and Strung stimulus sets were selected as they were novel objects for the participants, these trials would be similar to the abstract image trials used by Shimojo et al. (2003). Greebles were selected as they are a commonly used control stimulus for faces as they are symmetrical and follow specific rules that can be learned by participants. Finally, chairs were selected as they are highly familiar stimulus set that participants would have previous cognitive representations of. In block 1 each image (400 X 400 pixels) was centrally presented for 2500 msec and was preceded by a fixation cross. After the image disappeared from view participants were asked to rate the attractiveness of the stimuli on a 7-point scale where 1 is unattractive and 7 was attractive by pressing a number on the provided keypad. The purpose of block 1 was to compare participant attractiveness ratings to the rating of pilot participants, no significant differences were observed.

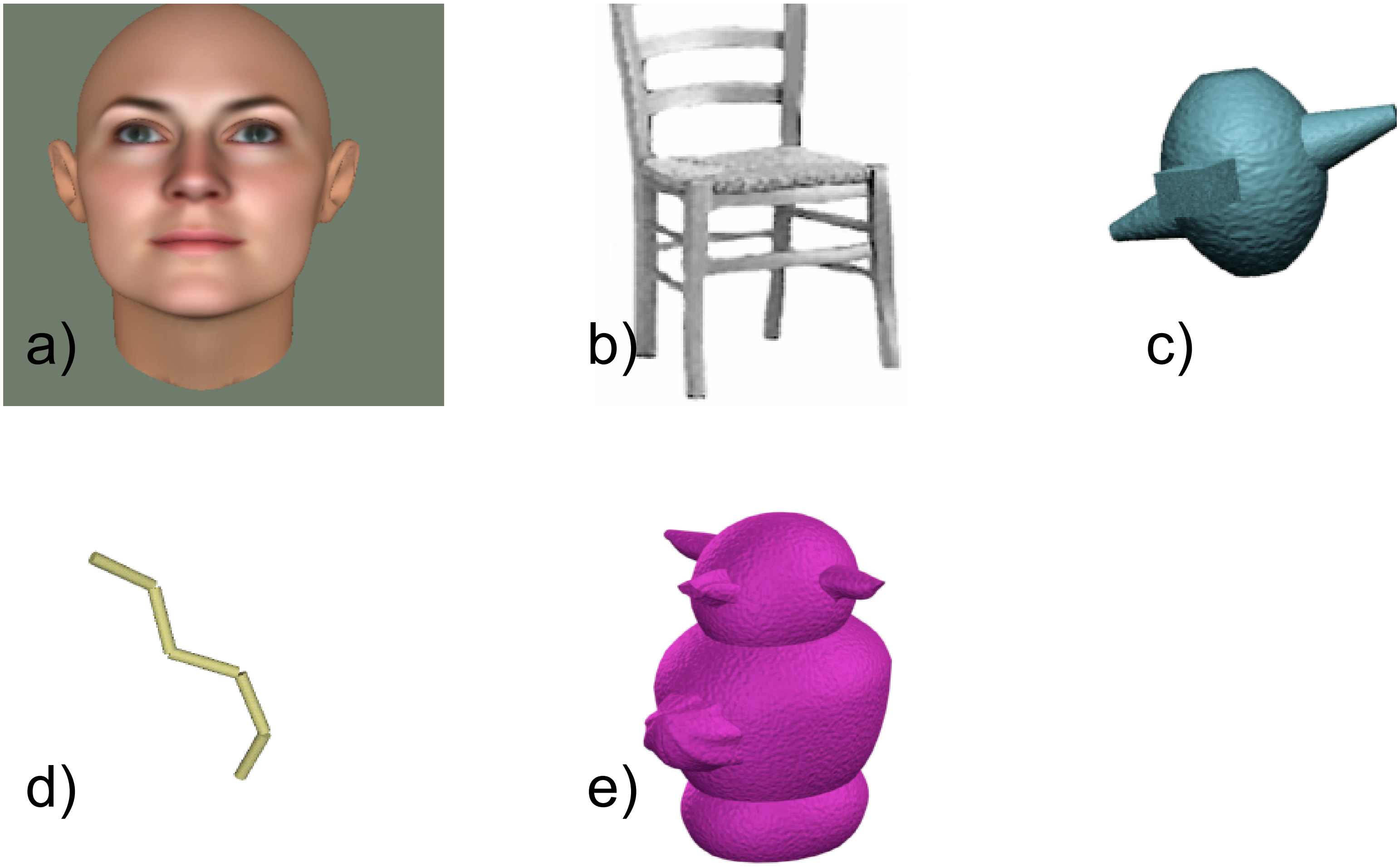

Figure 2-1. Sample images of stimuli used in study 1: a) sample face created using FaceGen, b) Chair stimuli, c) Geon Stimuli, d) String object, & e) Greeble stimuli. Chair, Geon, String & Greeble images are courtesy of Michael J. Tarr, Brown University, http://www.tarrlab.org/.

Block two contained 206 trials: 84 face trials and 122 object trials. During block 2, images were paired on attractiveness from previously collected pilot data. Images were paired to maximize attractiveness difference. Images were centered on the visual display and presented vertically (see Figure 2-2) with one appearing in the upper visual field and one in the lower visual field. Images were scaled such that their longest dimensions occupied 16º of visual angle (400 pixels). Images were preceded by a fixation cross and presented for 2500 msec. Participants were asked to select which image they preferred selecting either top (8 on the keypad) or bottom (2 on the keypad) by pressing a number on the keypad provided.

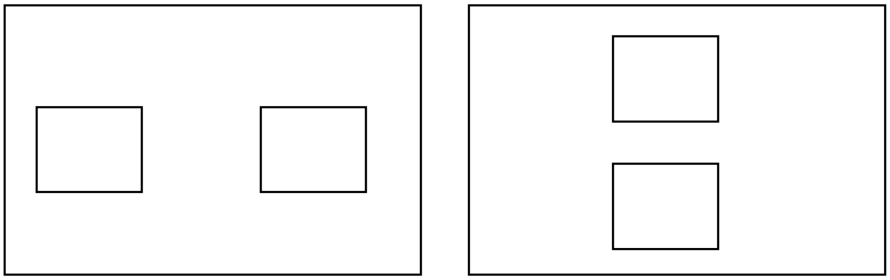

Figure 2-2. A comparison of horizontally and vertically paired stimuli. Previous experiments investigating the gaze cascade effect (Glaholt & Reingold, 2009; Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007;) presented stimuli horizontally and the current investigation tested the impact of pairing stimuli vertically.

Data Coding and Analysis

Participant eye movement data recorded when viewing the images during block 2 was coded using a customized application for iLab (Gitelman, 2002) that is ran using the platform Matlab. iView data files were converted into Matlab files using iLab. Regions of interest that matched the size and location of the images were then defined for both the top and bottom images. Fixation analysis was completed to calculate the number of fixations that were made to both the top and bottom and images. Following this a customized application was used to calculate the amount of time spent looking at each image (top or bottom) during 15 msec intervals across each trial. Using the fixation analysis each image (top or bottom) was assigned a value of 0 (did not look at the image), 0.5 (spent 50% of the interval viewing this image) or 1.0 (spent 100% of the interval viewing this image) for each interval. Both saccades and fixations recorded in the ROI were used in the analysis. Any time spent outside the ROI was excluded from the analysis, as a result values for each interval may be less than 1. Interval scores were summed across like trials (e.g. top preferred face, bottom preferred face etc.). Top preferred trials were defined as trials where the more attractive face was presented in the upper visual field. Bottom preferred trials were defined as trials where the more attractive face was presented in the lower field. Bias scores were then calculated by subtracting the total score for the non-preferred image from the total score for the preferred image divided by the number of trials. In this case for each interval a value of 1 would indicate complete bias towards the preferred image and a value of -1 would indicate a complete bias to the non-preferred image.

Averages and 95% confidence intervals were then calculated across all participants for each time interval for each stimulus type. Confidence intervals were used to detect the presence of the gaze cascade effect (significantly different from 0 in the final second and half of the trial) and if top and bottom preferred trials were different from one another.

Results

Several patterns were observed across trials. These patterns will be explained using face data from block 2 (see Figure 2-3). The first pattern observed is that participants looked first at the top presented image as indicated by the initial positive bias score for top preferred trials and the initial negative bias score for bottom preferred trials. The second pattern observed is that during both bottom and top preferred trials between 765 msec – 900 msec participants gaze direction switched from the top image to the bottom image.

A key difference between top and bottom preferred trials in gaze bias was observed during the final 1500 msec prior to decision. Previous research documented a progressive gaze bias towards the preferred image during the final 1500 msec termed the gaze cascade effect (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007). Consistent with previous research during the final 1500 msec (marked on the graph as the data following 1000 msec), the top preferred trials displayed a gaze bias that is significantly different than 0 as indicated by the 95% confidence intervals. In contrast, the bottom preferred trials did not display a gaze bias that was significantly different than 0. This difference is evidence that the gaze cascade effect was observed during top preferred face trials but not bottom preferred face trials. However, the gaze bias in top preferred face trials is not significantly different from the bias in the bottom preferred face trials.

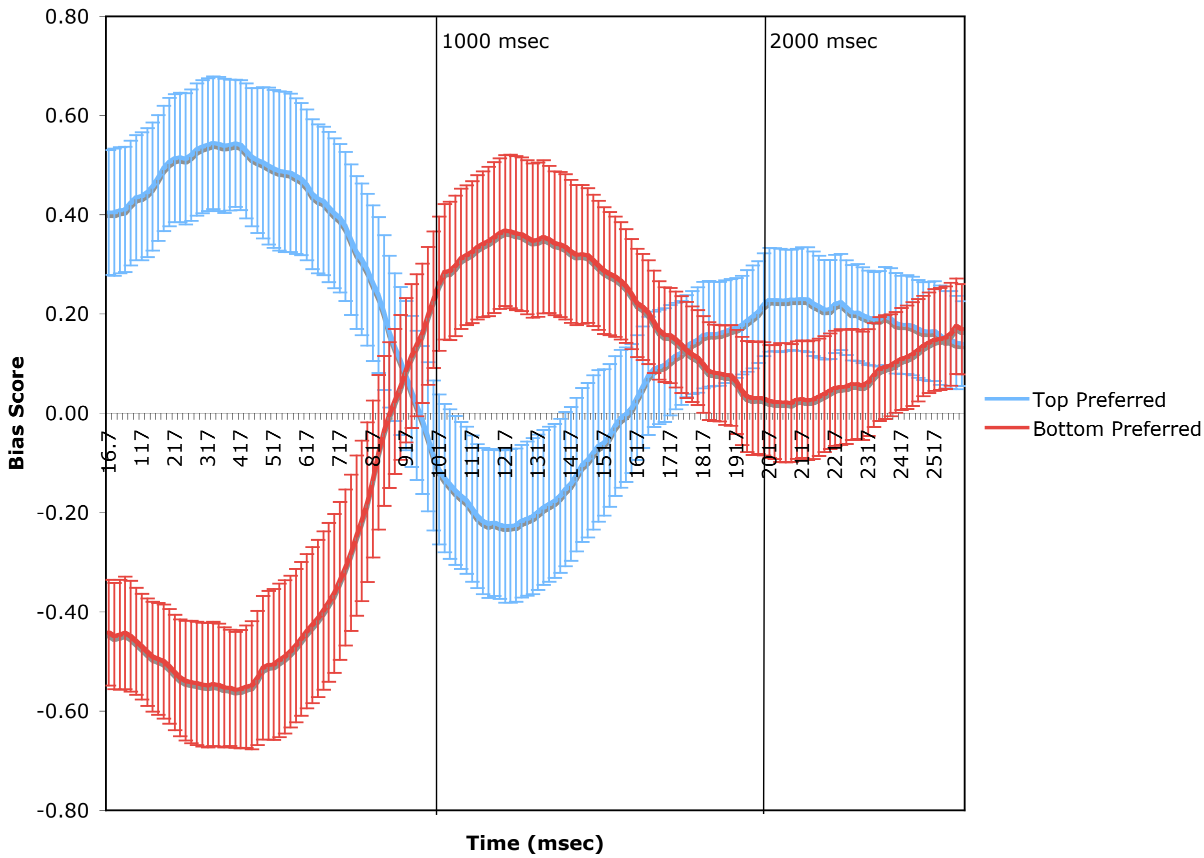

Figure 2-3. Results from the face stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

Similar viewing patterns were observed for the stimuli from String, Chair, Greeble, and Geon data sets (Figures 2-4, 2-5, 2-6 & 2-7). As well similar differences between top and bottom preferred trials using face stimuli were observed during object trials, where top preferred trials demonstrated more consistent gaze biases than bottom preferred trials. However, not all object trials displayed significant gaze biases. Neither the top preferred nor bottom preferred trials using string stimuli displayed a significant gaze bias during the final 1500 msec (see Figure 2-4). Additionally, gaze biases during top and bottom preferred trials using String stimuli were not significantly different from each other. Trial data using the Chair stimulus set displayed a similar pattern of gaze biases where neither top nor bottom preferred trials were significantly different than zero or from one another (see Figure 2-5).

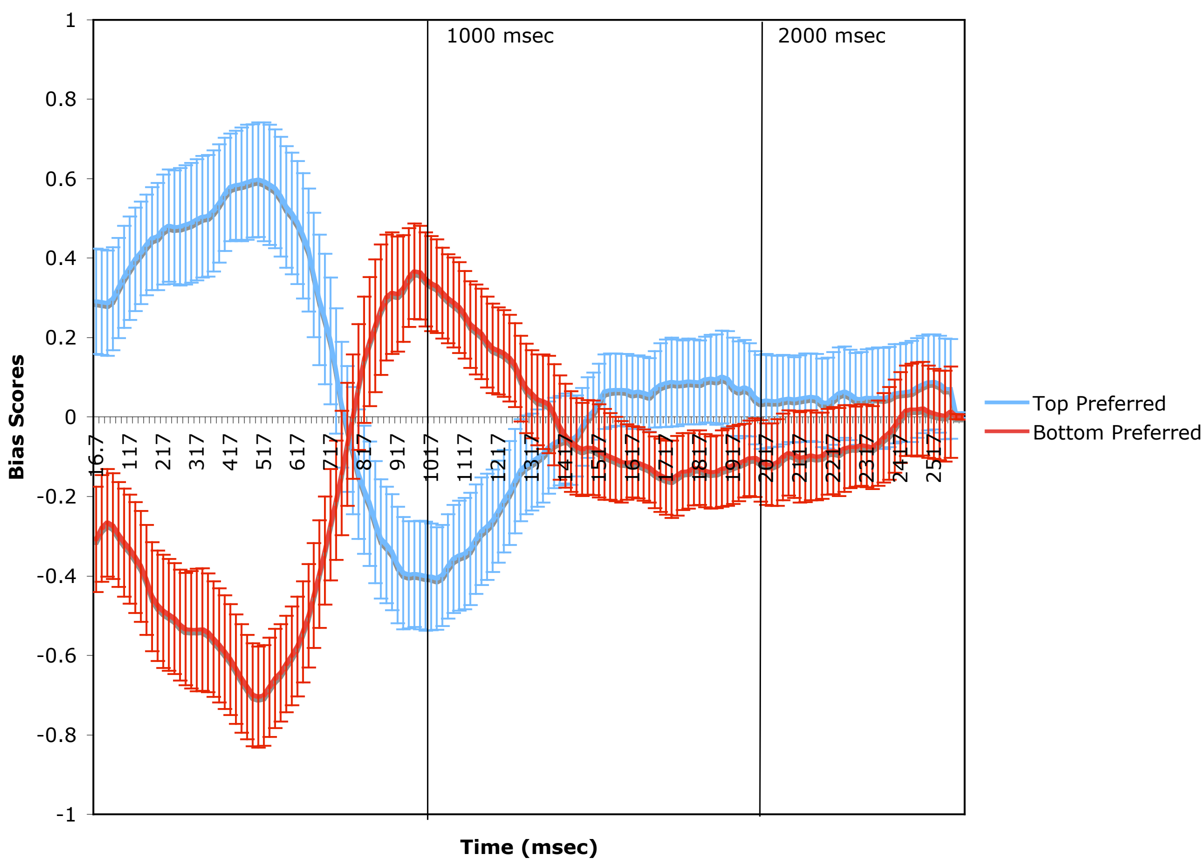

Figure 2-4. Results from the string stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against

trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

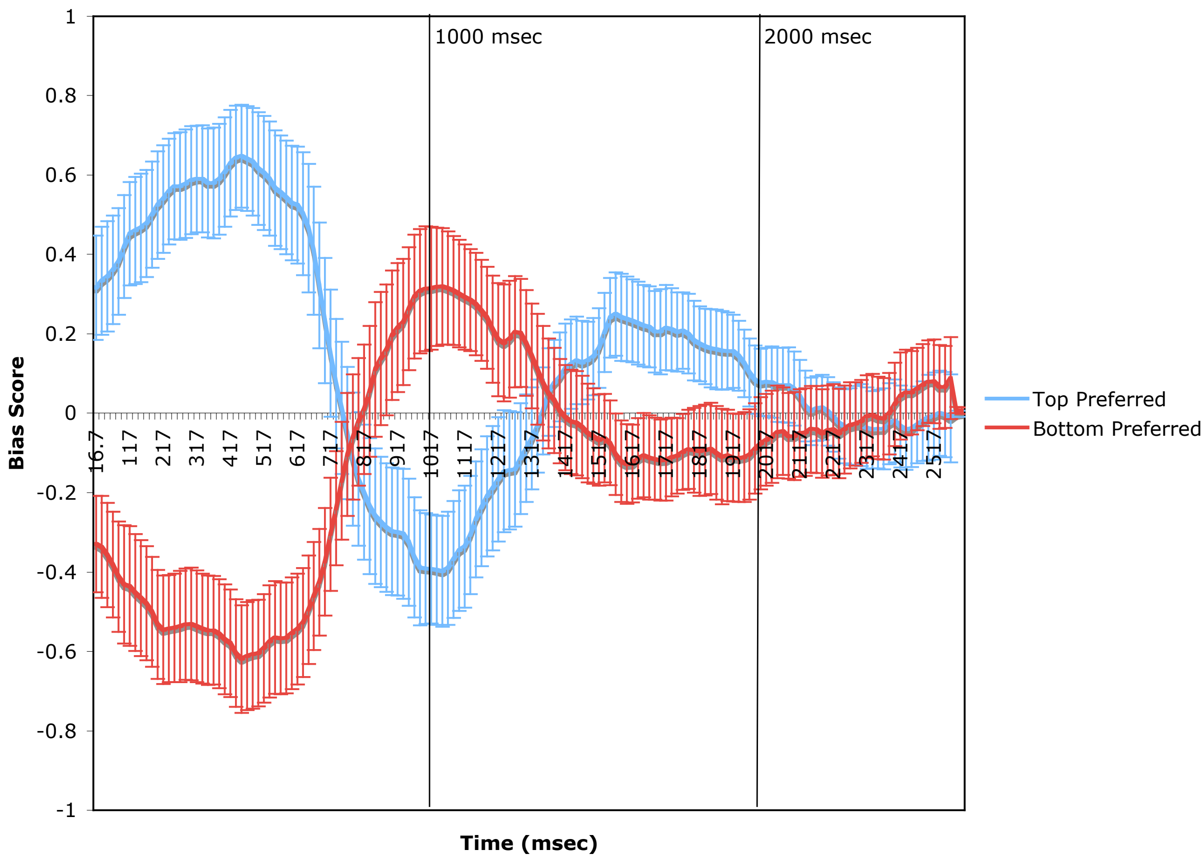

Figure 2-5. Results from the Chair stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

Greeble data displayed a gaze bias pattern similar to faces (see Figure 2-6). The top preferred Greeble trials displayed a gaze bias significantly different than 0 as indicated by 95% confidence intervals. However, the bottom preferred Greeble trials did not display a gaze bias that is significantly different than 0. The gaze bias patterns of top and bottom preferred Greeble trials were not significantly different from one another. An interesting qualitative observation to note during Greeble trials was that participants found it very difficult to make preference decisions. Participants reported disliking the Greeble stimuli.

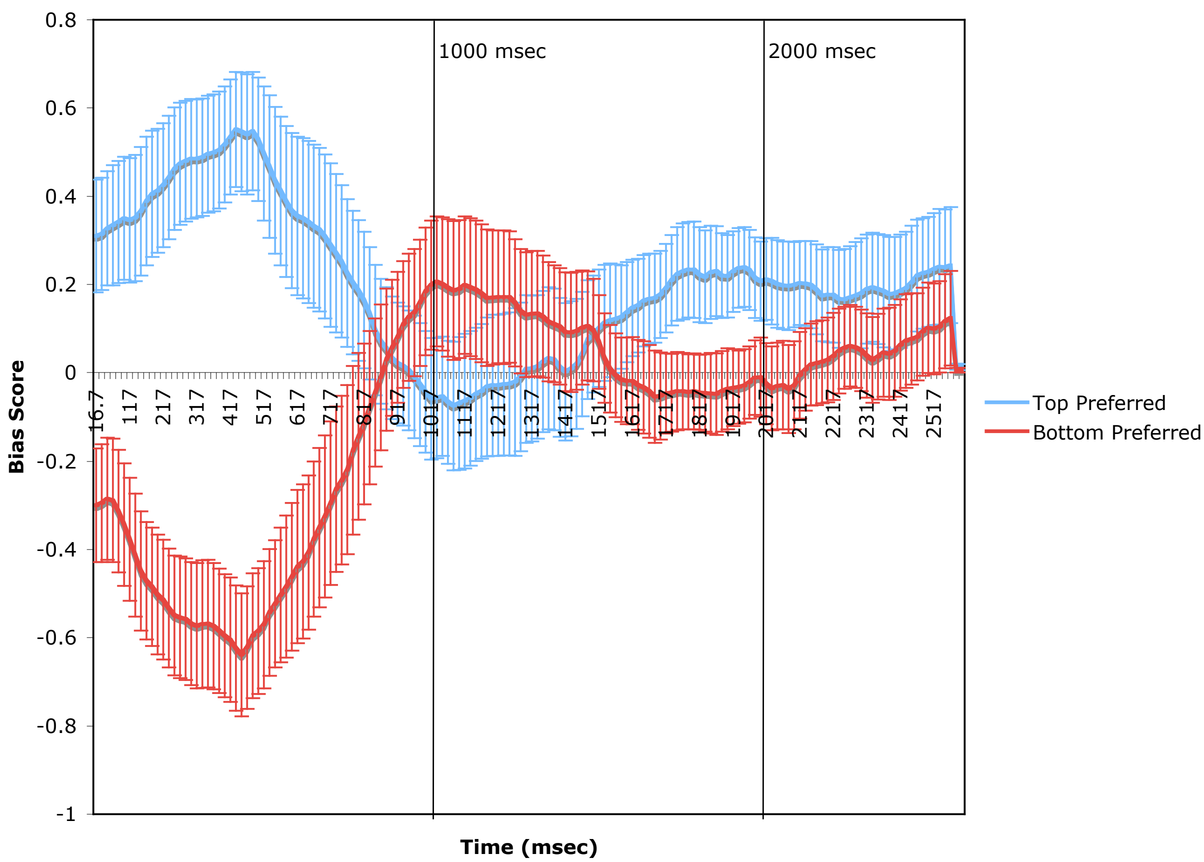

Figure 2-6. Results from the Greeble stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

The Geon data displayed similar gaze direction patterns (see Figure 2-7) as the String and Chair data. Neither the top preferred nor the bottom preferred trials displayed a gaze bias that was significantly different than 0. Also, the top and bottom preferred trials did not differ from one another.

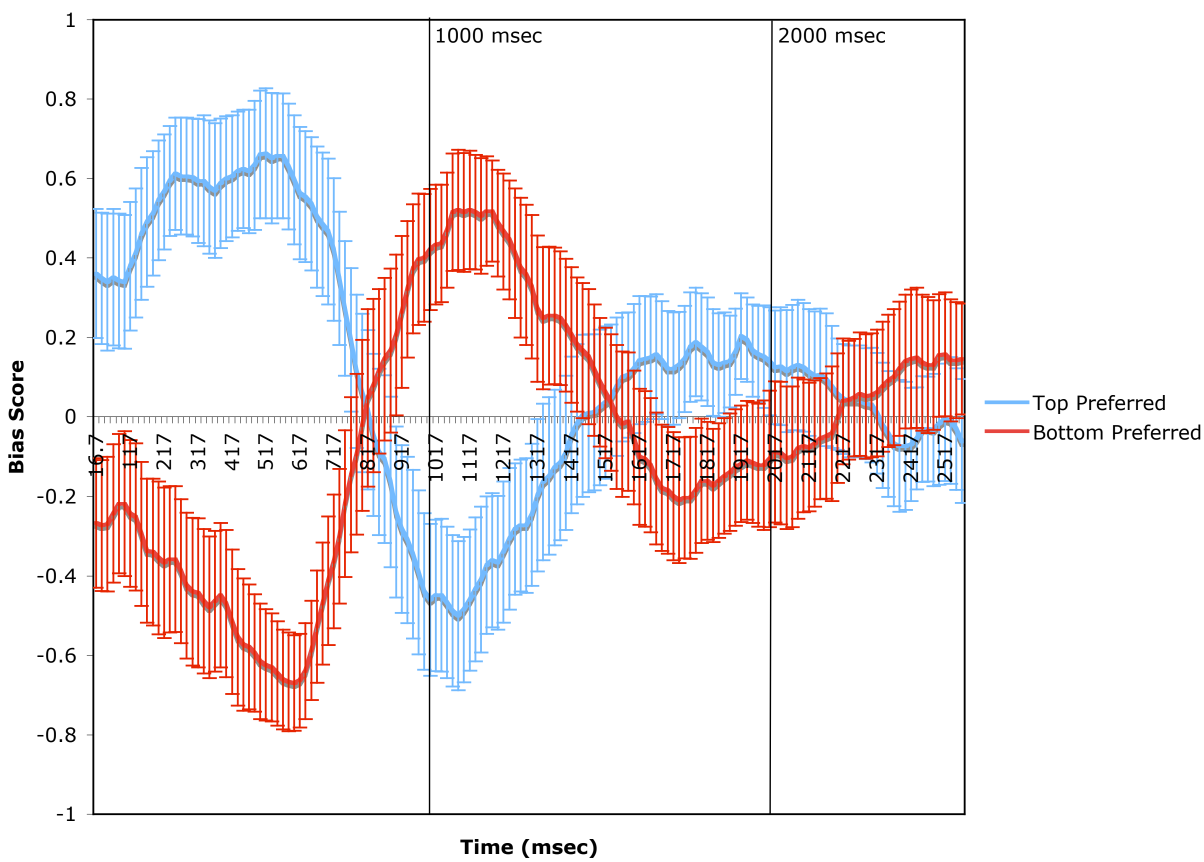

Figure 2-7. Results from the Geon stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

Discussion

The purpose of the current study was to investigate if using vertically paired stimuli rather than horizontally paired stimuli would impact the gaze cascade effect. It was hypothesized that presenting stimuli vertically rather than horizontally would impact the gaze cascade effect and the results from the current study support this. Primarily, the gaze cascade effect was not consistently observed across trials when stimuli were presented vertically rather than horizontally as in previous studies. The gaze cascade effect was reliably seen on trials where the preferred image was presented in the upper visual field but not when the preferred image was presented in the lower visual field.

A series of experiments was used to investigate how our unconscious behaviours play a role in making preference decisions, investigating the influence of eye movements when making preference decisions (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007). The results from these studies led to the formation of a dual-contribution model for preferential decision-making that involves a two-part process for orienting structures. The initial process is linked to preferential looking (Birch et al., 1985) and the second process is the mere exposure effect (Kunst Wilson & Zajonc, 1980).

The gaze cascade effect includes input from orienting behaviour structures such as gaze and from a cognitive assessment system. The cognitive systems are thought to be responsible for comparing the current stimuli to a known template. Although their model incorporates feedback from cognitive assessment systems, it is thought that one's cognitive representations are relatively stable and that short-term influences would not be substantial. According to their model orienting behaviours also incorporate feedback, where gaze biases increase exposure and lead to increased preferences similar to the mere exposure effect. The decision module is then responsible for integrating the information from these two systems.

Shimojo and colleagues (2003) reported that when cognitive biases were weaker the gaze bias should be stronger such as with abstract stimuli. The current study investigated the presence of the gaze cascade effect when presented vertically using several types of stimuli including: faces, String objects, Chairs, Geons and Greebles. It was expected that the object data from the current study would display similar patterns as abstract stimuli in previous research due to weak cognitive biases. The object data from the current study did not exhibit the expected pattern. Instead, except for Greeble trials, the object data did not exhibit the gaze cascade effect. Further, similar to face trials Greeble trials only exhibited the gaze cascade effect when the preferred image was presented in the upper visual field.

The results of the current study can be linked to the mere exposure effect, the second process in the dual-contribution model presented by Shimojo and colleagues (2003). The mere exposure effect postulates that merely exposing yourself to an object can increase preference for that object. A review of previous eye-tracking research revealed interesting viewing patterns during visual search tasks. Primarily that we spend more time looking in the upper visual field (Gould & Schaffer, 1965; Previc, 1996) and that the majority of first saccades are made to the upper visual field (Chedru et al., 1973; Hall, 1985; Previc, 1996). The initial viewing bias towards the top image (regardless of whether it was the more attractive/preferred image) likely contributed to differences in gaze biases observed in the current study. Initial viewing patterns directed at the upper image may have impacted gaze biases without impacting image selection. Viewing biases towards the upper visual field may have had a greater impact on trials where the cognitive bias towards the image was weaker, such as in object trials. Given the relation between preference and exposure it is likely that natural viewing asymmetries highlighted by previous eye-tracking research that bias the upper visual field influence and increase preference for images presented in the upper visual field compared to those presented in the lower visual field.

Previc (1990) hypothesized upper and lower visual field differences are related to how objects are processed in space. Specifically that the lower visual field is more involved in near visual space that relies on global processing. The upper visual field is more involved in far visual space that relies on local perceptual processing. Previc (1998) identified four brain systems that mediate how we interact in the different areas of space: peripersonal, focal-extrapersonal, action-extrapersonal and ambient extrapersonal. Specifically of interest for the current topic are peripersonal space and focal-extrapersonal space. Peripersonal space is responsible for reaching behaviours that occur in near-body space and is located primarily in the dorsolateral cortex. The focal-extrapersonal system is involved in visual search of the environment and is located ventrolaterally in the inferior temporal and lateral frontal cortex.

Previc's (1998) explanation of visual field differences and how we interact with objects in space fits well with visual field differences observed in the current data. Preference or attractiveness judgments would require visual search of the environments and would occur in the focal-extrapersonal system. Previc indicates that the focal-extrapersonal system is biased to the upper visual field. Both Previc and past eye-tracking research support the idea that participants would spend a greater length of time looking at objects in the upper visual field. Given the relationship between the gaze cascade effect, the mere-exposure effect and the bias of the focal-extrapersonal system natural viewing asymmetries provide an explanation for how presenting stimuli vertically impacts the gaze cascade effect.

A possible limitation to the current study is that top and bottom preferred trials are defined based on previously provided attractiveness ratings rather than current participant choice.

However, as no significant differences were observed between the attractiveness ratings of the current participants and the pilot participants similar preferences were expected.

Study 2 investigated how presenting stimuli vertically will impact the gaze cascade effect when decision difficulty is manipulated. Shimojo and colleagues (2003) observed a larger gaze cascade effect when choice difficulty was increased, where maximizing or minimizing the attractiveness difference between the two faces manipulated choice difficulty. The impact of choice difficulty was described using similar logic to when abstract stimuli were used. The closer the two faces were in attractiveness the weaker the cognitive bias would be to either face thus causing orienting biases to play a larger role in preference formation. It would also be interesting to investigate differences in the gaze cascade effect when the preferred image is presented in the right or left visual field, as viewing asymmetries have been observed between the left and right visual fields.

CHAPTER 3
STUDY 2

Introduction

This chapter is a manuscript in preparation and contains some repetition from the general introduction.

Past research has investigated characteristics, such as symmetry and averageness, which contribute to our preferences providing us with a detailed understanding of what we like. However, more recently researchers have begun to investigate *how* our preferences are formed rather than *what* we prefer. Our decisions and preferences shape our actions and behaviours. For example, we are more likely to interact with a stimulus we prefer than one we don't. Simion, Shimojo and colleagues (2003; 2006; 2007) investigated the influence of orienting behaviours on preference formation and observed a progressive bias towards the preferred image, termed the gaze cascade effect (Shimojo et al., 2003). The gaze cascade effect is strongest during the final 1.5 seconds of a trial and can indicate a bias as strong as 83% in some cases. Using a series of manipulations including restricting the viewing area, interrupting the decision and purposefully biasing participants gaze they were able to display the robustness of the gaze cascade effect (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007).

Simion, Shimojo and colleagues (2003, 2006, 2007) used two control tasks (which face is rounder and which face do you dislike more) to investigate if the gaze cascade effect was unique to preference decisions or if it is part of the decision making process. It was possible that the gaze cascade effect may have been the result of making a decision or trying to remember which image was selected. Neither control task displayed a significant gaze bias at the start or end of the trial leading Simion and colleagues (2003) to argue that the gaze cascade effect was unique to preference decisions.

Additionally, Shimojo and colleagues (2003) investigated the gaze cascade effect and the impact of decision difficulty on orienting behaviours. Decision difficulty was manipulated by maximizing or minimizing the attractiveness difference between the two faces creating two levels of decision difficulty, easy and hard. Gaze likelihood analysis was used to create a growth curve for each trial type displaying the percentage of time spent looking at the preferred image. If no viewing bias occurs growth curves would start and end at chance levels indicating that participants were equally likely to be looking at either image. At trial onset curves started at chance levels, indicating that there was no initial gaze bias towards either image. In both attractiveness conditions (easy and hard) prior to making a decision participants gaze was biased towards the selected image at a level significantly higher than chance. In some instances up to 83% of participants time was spent looking at the chosen image. The gaze cascade effect was particularly strong in the final second and half before the decision was made. Interestingly, the gaze cascade was larger in the difficult condition than the easy condition. These patterns were not related to length of time to reach a decision, as there was no correlation between these two variables.

The results from this study led the researchers to develop a dual-contribution model for preferential decision-making (Shimojo et al., 2003). This model includes input from orienting behaviour structures such as gaze and from a cognitive assessment system. The cognitive systems are thought to be responsible for comparing the current stimuli to a known template. Although their model incorporates feedback from cognitive assessment systems, it is thought that one’s cognitive representations are relatively stable and that short-term influences would not be substantial. According to their model orienting behaviours also incorporate feedback, where gaze increases exposure and leads to increased preferences similar to the mere exposure effect. The decision module is then responsible for integrating the information from these two systems. However, the robust nature of the gaze cascade effect has not been supported by more recent research.

Glaholt and Reingold (2009) sought to extend the research and further investigate the robust nature of the gaze cascade effect using a real world stimuli set instead of computer-generated faces. The methods used were identical to those used by Shimojo and colleagues (2003) except photographs of artwork were used in place of computer-generated faces. Their purpose was to further investigate the time course of the gaze cascade effect and provide further evidence that it is a process unique to preference decisions, regardless of stimuli type. Their control task asked which photo was taken most recently. They observed a similar gaze cascade pattern in all of their preference conditions (2-alternative forced choice, gaze contingent display and 8- alternative forced choice). Interestingly, they also observed the gaze cascade effect during their control task, which Shimojo and colleagues (2003) and Simion and Shimojo (2006 & 2007) did not observe. Simion, Shimojo and colleagues (2003) provided graphical data and qualitative interpretations stating that the gaze cascade effect was not present during their control trials. Glaholt and Reingold (2009) suggest that the gaze cascade effect might be associated with visual decisions and is not unique to preference decisions.

Additionally, in Study 1 the robustness of the gaze cascade effect was tested when images were positioned vertically rather than horizontally as in the previous gaze cascade experiments (Glaholt & Reingold, 2009; Shimojo et al., 2003). Past eye-tracking research indicates that participants spend more time scanning the upper visual field than the lower visual field during visual search tasks (Gould & Schaffer, 1965; Previc, 1996). Further, participants are more likely to direct their first saccade to the upper visual field (Chedru et al., 1973; Hall, 1985). As the gaze cascade effect is strongly linked to the mere exposure effect it is likely due to natural viewing asymmetries presenting the stimuli horizontally may impact the gaze cascade effect.

Shimojo and colleagues (2003) also observed a stronger gaze cascade effect when the decision difficulty was increased (i.e. the attractiveness of the two objects were minimized). This difference was associated with weaker cognitive biases due to how close the attractiveness values of the two faces were. The current study further tested the robustness of the gaze cascade effect by investigating the impact of choice difficulty when images are presented vertically rather than horizontally. Similar to the work of Shimojo and colleagues (2003), two levels of choice difficulty will be included: easy (attractiveness value between the two faces will be maximized) and hard (attractiveness value between the two faces will be minimized). It is predicted that the gaze cascade effect will be strongest when the decision is difficult. It is also predicted that the gaze cascade effect will only be present when the preferred image is presented in the upper visual field.

Methods

Participants

The current study tested 36 right-handed participants (5 male). All participants were undergraduate students from the University of Saskatchewan participating for course credit in Psychology 110. All participants were naïve to the purposes of the study.

Methods

After providing informed consent participants completed a brief demographics questionnaire that included handedness and footedness questions. Next participants were centered and seated in front of a computer screen and a Remote Eye-tracking Device (RED). The RED used is the SMI iView REDII. The RED can be used to record and measure eye movement without any physical contact with the participant. The SMI iView REDII system is a two-computer system linked using a serial port to trigger stimulus presentation. Motorized focus, iris, and zoom control provide automatic or manual remote operation from a second computer. The RED was calibrated by the experimenter using a 9-point calibration grid for each participant. To maintain continuous recording of eye-movements and maintain calibration participants were asked to keep their head as still as possible. To assist participants in stabilizing their head position a chin rest was provided and adjusted to their comfort level.

Participant's eye movements were recorded during two blocks of trials. Block one contained 228 trials: 160 face trials and 68 object trials (see Figure 3-1). Faces were created using Poser. Poser was selected because in Study 1 participants reported that faces were not realistic and that it was hard to distinguish female faces from male faces. Poser creates more realistic faces allowing for hair and gaze direction to be manipulated. Pilot tests revealed female faces in greyscale produced the most consistent attractiveness ratings, so only they were used during face trials. Object trials consisted of chair or String stimuli and were provided from the Tarr Lab online database. In block 1 each image (400 X 400 pixels) was centrally presented for 3000 msec and was preceded by a fixation cross. After the image disappeared from view participants were asked to rate the attractiveness of the stimuli on a 7-point scale where 1 is unattractive and 7 was attractive by pressing a number on the provided keypad. The purpose of block 1 was to compare participant attractiveness ratings to the rating of pilot participants, no significant differences were observed.

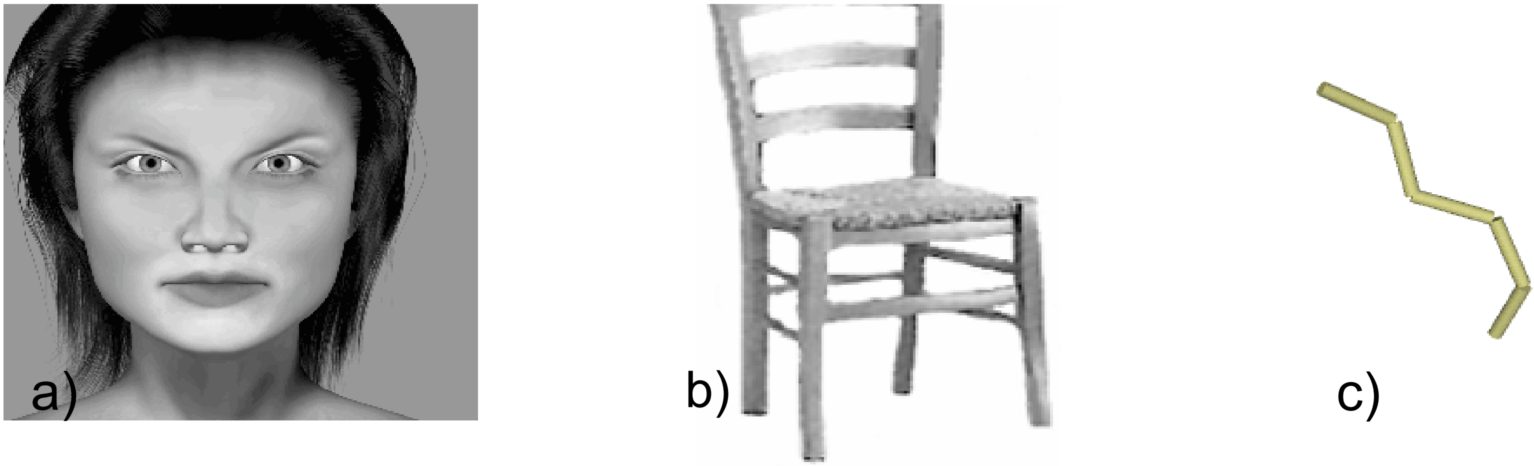

Figure 3-1. Sample image of stimuli used in study 2: a) sample face created using Poser, b) Chair stimuli, & c) String object. Chair & String images are courtesy of Michael J. Tarr, Brown University, http://www.tarrlab.org/.

Block 2 contained 228 trials: 160 face trials and 68 object trials. During block 2, images were paired on attractiveness from previously collected pilot data. Images in face trials were paired to manipulate decision difficulty either maximizing (easy decision) or minimizing (hard decision) the attractiveness difference. Three categories of decision difficulty were used: high high (minimized attractiveness difference of two highly attractive faces), low low (minimized attractiveness difference of two unattractive faces) and high low (maximized attractiveness difference of one attractive and one unattractive face). Images were centered on the visual display and presented vertically with one appearing in the upper visual field and one in the lower visual field. Images were scaled such that their longest dimensions occupied 16º of visual angle (400 pixels). Images were preceded by a fixation cross and presented for 3000 msec. Participants were asked to select which image they preferred selecting either top (8 on the keypad) or bottom (2 on the keypad) by pressing a number on the keypad provided.

Data Coding and Analysis

Participant eye movement data recorded when viewing the images during block 2 was coded using a customized application for iLab (Gitelman, 2002) that is ran using the platform Matlab. iView data files were converted into Matlab files using iLab. Regions of interest that matched the size and location of the images were then defined for both the top and bottom images. Fixation analysis was completed to calculate the number of fixations that were made to both the top and bottom and images. Following this a customized application was used to calculate the amount of time spent looking at each image (top or bottom) during 15 msec intervals across each trial. Using the fixation analysis each image (top or bottom) was assigned a value of 0 (did not look at the image), 0.5 (spent 50% of the interval viewing this image) or 1.0 (spent 100% of the interval viewing this image) for each interval. Both saccades and fixations recorded in the ROI were used in the analysis. Any time spent outside the ROI was excluded from the analysis, as a result values for each interval may be less than 1. Interval scores were summed across like trials (e.g. top preferred face, bottom preferred face etc.). Top preferred trials were defined as trials where the more attractive face was presented in the upper visual field. Bottom preferred trials were defined as trials where the more attractive face was presented in the lower field. Bias scores were then calculated by subtracting the total score for the non-preferred image from the total score for the preferred image divided by the number of trials. In this case for each interval a value of 1 would indicate complete bias towards the preferred image and a value of -1 would indicate a complete bias to the non-preferred image.

Averages and 95% confidence intervals were then calculated across all participants for each time interval for each stimulus type. Confidence intervals were used to detect the presence of the gaze cascade effect (significantly different from 0 in the final second and half of the trial) and if top and bottom preferred trials were different from one another.

Results

Several patterns, similar to those from study 1, were observed across trials in study 2. These patterns will be explained using face data from block 2 (see Figure 3-2). The first pattern observed is that participants look first at the top presented image; indicated by an initial positive bias score for top preferred trials and an initial negative bias score for bottom preferred trials. The second pattern observed is that during both bottom and top preferred trials between 765 msec – 900 msec participants gaze direction switches from the top image to the bottom image.

A key difference in gaze bias was observed between top and bottom preferred trials during the final 1500 msec prior to decision. Simion, Shimojo and colleagues (2003; 2006; 2007) previously documented a progressive gaze bias towards the image they preferred during the final 1500 msec termed the gaze cascade effect. Consistent with previous research during the final 1500 msec, the top preferred trials displayed a gaze bias that is significantly different than 0 as indicated by the 95% confidence intervals. In contrast, the bottom preferred trials did not display a gaze bias that was significantly different than 0. This difference is evidence that the gaze cascade effect was observed during top preferred face trials but not bottom preferred face trials. However, the gaze bias in top preferred face trials is not significantly different from the bias in the bottom preferred face trials.

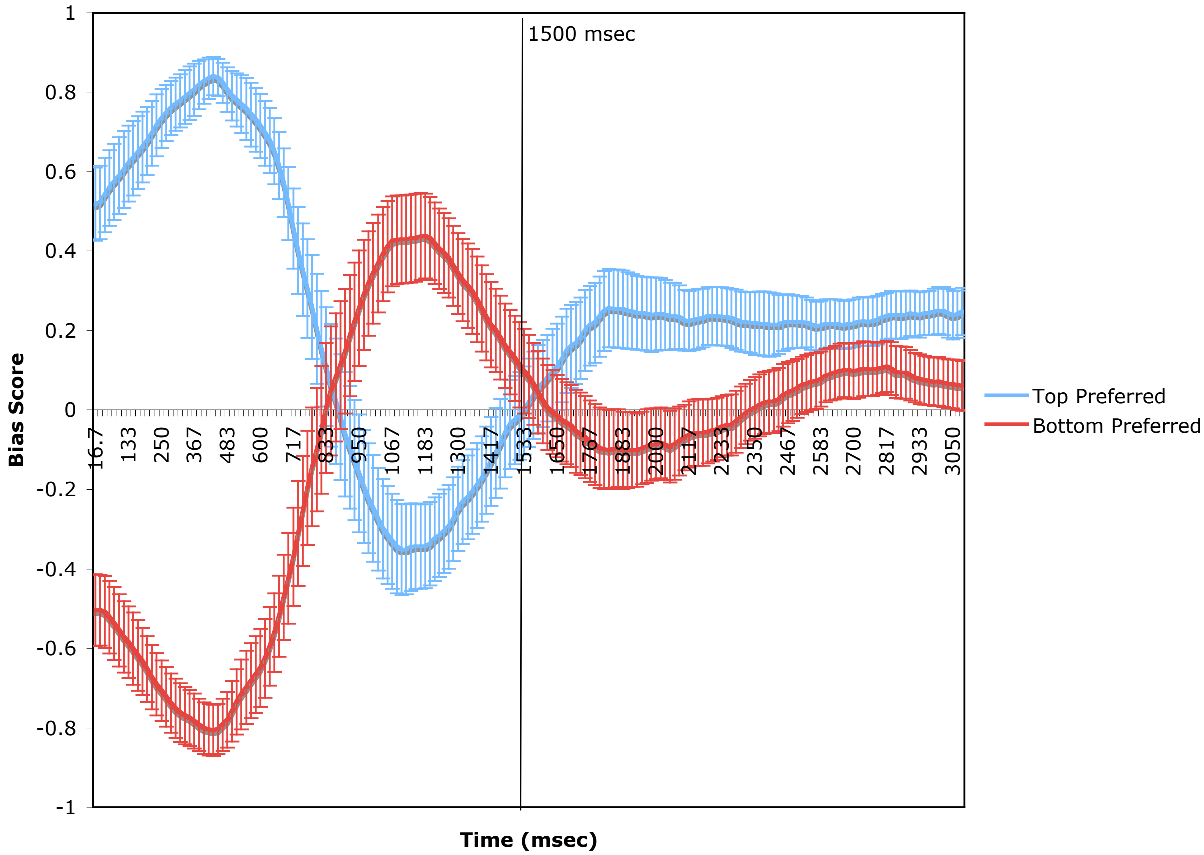

Figure 3-2. Results from the face stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

Similar viewing patterns were observed for the String (see Figure 3-3) and chair (see Figure 3-4) stimuli data sets. Similar differences were observed between top preferred and bottom preferred object trials. However, top preferred object trials did not display as consistent of a gaze bias as face trials. String trials displayed a significant gaze bias in top preferred trials only similar to the face trials (Figure 3-3). Neither top nor bottom preferred trials using chair data displayed a gaze bias significant from 0 (Figure 3-4). Further, top and bottom preferred chair trials did not differ from one another. Identical patterns were observed for trials where gaze direction of the preferred stimulus was averted.

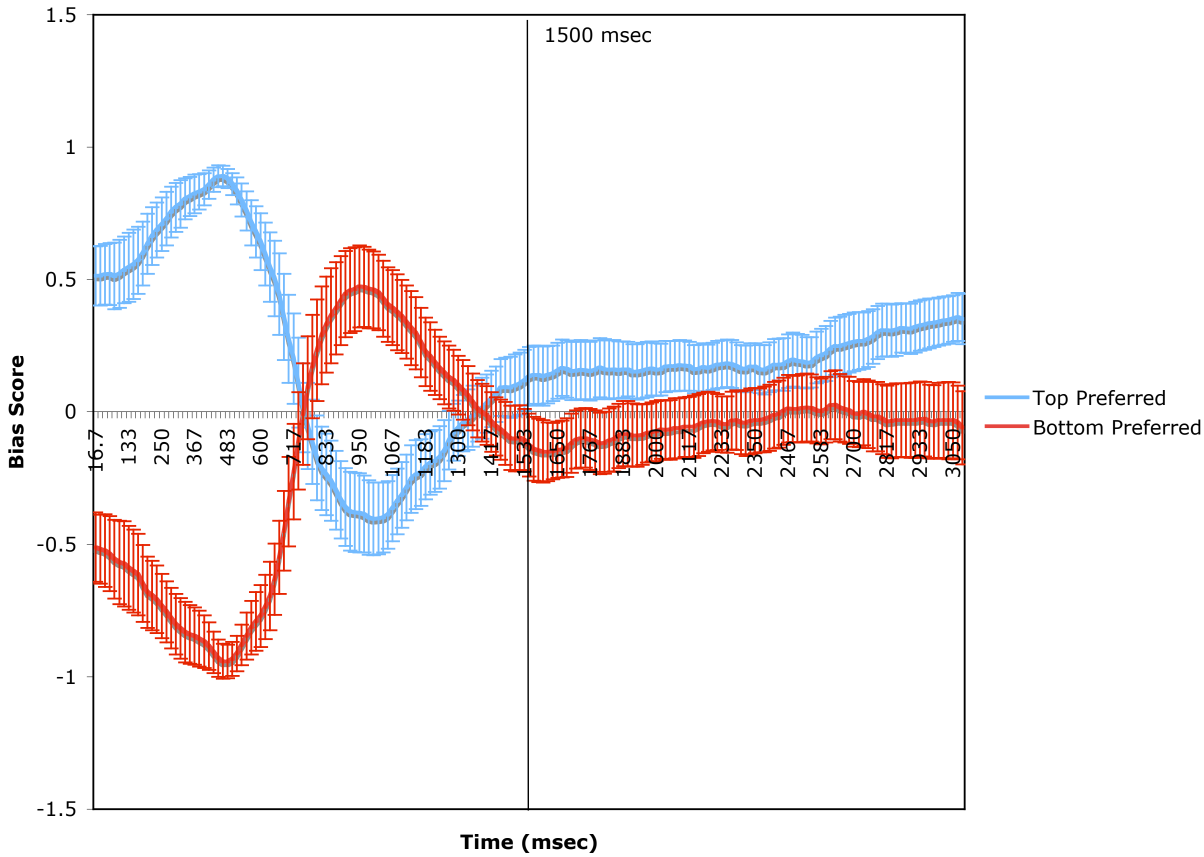

Figure 3-3. Results from the String stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

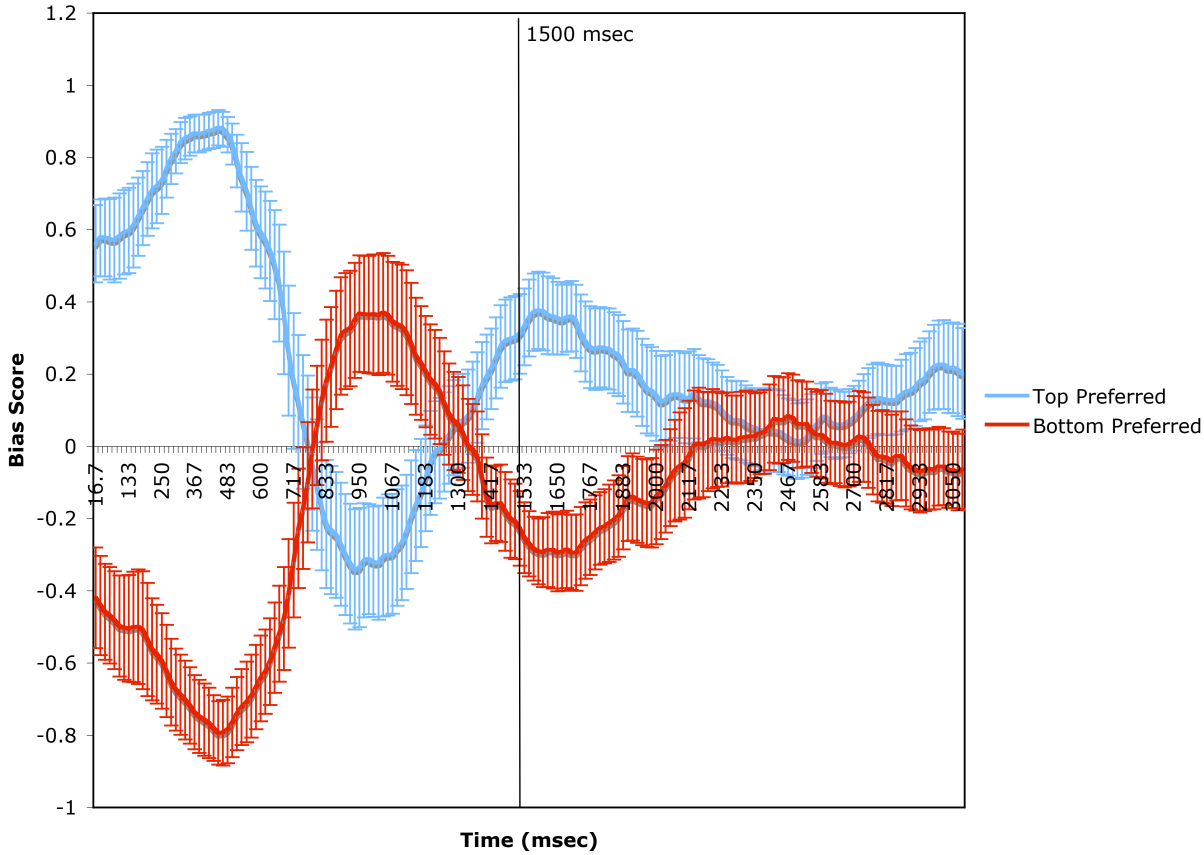

Figure 3-4. Results from the Chair stimulus set. The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

Choice Difficulty

In a previous investigation Shimojo and colleagues (2003) manipulated choice difficulty by maximizing or minimizing the attractiveness difference between the two images. They observed that the gaze cascade effect was more pronounced in trials where the decision difficulty was increased (or the attractiveness difference between the two images was minimized). The current study sought to further investigate the impact of choice difficulty on the gaze cascade effect. The current study included 3 levels of choice difficulty: high/high (attractiveness difference is minimized using two attractive faces), low/low (attractiveness difference is minimized using two unattractive faces) and high/low (attractiveness difference is maximized using one attractive and unattractive face). According to previous research the gaze cascade effect should be strongest in trials where the attractiveness difference is minimized.

The high/high condition produced a similar graph to all face and object data. It is clear that participants in both the top and bottom preferred condition examined the top face first (see Figure 3-5). Similar to previous data the top preferred trials in the high/high condition display a significant gaze cascade effect in the final 1500 msec as evidenced by the 95% confidence interval. However, as shown previously the bottom preferred trials do not display a significant gaze cascade effect in the high/high condition.

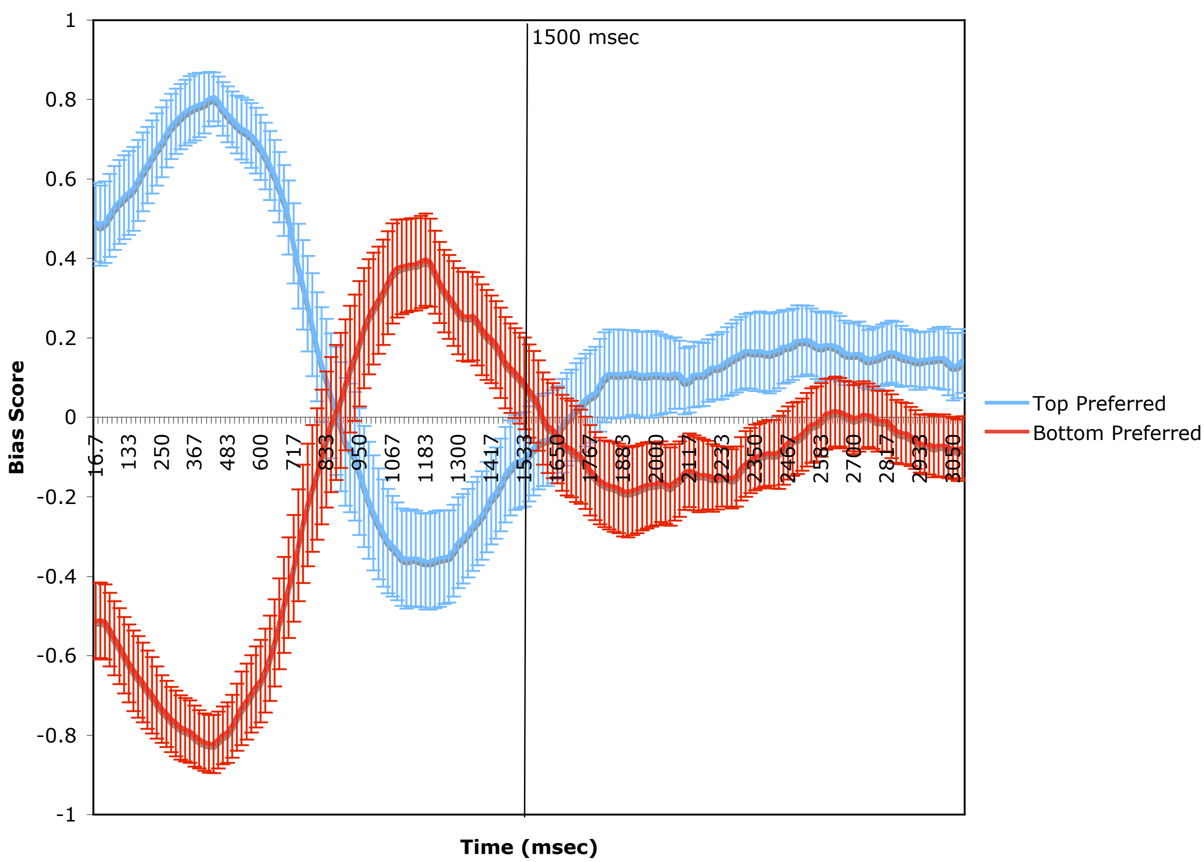

Figure 3-5. Results from the face stimulus set when decision difficulty is maximized using highly attractive faces (High/High condition). The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

Similar to the high/high condition the low/low condition was expected to exhibit the largest gaze cascade effect due to a limited cognitive bias as predicted by Shimojo and colleagues (2003). However, similar to the high/high condition results were not as expected but were similar to previous findings (see Figure 3-6). The top preferred condition exhibited a significant gaze cascade effect in the final 1500 msec as evidenced by the 95% confidence intervals. However, it was not as strong in the high/high condition. The bottom preferred trials did not display a significant gaze cascade effect during the entire last 1500 msec however during the last ~ 500 msec a gaze bias significantly different than 0 was displayed towards the preferred image.

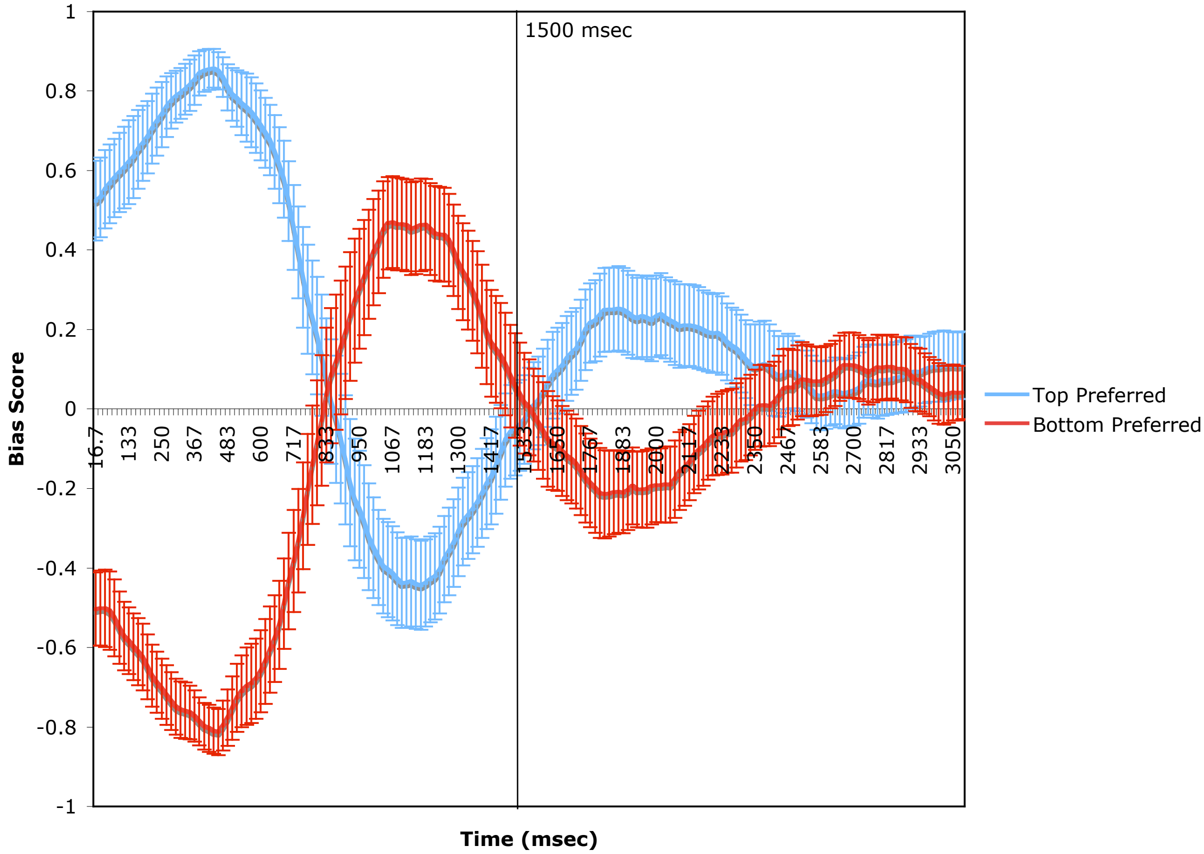

Figure 3-6. Results from the face stimulus set when decision difficulty is maximized using unattractive faces (Low/Low condition). The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

It was predicted that the high/low conditions would exhibit a smaller gaze cascade effect as there would be a larger cognitive bias to guide the decision and would require less reliance on the input from orienting structures. The high/low condition exhibited a significant gaze cascade effect for both the top and bottom preferred trials as expected (see Figure 3-7). However, not as expected the gaze cascade effect in the high/low condition was stronger than in previous conditions (high/high & low/low) indicating more reliance on orienting structures.

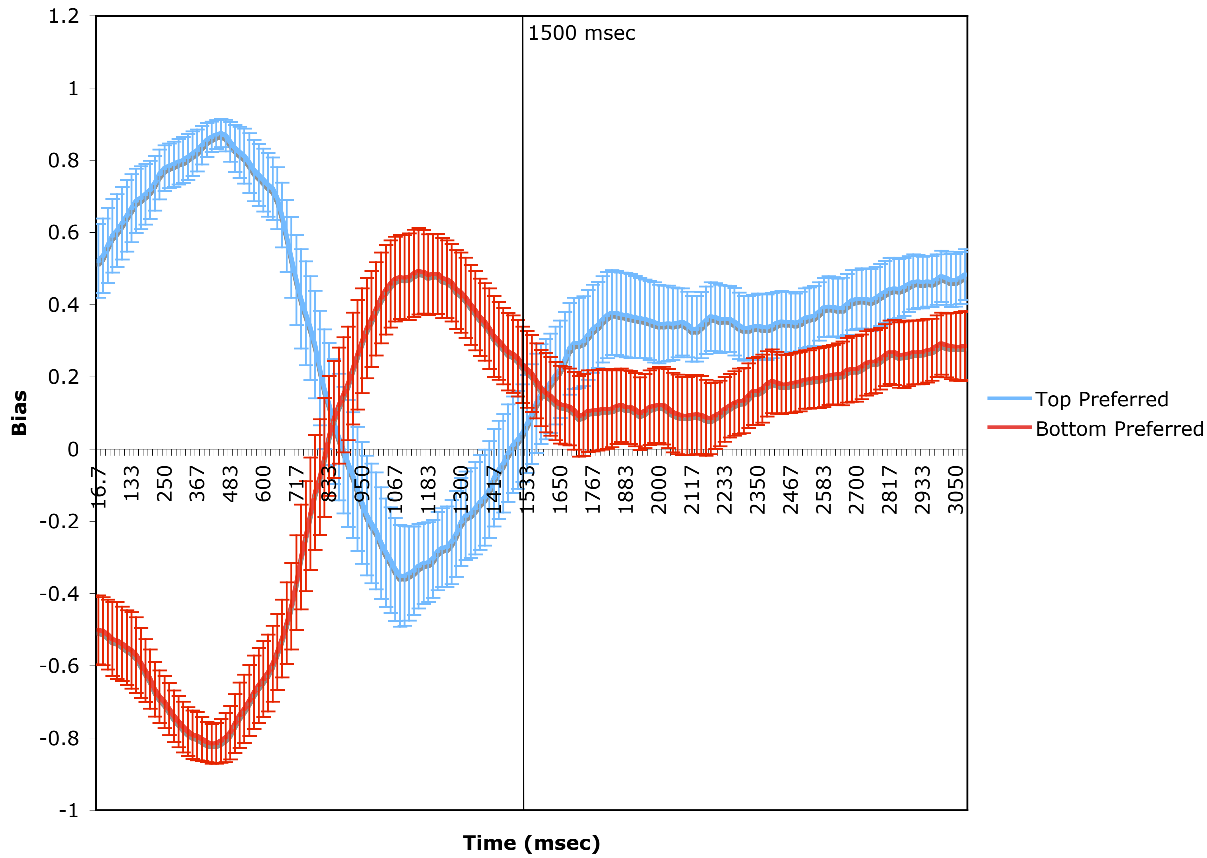

Figure 3-7. Results from the face stimulus set when decision difficulty is minimized by pairing attractive and unattractive faces (High/Low condition). The solid lines labeled top preferred and bottom preferred represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-preferred subtracted from the preferred viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the preferred stimulus was presented in the upper visual field and the red line represents when the preferred stimulus was presented in the lower visual field.

Discussion

The results of the current study were similar to those from study 1. The gaze cascade effect was reliably seen in trials where the preferred image was presented in the upper visual field but was not reliably seen when the image was presented in the lower visual field. The primary aim of study 2 was to investigate the impact of choice difficulty on the gaze cascade effect when images were presented vertically rather than horizontally as in previous work by Simion, Shimojo and colleagues (2003; 2006; 2007). Based on previous findings it was expected that the largest gaze cascade effect would be seen in the conditions where choice difficulty was increased by minimizing the attractiveness difference between the two faces. It was predicted that increasing choice difficulty would minimize cognitive biases and increase the need to rely on orienting biases. An increased reliance on orienting biases would be indicated by a stronger gaze cascade effect in trials where the choice difficulty was increased. However, the opposite was observed in the current investigation. The high/low condition where choice difficulty was minimized exhibited a significant gaze cascade effect in both the top and bottom preferred trials and exhibited greater strength than in other conditions as indicated by larger gaze biases. The high/high and low/low conditions where choice difficulty was increased exhibited significant gaze cascade effects in the top preferred trials but not in the bottom preferred trials.

As discussed in study 1 the difference in gaze biases between top and bottom preferred trials might be linked to natural asymmetries in visual search patterns. Previc (1998) postulated that these differences can be explained by how we interact with objects in 3-dimensional space. Specifically that the lower visual field is more involved in near visual space that relies on global processing. The upper visual field is more involved in far visual space that relies on local perceptual processing. Previc (1998) identified four brains systems that mediate how we interact in the different areas of space: peripersonal, focal-extrapersonal, action-extrapersonal and ambient extrapersonal. Specifically of interest for the current topic are peripersonal space and focal-extrapersonal space. Peripersonal space is responsible for reaching behaviours that occur in near-body space and is located primarily in the dorsolateral cortex. The focal-extrapersonal system is involved in visual search of the environment and is located ventrolaterally in the inferior temporal and lateral frontal cortex.

Eye-tracking research investigating visual search patterns has indicated our first saccade is most likely to be directed to the upper visual field and that we spend more time looking in the upper visual field (Chedru et al., 1973; Hall, 1985). Given the relation between the gaze cascade effect and the mere exposure effect it is likely that viewing asymmetries between the upper and lower visual field impact the gaze cascade effect. The results of study 1 and study 2 support this as the gaze cascade effect was not reliably seen in the lower visual field but was consistently seen in the upper visual field where there is a natural viewing/orienting bias.

Natural viewing biases to the upper visual field can be linked to the orienting biases and the mere exposure effect outlined in the dual-contribution model proposed by Shimojo and colleagues (2003). According to their model orienting behaviours also incorporate feedback, where gaze biases increase exposure and lead to increased preferences similar to the mere exposure effect. Natural viewing biases observed in eye-tracking research might lead to orienting biases and increased preference as observed in both study 1 and study 2. Based on past research it would be predicted that in a situation where choice difficulty was increased orienting biases and possibly natural viewing biases would play a larger role in preference formation.

The purpose of the current study was to further investigate the impact of choice difficulty on the gaze cascade effect when stimuli were presented vertically rather than horizontally. Shimojo and colleagues (2003) observed larger gaze cascade effects when the choice difficulty was maximized. This difference was attributed to a decreased cognitive bias when the faces are more similar in attractiveness, which leads to orienting biases playing a larger role in the development of preference formation. The current study did not support past findings, in fact larger gaze cascade effects were seen in trials where the attractiveness difference was maximized rather than minimized. In trials where the attractiveness difference was minimized the gaze cascade effect was only seen in trials where the preferred image was presented in the upper visual field.

A possible explanation for the current finding could be that in the absence of a strong cognitive bias the natural viewing bias towards the upper visual field plays a larger role leading to increased preference for the top image and decreasing possible orienting biases to the lower visual field. This explains why the top preferred conditions reliably display the gaze cascade effect where the bottom preferred trials do not. The strength of the gaze cascade effect seen in the high/low condition where the attractiveness difference is maximized is likely the result of a strong cognitive bias that is paired with a strong orienting bias.

A second possible explanation for the inconsistent gaze cascade effect is that in trials where the attractiveness difference was minimized and the cognitive bias was decreased that no preference was formed and participants selected images randomly. A third possible explanation is that given the closeness in attractiveness between the two images participants less reliably selected the image rated as more attractive by pilot participants. This would mean that the gaze curves of the top and bottom preferred images may not be accurately reflecting participant preference.

Finally, recent findings presented by Glaholt and Reingold (2009) suggest that the gaze cascade effect may be the reflection of a visual decision and is not isolated to preference decisions as previously indicated. Drawing their conclusions from a recent study where the gaze cascade effect was observed in both their experimental and control tasks, unlike the work of Simion, Shimojo and colleagues (2003, 2006, & 2007). The first two studies are unable to address this concern as no control task was used. Future research should further investigate the role of the gaze cascade effect in visual decision tasks that are not related to our preferences. If

Glaholt and Reingold are correct the gaze cascade effect should be present in any visual decision regardless of the stimuli or question. Study 3 will investigate the presence of the gaze cascade effect during a simple visual decision using a perceptual viewing task, such as indicating which stimuli is more concave.

CHAPTER 4
STUDY 3

Introduction

This chapter is a manuscript in preparation and contains some repetition from the general introduction.

Shimojo and colleagues (2003) investigated the role of orienting biases during preference decisions, specifically examining the role of gaze. They predicted that orienting biases would play an important role in preference formation due to their relation with exposure. In their experiments two faces were horizontally paired and presented across the left and right visual fields and participants were asked to select which face they thought was more attractive. A progressive bias towards the preferred image was observed as the participant neared their decision, particularly in the final 1.5 seconds prior to decision, termed the ‘gaze cascade effect’.

A dual-contribution model for preferential decision-making was developed that included input from orienting behaviour structures such as gaze and from a cognitive assessment system (Shimojo et al., 2003). The cognitive systems are thought to be responsible for comparing the current stimuli to a known template. Although their model incorporates feedback from cognitive assessment systems, it is thought that one’s cognitive representations are relatively stable and that short-term influences would not be substantial. According to their model orienting behaviours also incorporate feedback, where gaze biases increase exposure and lead to increased preferences similar to the mere exposure effect. The decision module is then responsible for integrating the information from these two systems.

The role of orienting behaviours was detailed further separating it into a two-part process. The first process is linked to preferential looking (Birch et al., 1985). Simply stated preferential looking is linked to the notion that we will look longer at images that we prefer or that are attractive. This behaviour has been primarily demonstrated in infants and has been documented shortly after birth (Slater et al., 1998). The second process is the mere exposure effect proposed by Zajonc (1968) and further documented by Kunst Wilson and Zajonc (1980). Simply stated the mere-exposure effect indicates that previously exposing a participant to a stimulus, even if they are not aware of the presentation, will increase familiarity and can lead to an increased preference towards the previously exposed stimuli. Together these processes create a positive feedback loop that leads to an orienting bias.

A series of experiments were used to investigate several factors and demonstrate the robust nature of the gaze cascade effect: observing its presence when viewing faces (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007); abstract objects (Shimojo et al., 2003); and using a gaze contingent display (Simion & Shimojo, 2006). Additionally, they were able to artificially induce preferences by biasing the viewing times of stimuli (Shimojo et al., 2003). Finally, the effect was still present when viewing was interrupted prior to a decision being made (Simion & Shimojo, 2007).

Two control tasks were used to ensure that gaze patterns could be attributed to preference decisions and not to general decision making: which face is rounder and which face is less attractive. At trial onset the control tasks and the attractiveness task displayed similar patterns indicating that participants were investigating both images equally. As stated earlier when participants neared their decision in the attractiveness conditions a progressive bias towards the preferred image was observed. No such bias was observed in the control conditions indicating that the gaze cascade effect was not the result of making a decision or remembering which image was preferred.

Glaholt and Reingold (2009) sought to replicate the gaze cascade effect using photographs of artwork to try to use more real-world stimuli than computer generated faces. Their goal was to further investigate the time course of the gaze cascade effect and provide further evidence that it is a process unique to preference decisions, regardless of stimuli type. They observed a similar gaze cascade pattern in all of their preference conditions (2-alternative forced choice, gaze contingent display and 8-alternative forced choice). Interestingly, they also observed the gaze cascade effect during their control task (which photo do you think was taken most recently?), which was not previously observed (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007). Shimojo et al. (2003) provided graphical data and qualitative interpretations indicating that the gaze cascade effect was not present during their control trials. Glaholt and Reingold (2009) conclude based on their results that the gaze cascade effect might be associated with visual decisions and is not unique to preference decisions.

Similar to Glaholt and Reingold (2009) the goal of the first two studies in the current thesis was to further investigate whether the gaze cascade effect is robust. The first two studies investigated the impact of presenting stimuli vertically across the upper and lower visual fields rather than horizontally across the right and left visual fields as in previous research. Past eye-tracking investigations have demonstrated natural viewing asymmetries indicating that participants spend more time searching the upper visual field (Previc, 1996; Gould & Schaffer, 1968; Chedru et al., 1973) and are more likely to direct their first saccade to the upper visual field (Chedru et al., 1973; Hall, 1985). Given the relation between exposure and the gaze cascade effect it was predicted that presenting images across the upper and lower visual fields would impact the gaze cascade effect. Results from the previous two studies supported the hypothesis that using vertically paired stimuli would impact the gaze cascade effect. In fact the gaze cascade effect was only reliably displayed in trials where the preferred stimulus was presented in the upper visual field.

Additionally, Shimojo and colleagues (2003) investigated the experimental condition of choice difficulty, positing that when the two images were more similar in attractiveness the cognitive bias would be decreased and orienting biases would play a larger role in preference formation. In their studies larger gaze cascade effects were observed in conditions where decision difficulty was increased and abstract images were used. Study 2 attempted to replicate these findings by minimizing or maximizing the attractiveness difference between the two faces. The results of study 2 did not support the previous findings; in fact trials where decision difficulty was increased displayed the smallest gaze cascade effect and trials where the difficulty was decreased displayed the largest gaze cascade effect.

As a result of difficulties replicating the robust nature of the gaze cascade effect it is important to further investigate its role in preference formation and decision making in general. Glaholt and Reingold (2009) suggest that the gaze cascade effect is not unique to preference decisions but instead is evident when any visual decision has been made. The previous two investigations did not make use of control tasks so cannot further investigate this hypothesis. The purpose of the current study is to investigate the role of the gaze cascade effect in simple visual decisions. The current study will investigate the presence of the gaze cascade effect in a perceptual viewing task. Participants will be presented with two spheres that are mirror images and will use lighting biases to interpret which sphere is more concave or convex.

Methods

Participants

The current study tested 20 right-handed participants (5 male) with a mean age of 22.5 years. Three participants were excluded as a result of insufficient eye-tracking data. All participants were undergraduate students from the University of Saskatchewan participating for course credit in Psychology 110. All participants were naïve to the purposes of the study.

Methods

After providing informed consent participants completed a brief demographics questionnaire that included handedness and footedness questions. Next participants were centered and seated in front of a computer screen and a Remote Eye-tracking Device (RED). The RED used is the SMI iView REDII. The RED can be used to record and measure eye movement without any physical contact to the participant. The SMI iView REDII system is a two-computer system linked using a serial port to trigger stimuli presentation. Motorized focus, iris, and zoom control provide automatic or manual remote operation from a second computer. The RED was calibrated by the experimenter using a 9-point calibration grid for each participant. To maintain continuous recording of eye-movements and maintain calibration participants were asked to keep their head as still as possible. Viewing distance and head orientation was held constant using a chin rest that was adjusted to their comfort level. The tasks were administered on a computer (PIII 450) interfaced with a 19-inch SVGA monitor running at 1024 X 768 resolution.

During block 1 participants were presented with a centrally positioned sphere and were required to indicate if the sphere was concave or convex using a button press (see Figure 4-1 for sample images). All images were preceded by a fixation cross. Perceptually ambiguous spheres were presented to participants and were lit from one of 14 orientations (-22.5°, -45°, -67.5°, -90°, -112.5°, -135°, -157.5°, +22.5°, +45°, +67.5°, +90°, +112.5°, +135° or +157.5°) to create the appearance of convexity or concavity. Participant's eye movements were recorded during for 120 trials. Trials had a maximum trial length of 10 000 msec.

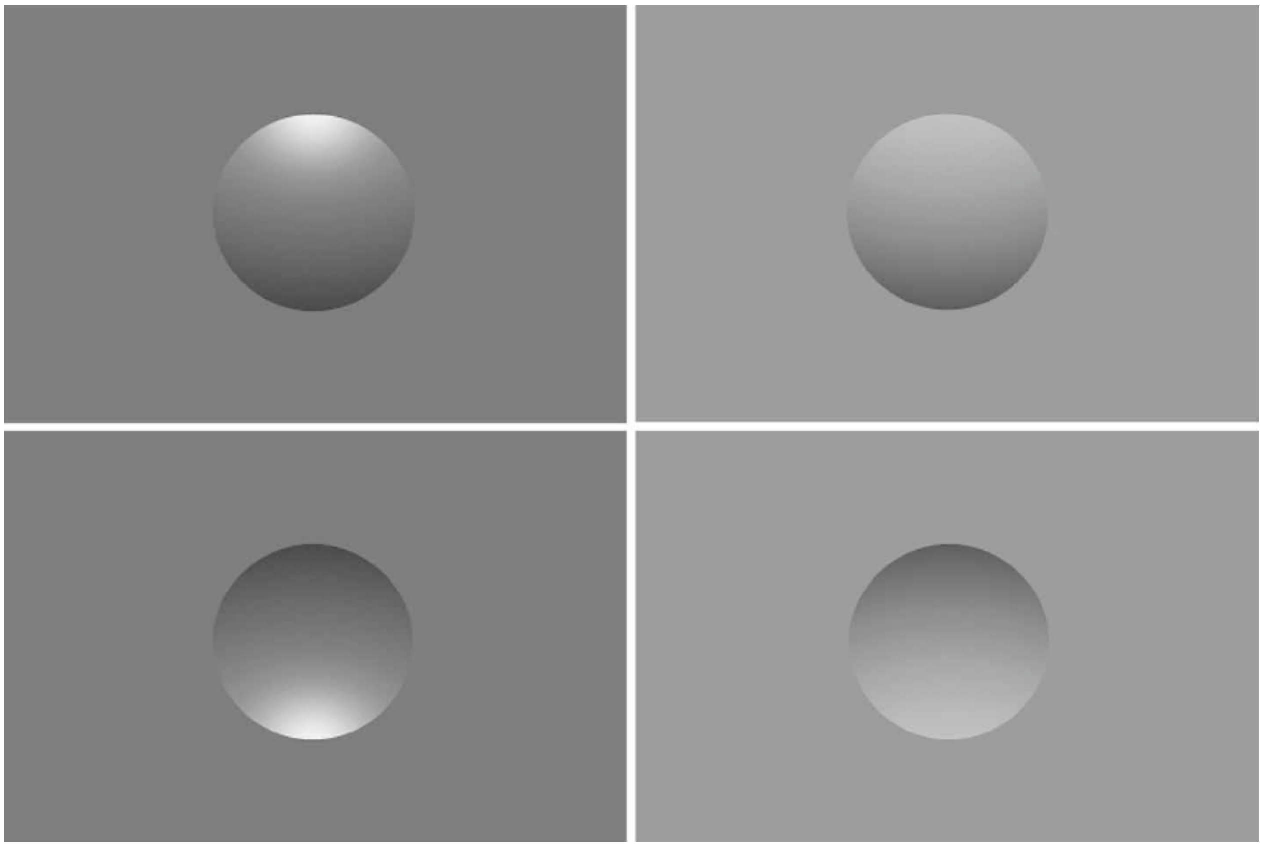

Figure 4-1. Sample stimuli for study 3. In block 1 each sphere was presented individually and was rated as convex or concave. In block 2 spheres were presented as mirror images and participants were asked to select which image was more concave.

During block 2 images were centered on the visual display and presented vertically paired with one appearing in the upper visual field and one in the lower visual field. Images were preceded by a fixation cross and presented for a maximum of 10 000 msec. Participants were asked to select which image they thought looked more concave by pressing 8 on the keypad to select the bottom image or pressing 2 on the keypad to select the top image. Participant's eye movements were recorded during 60 trials.

Data Coding and Analysis

Participant eye movement data recorded when viewing the images during block 2 was coded using a customized application for iLab (Gitelman, 2002) that is ran using the platform Matlab. iView data files were converted into Matlab files using iLab. Regions of interest that matched the size and location of the images were then defined for both the top and bottom images. Fixation analysis was completed to calculate the number of fixations that were made to both the top and bottom and images. Following this a customized application was used to calculate the amount of time spent looking at each image (top or bottom) during 15 msec intervals across each trial. Using the fixation analysis each image (top or bottom) was assigned a value of 0 (did not look at the image), 0.5 (spent 50% of the interval viewing this image) or 1.0 (spent 100% of the interval viewing this image) for each interval. Both saccades and fixations recorded in the ROI were used in the analysis. Any time spent outside the ROI was excluded from the analysis, as a result values for each interval may be less than 1. Interval scores were summed across like trials (e.g. top preferred face, bottom preferred face etc.). Top preferred trials were defined as trials where the more attractive face was presented in the upper visual field. Bottom preferred trials were defined as trials where the more attractive face was presented in the lower field. Bias scores were then calculated by subtracting the total score for the non-preferred image from the total score for the preferred image divided by the number of trials. In this case for each interval a value of 1 would indicate complete bias towards the preferred image and a value of -1 would indicate a complete bias to the non-preferred image.

Averages and 95% confidence intervals were then calculated across all participants for each time interval for each stimulus type. Confidence intervals were used to detect the presence of the gaze cascade effect (significantly different from 0 in the final second and half of the trial) and if top and bottom preferred trials were different from one another.

Results

Behavioural Data

Behavioural data was analyzed to ensure that participants displayed the expected bias towards selecting images lit from the left. Bias scores were calculated for all pairs. Negative scores indicate a bias towards left-lit images and positive scores indicate a bias towards right-lit images. It was predicted that participants would should a significant bias towards left-lit images.

One-sample t-tests (test value=0) demonstrated a significant bias for left-lit images (M=-5.313, S.D.=5.752), $t(191)=-12.798$, $p<.001$. The angle that spheres are lit from can affect the appearance of concavity. Images from the top may appear more concave than images lit from the bottom. Thus it was important to investigate if images lit from both the top and bottom displayed significant left biases. One-sample t-tests (test value=0) demonstrated that both top-lit ($t(95)=-7.701$, $p<.001$; M=-4.667, S.D.= 5.938) and bottom-lit ($t(95)=-10.585$, $p<.001$; M=-5.958, S.D.=5.515) images demonstrated a significant left bias.

Eye-Tracking Data

The purpose of the current study was to further investigate if the gaze cascade effect is unique to preference decisions as indicated by Shimojo et al. (2003) or present in all visual decisions as predicted by Glaholt and Reingold (2009). The gaze cascade effect was investigated using a simple visual decision task. Participants were presented with two perceptually ambiguous spheres and were asked to select which sphere appeared more concave. Based on previous research bias scores for the final 1500 msec of all trials were calculated and compared across participants and trials. 95% confidence intervals were used to test if bias scores were significantly different from 0 and to test if bias scores for top and bottom images were significantly different from one another.

As indicated by 95% confidence intervals during the final 1500 msec participants do not indicate a significant bias towards the selected image whether it was presented in the upper or lower visual field (see Figure 4-2).

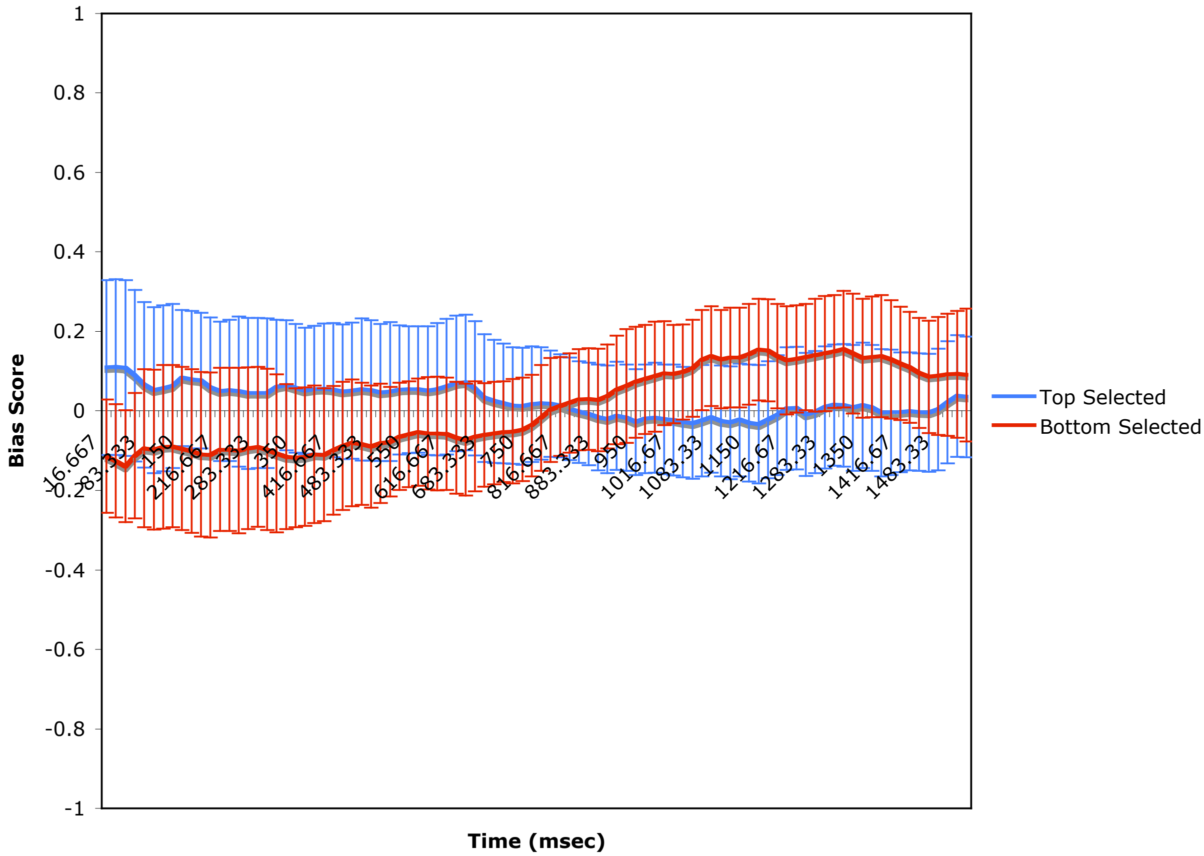

Figure 4-2. Results from the spheres stimulus set. The solid lines labeled top selected and bottom selected represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-selected subtracted from the selected viewing time. Bias scores range from -1 indicating that no time was spent looking at the preferred image to +1 indicating that all time was spent looking at the preferred image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the selected stimulus was presented in the upper visual field and the red line represents when the selected stimulus was presented in the lower visual field.

Judgments of concavity become more difficult as the lighting shifts from the top of the sphere to the bottom of the sphere. Trials were analyzed separately based on which direction the sphere was lit from. Spheres were divided into two categories: top lit and bottom lit. Top lit spheres were defined as spheres lit from 0-90 degrees. Bottom lit spheres were defined as spheres lit from 91-180 degrees. Concavity decisions regarding bottom lit spheres would be more difficult. Previous gaze cascade effect research revealed that difficult decisions display larger gaze cascade effects. Neither top (see Figure 4-3) nor bottom lit (see Figure 4-4) trials displayed a significant gaze cascade effect regardless if the selected image was presented in the upper or lower visual field.

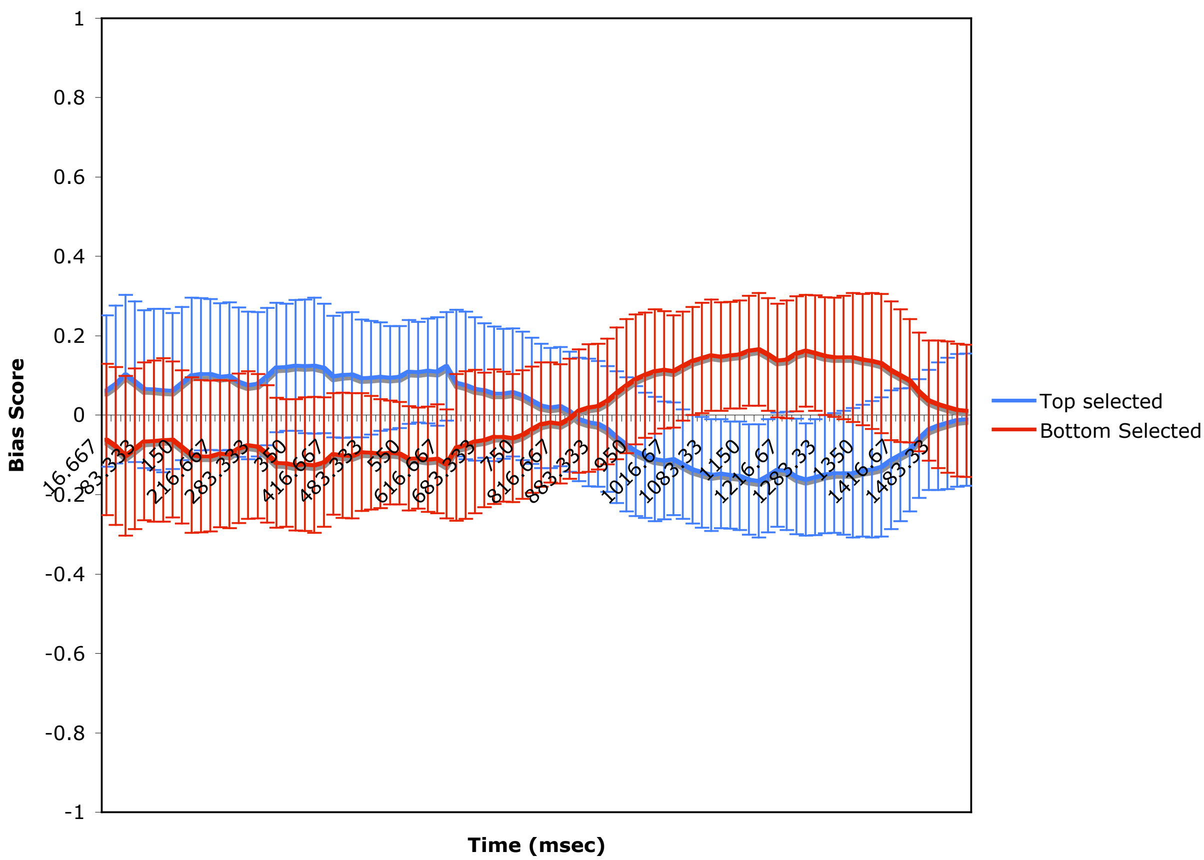

Figure 4-3. Results from the top lit spheres, top lit spheres are spheres lit from 0-90 degrees. The solid lines labeled top selected and bottom selected represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-selected subtracted from the selected viewing time. Bias scores range from -1 indicating that no time was spent looking at the selected image to +1 indicating that all time was spent looking at the selected image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the selected stimulus was

presented in the upper visual field and the red line represents when the selected stimulus was presented in the lower visual field.

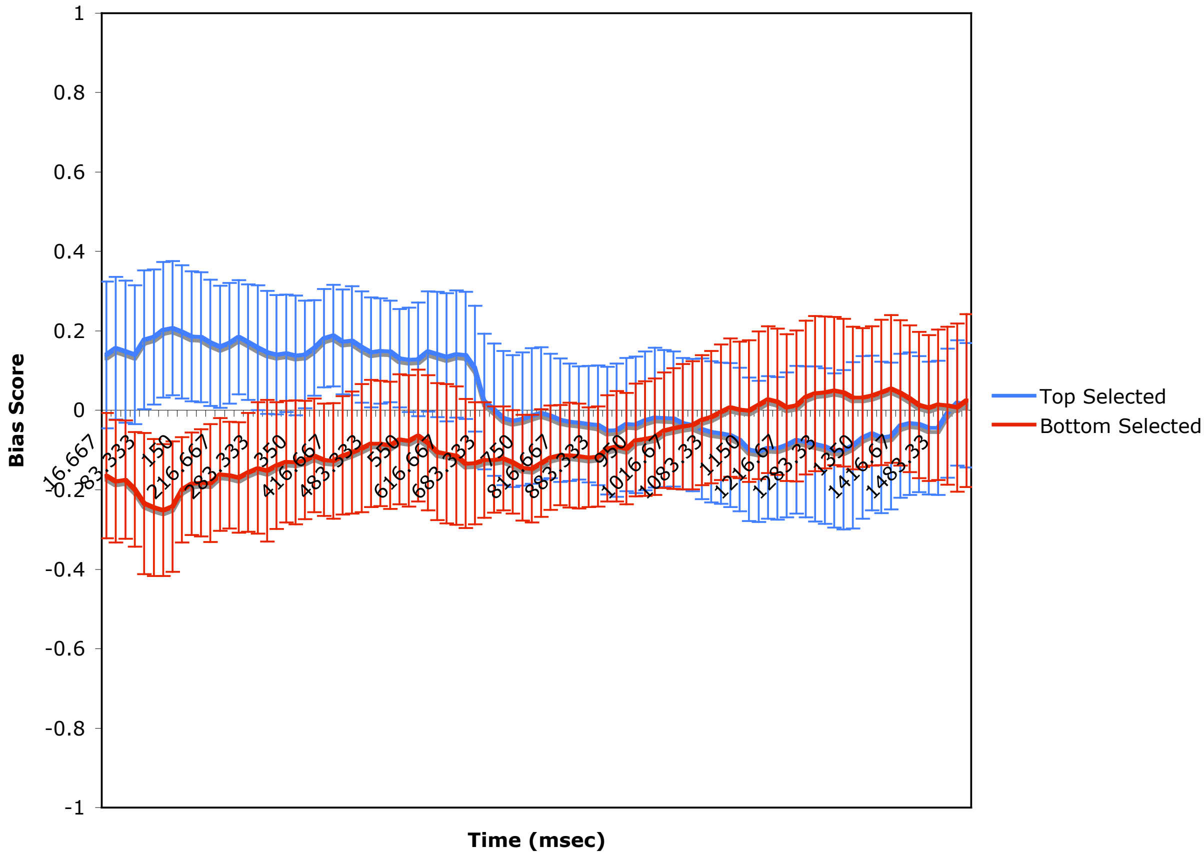

Figure 4-4. Results from the bottom lit spheres, bottom lit spheres are spheres lit from 91-180 degrees. The solid lines labeled top selected and bottom selected represent bias scores calculated from the observers gaze. Bias scores represent the average viewing time of the non-selected subtracted from the selected viewing time. Bias scores range from -1 indicating that no time was spent looking at the selected image to +1 indicating that all time was spent looking at the selected image. Bias scores are plotted against trial time in msec. The error bars represent 95% confidence intervals. The blue line represents gaze patterns when the selected stimulus was presented in the upper visual field and the red line represents when the selected stimulus was presented in the lower visual field.

Discussion

The purpose of the current study was to further investigate if the gaze cascade effect is unique to preference decisions or present in all visual decision tasks. A simple visual decision task was used where participants were asked to select which sphere appears more concave. The results indicate that both top and bottom images were investigated for significant periods of time during the final 1500 msec of trials. There were no significant differences between the bias scores of the top and bottom images, regardless of which image was selected by participants. As the spheres were perceptually ambiguous concavity was defined as the sphere that was lit from the left. As biases towards the two images did not differ from one another it can be concluded that no gaze cascade effect was observed in the current task.

The gaze cascade effect is a progressive bias towards preferred stimuli as participants near their decision point, specifically in the final 1.5 seconds prior to decision (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007). The initial investigation used two control tasks (which face is rounder & which face do you dislike more) to determine if the gaze cascade effect was unique to preference decision or part of he decision-making process (Shimojo et al. 2003). Graphical data and qualitative description of the gaze likelihood curves indicated that neither control task reached saturation indicating that the gaze cascade effect is unique to preference decisions and not part of the decision-making process. Preference trials displayed a significant bias towards the preferred stimuli at times up to 83% of viewing time was directed towards the preferred image.

However, an investigation by Glaholt and Reingold (2009) observed the gaze cascade effect in their experimental and control tasks, which led to the conclusion that the gaze cascade effect is not unique to preference decisions but present in all visual decisions. Glaholt and Reingold sought to replicate the work of Shimojo and colleagues (2003) and further demonstrate the robust nature of the gaze cascade effect using more realistic stimuli. Glaholt and Reingold (2009) observed the gaze cascade effect across all experimental conditions including 2 and 8 alternative forced choice conditions and using a gaze contingent display. Photographs of artwork were used in place of computer-generated faces. Interestingly, the control task (which photo was taken most recently) also exhibited the gaze cascade effect. Glaholt and Reingold (2009) concluded that the gaze cascade effect is not unique to preference decisions but is possibly present in all visual decisions. The results of the current investigation support the findings of Shimojo et al. (2003) that the gaze cascade effect is not present during all visual decision tasks that have been used as control tasks but is instead unique to preference decisions. Even though gaze biases were observed in the current study no difference was observed between the selected and non-selected image.

The conflicting results of the current investigation and the results of Glaholt and Reingold (2009) could be explained by investigating their selection of a control task. It is possible that when judging which photo was taken most recently participants are selecting photos based on preference. It is possible that photos participants selected as being taken most recently have a qualitatively different look that may lead participants to prefer the image. Photographic stimuli used by Glaholt and Reingold (2009) may have also been more complex than face or abstract stimuli used previously. Conversely, the control tasks selected by Shimojo et al. (2003) can be differentiated from attractiveness decisions. Although which face is less attractive is semantically opposite it is known to activate different brain regions than attractiveness decisions. Further, which face is rounder has not been linked to previous ratings of attractiveness and can be systematically evaluated against a participant's definition of roundness. The stimuli used in the current investigation were perceptually ambiguous using lighting manipulations to create the appearance of concavity or convexity. The sphere stimuli contained no local forms, were not in colour and were perceptually simple. Finally, participants were provided with a clear definition for concavity and convexity to use when evaluating the sphere stimuli. It is possible that the control task used by Glaholt and Reingold (2009) was a more complex visual decision that required detailed investigation by the participants resulting in different gaze patterns similar to the gaze cascade effect. It is also possible that the control task used by Glaholt and Reingold (2009) involved participants subconsciously selecting images they preferred as a result of qualitative differences in the images.

Possible limitations exist from using a highly different control task. It is possible that the visual decision required in the spheres task was too simple and as a result may not produce the gaze cascade effect. Future research should investigate gradations of visual decisions manipulating difficulty to determine when/if the gaze cascade effect is present in a non-preference task. It is possible that more complex visual decisions will display different gaze biases. The absence of the gaze cascade effect may also be the result of the largely objective nature of the spheres task. Participants were provided with definitions of concavity and convexity and allowed several practice trials to ensure they were able to complete the task. The objective nature of the task may have resulted in different search patterns preventing inhibiting the gaze cascade effect. Future research should investigate the appropriateness of different control tasks manipulating complexity and the objectiveness of the task.

CHAPTER 5
GENERAL DISCUSSION

Extensive research has investigated characteristics that lead to an increased preference for objects or faces, demonstrating that symmetry and averageness lead to increased preferences for faces and objects. Recently, research has begun to focus on how these preferences are formed rather than what we prefer (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007; Glaholt & Reingold, 2009). The focus of recent investigations has been on the relation between orienting structures such as gaze and preference formation. It is important to investigate how preferences are formed as our preferences can impact our behaviours. For example, we are more likely to interact with stimuli that we find attractive (Kampe et al., 2001) or to make positive associations towards attractive stimuli (Grammer et al., 2003).

As participants near their decision point a progressive gaze bias is observed towards the preferred stimuli. The progressive bias is particularly strong in the final 1500 msec prior to a decision being made. At times up to 83% of participants gaze is directed towards the preferred stimuli. Gaze biases observed were used to develop a dual-contribution model for preferential decision-making (Shimojo et al., 2003). This model involves input from orienting behaviour structures such as gaze and from a cognitive assessment system. According to their model orienting behaviours incorporate feedback, where gaze biases increase exposure and lead to increased preferences similar to the mere exposure effect. The decision module is then responsible for integrating the information from these two systems, when the cognitive basis for a decision is weak (i.e. difficult decisions or abstract stimuli) the orienting systems will play a larger role in the decision making process.

A series of experiments was used to investigate several factors and demonstrate the robust nature of the gaze cascade effect: observing its presence when viewing faces (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007), abstract objects (Shimojo et al., 2003), and using a gaze contingent display (Simion & Shimojo, 2006). Additionally, they were able to artificially induce preference through biasing the viewing times of stimuli (Shimojo et al., 2003). Finally, the effect was still present when viewing was interrupted prior to a decision being made (Simion & Shimojo, 2007). To investigate preferences pairs, of computer generated faces or abstract objects were horizontally paired and presented on the screen spanning the right and left visual fields and two control tasks were used to ensure that patterns could be attributed exclusively to preference formation and not to general decision-making processes (Shimojo et al., 2003; Simion & Shimojo, 2006; Simion & Shimojo, 2007). Graphical data and qualitative descriptions of control tasks demonstrated that the likelihood curves of control tasks did not reach saturation and did not display the gaze cascade effect.

However, a recent investigation by Glaholt and Reingold (2009) that sought to further investigate the gaze cascade effect using ‘real-world stimuli’ observed conflicting results. Photographs of artwork were horizontally paired and presented to participants asking them to select which image they preferred. The expected gaze cascade effect was observed across all preference conditions. Interestingly, their control task, which photo was taken more recently, also displayed the gaze cascade effect resulting in the conclusion that the gaze cascade effect is not unique to preference decisions but is possibly present in all visual decision tasks.

The current thesis investigated the gaze cascade effect examining the impact of where images are positioned in space, the impact of choice difficulty and investigating gaze biases during simple visual decision tasks. Past eye-tracking research has investigated natural visual search patterns and has revealed natural viewing asymmetries. Participants are biased towards the upper visual field dedicating significantly more of their viewing time to the upper visual field and are more likely to direct their first saccade to the upper visual field. Given the unique relation between exposure and preference formation demonstrated by the gaze cascade effect it was important to investigate the impact of where preferred images are presented in visual space.

Previous investigations of the gaze cascade effect have paired stimuli horizontally so that they are presented across the left and right visual field and investigations have never analyzed gaze biases by their location in visual space. The first two studies of the current thesis paired stimuli vertically so that they would be presented across the upper and lower visual fields to investigate the impact of natural viewing asymmetries on the gaze cascade effect. As expected the gaze cascade effect could be qualified by where the preferred image was presented in the participant's visual space. The gaze cascade effect was only reliably seen during trials where the preferred image was displayed in the upper visual field. There are two possible explanations that could describe the impact of visual space. The first explanation is that participant's natural viewing biases towards the upper visual field increases the exposure for this image and increases participant preference for this image thus strengthening the gaze cascade effect observed. The second explanation is that participants gaze patterns reflect their natural viewing biases but do not reflect their actual preference. The current investigations defined preference using attractiveness ratings from pilot participants that were used to match the stimuli to maximize attractiveness differences. It is possible that during bottom preferred trials participants actually selected the top image as reflected by their gaze biases even though the bottom image was pre-defined as the more attractive image. The second explanation is less likely as participant ratings of attractiveness did not significantly differ from the ratings of attractiveness given by pilot participants.

The dual-contribution model established by Shimojo et al. (2003) suggests that orienting biases will have a greater influence during preference decisions where the cognitive biases are weaker such as when abstract/unfamiliar stimuli are used or when the attractiveness difference has been minimized so that images are highly similar to one another. As a result of the findings of the first study it was important to further investigate the relation between where the image is located in visual space and how decision difficulty impacts the gaze cascade effect. Similar methods were used as in previous experiments except now maximizing or minimizing the attractiveness difference between the two images manipulated decision difficulty. Manipulating the decision difficulty will directly impact the degree of cognitive bias increasing the reliance on orienting structures such as gaze.

Shimojo et al. (2003) observed the largest gaze cascade effect in conditions where the decision difficulty was maximized (decreased the attractiveness difference between the two images) or when abstract stimuli were used. Study 2 of the current thesis did not observe a similar pattern. Similar to study 1 the gaze cascade effect was only reliably seen in trials where the preferred image was presented in the upper visual field. However, the strongest gaze cascade effect was seen during the high/low condition where the attractiveness difference was maximized, thus increasing the cognitive bias. Further, in study 1 trials where unfamiliar or abstract stimuli were used, such as Greebles, Geons or String objects no difference in the strength of the gaze cascade effect was observed. It is possible that using vertically paired stimuli when cognitive biases are weaker results in natural viewing asymmetries having a greater impact on preference formation. Thus, in trials where cognitive biases are weaker there may have been an increase tendency to select the top image even if the previously higher rated image was presented in the lower visual field.

In response to the conflicting evidence presented by Glaholt and Reingold (2009) study 3 sought to investigate the role of gaze biases in a simple visual decision task that is not associated with preferences. Perceptually ambiguous spheres were used to further investigate the gaze cascade effect. The spheres were lit to create the appearance of concavity or convexity and were presented to participants who were asked to select which sphere appears more concave. The final 1500 msec of all trials was analyzed to investigate the presence of the gaze cascade effect. Although, during the final 1500 msec participants investigated both the top and bottom images for significant time periods, gaze biases for the two images did not differ from one another suggesting that no gaze cascade effect was present. This allows for the conclusion that the gaze cascade effect is unique to preference decisions as described by Shimojo et al. (2003) and is not present during all visual decisions as presented by Glaholt and Reingold (2009). There are several possible explanations for the conflicting findings, perhaps the control task used by Glaholt and Reingold actually reflected participant preference as a result of qualitative differences in the images selected as being more recent. Perhaps, the gaze cascade effect is observed in complex visual decisions and the sphere task selected is reflecting a more basic visual evaluation that does not require the gaze cascade effect.

The current thesis has investigated and demonstrated that where an image is presented in visual space can influence our preferences and how we interact with that object. Previc (1990, 1998) has previously discussed the relationship of where objects are in space to how we interact with them, hypothesizing that four distinct systems exist that are linked to how we interact with objects based on where they are located in our personal space. The current research supports the theory presented by Previc who suggests that visual search tasks that involve evaluating what or whom the object is would favor the upper visual field.

Limitations

The current research had several possible limitations. One potential limitation is the definition of the preferred images. Preferred images were defined using attractiveness ratings from pilot participants. It is possible that participants did not select the previously higher rated image as the preferred image. Though, analysis of attractiveness rating between actual and pilot participants did not reveal any significant differences.

A second possible limitation may be controlling the trial length and forcing a decision at a set point in time. Previous research by Shimojo et al. (2003) allowed participants an unlimited amount of time to make their decision. Allowing an unlimited amount of time ensures that participants have had enough time to make a decision and that they have reached a decision. Standardizing the trial length risks that participant may have not made a decision at the end of the trial or had made a decision prior to the end of the trial and the final gaze patterns are not reflective of the actual time leading up to their decision. However, the trial lengths selected for study 1 and study 2 were within the average range of trial length from previous research. Additionally, Simion and Shimojo (2007) observed the onset of the gaze cascade effect when the decision was interrupted indicating that the gaze cascade effect could still be observed using standardized trial lengths.

A third limitation is related to the control task used in study 3. The task in study 3 used novel stimuli and participants, which makes it difficult to compare to the results from studies 1 and 2. It is possible that the task used in study 3 too simple or perceptually different than the attractiveness task. The perceptual differences or difficulty may be related to absence of the gaze cascade effect.

Future Research

The current thesis has extended the current knowledge on how preferences decisions are made and linked preferences to naturally observed viewing asymmetries. However, more research is required to further understand how our preferences are formed and potential variables that may impact these preferences.

Natural viewing asymmetries have also been observed that demonstrate biases to the participants left visual field. Though some previous investigations have observed a bias to the right visual field (Chedru et al., 1973). It would be interesting to examine previous gaze cascade data by location of the preferred image to see if left/right differences also exist. The results of the current thesis and previous eye-tracking research would predict that the gaze cascade effect would be stronger in the left visual field and possibly not present in the right visual field. It would also be interesting to investigate previous gaze cascade research that involved 4 item forced choice designs to compare the differences between top left, top right, bottom left and bottom right. It would be expected that stronger gaze cascade effects would be observed for images presented in the top left hand corner of the display where scanning is most likely to start and natural viewing asymmetries are the strongest.

The uniqueness of the gaze cascade effect should also be further investigated to establish if it is present in other visual decision tasks and what characteristics about these visual decision tasks most impact its presence of if it is unique to preference decisions. For example, the gaze cascade effect may be more likely to be present in complex visual decision tasks.

The systems of personal space outlined by Previc (1990, 1998) are linked neuroanatomical structures. Given the impact of image location on the gaze cascade effect it is important that future research investigate the activation patterns associated with preference decisions the gaze cascade effect and how activation patterns are influenced by location of the preferred image in visual space.

Finally, the gaze cascade effect has obvious implications for influencing individual preferences and could provide an important tool for advertising and marketing research with regards to product placement in print and television advertisements. For instance, the current thesis indicates that to increase preference for a product you might display it in the upper visual field to increase viewing time. Future research should further investigate the impact of image location on influencing individual preferences and how this may increase a participants liking for one object over another.

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APPENDIX A
ETHICS CERTIFICATE OF APPROVAL STUDY 1: THE ATTRACTIVENESS OF UNFAMILIAR STIMULI

UNIVERSITY OF SASKATCHEWAN

Behavioural Research Ethics Board (Beh-REB)

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	BEH#
Lorin J. Elias	Psychology	06-297

INSTITUTION(S) WHERE RESEARCH WILL BE CONDUCTED (STUDY SITE)
University of Saskatchewan

Saskatoon SK

SPONSOR
UNFUNDED

TITLE
The Relation Between Gaze & Attractiveness

APPROVAL DATE	EXPIRY DATE	APPROVAL OF
04-Jan-2007	03-Jan-2008	Application Consent Form Questionnaire

CERTIFICATION
The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http://www.usask.ca/research/ethics_review/

[redacted]

Jan 8/07
Signature Date

Please send all correspondence to:

Ethics Office
University of Saskatchewan
Room 306 Kirk Hall, 117 Science Place
Saskatoon SK S7N 5C8
Telephone: (306) 966-2084 Fax: (306) 966-2069

APPENDIX B

CONSENT FORM STUDY 1: THE ATTRACTIVENESS OF UNFAMILIAR STIMULI

CONSENT FORM

You are invited to participate in a study entitled The Attractiveness of Unfamiliar Stimuli (E38). Please read this form carefully, and feel free to ask questions you might have.

Researcher(s):	Jennifer Burkitt, Department of Psychology	966-6699
	Lorin J. Elias, Department of Psychology	966-6670

Purpose: The current study will investigate what stimulus properties are related to people's judgments of attractiveness. Properties will include the complexity and biological relevance of the stimuli.

Procedure: Participants will complete a general demographics questionnaire to assess handedness. Following completion of the questionnaire participants will first view single images and will assign attractiveness judgments. Participants will then view images in pairs and select the image they prefer. Participation should take no more than 1 hour.

Potential Risks: There are no known risks.

Potential Benefits: Participants will gain experience with experimental psychology and if they wish they will be given an opportunity to learn the results of the study (only group results will be released). Each participant will receive two credits for their participation.

Storage of Data: All data will be stored in Arts 147 for a minimum of 5 years.

Confidentiality: Although the data from this study will be published and presented at conferences, the data will be reported in aggregate form, so that it will not be possible to identify individuals. Moreover, the consent forms will be stored separately from all testing materials (i.e. questionnaires, response scores & latencies), so that it will not be possible to associate a name with any given set of responses. Please do not put your name or other identifying information on the testing materials.

Right to Withdraw: Your participation is voluntary, and you may withdraw from the study for any reason, at any time, without losing your research credit. You may withdraw without loss of relevant entitlements, for example your decision to withdraw will not affect your access to services, grades in Psychology 110. If you withdraw from the study at any time, any data that you have contributed will be destroyed at the time of your request to withdraw.

Questions: If you have any questions concerning the study, please feel free to ask at any point; you are also free to contact the researchers at the numbers provided above if you have questions at a later time or would like to learn the results of the study. The University of Saskatchewan Behavioural Research Ethics Board has approved this study on ethical grounds on January 8, 2007. Any questions regarding your rights as a participant may be addressed to that committee through the Ethics Office (966-2084). Out of town participants may call collect. Also, indicate how participants may find out about the results of the study.

Consent to Participate: I have read and understood the description provided above; I have been provided with an opportunity to ask questions and my questions have been answered satisfactorily. I consent to participate in the study described above, understanding that I may withdraw this consent at any time. A copy of this consent form has been given to me for my records."

_________________________________ ______________________________
(Signature of Participant) (Date)

____
(Signature of Researcher)

APPENDIX C
DEBRIEFING FORM STUDY 1: THE ATTRACTIVENESS OF UNFAMILIAR STIMULI

Debriefing Form - The Attractiveness of Unfamiliar Stimuli (E38)

Past research has demonstrated that infants will gaze longer at objects that they prefer. It has also been documented that infants will gaze longer at faces that have previously been rated as being attractive, suggesting that infants prefer attractive faces. Further, there is evidence that previous exposure to an object can induce preference for unfamiliar objects (i.e. simple polygons). However, there has been no past research indicating that adults will gaze longer at images or faces they consider attractive. The goal of the current study was to investigate if previous exposure to objects could induce higher attractiveness ratings for unfamiliar stimuli such as string objects and greebles. A secondary goal of the experiment was to validate measures of gaze duration in infant literature as indicating preference.

The current study predicted that people would gaze longer at images they rated as attractive. Further it was predicted that images that were previously presented would be preferred and rated as more attractive. Further the current project will also investigate how this effect is mediated by the complexity of the stimuli and the biological relevance of the stimuli. In order to investigate the relationship with complexity multiple sets of stimuli were used including: string objects, geons, chairs, greebles, & faces. All the objects used were computer-generated objects. Specifically the stimuli differed in symmetry (greebles) and familiarity (chairs) as these are both qualities that have been identified as being important to face identification and recognition and potentially to attractiveness. A variety of stimuli were used to identify similar patterns and to observe any potential inconsistencies in gaze length.

If you have any further questions regarding this study please contact Jennifer Burkitt (966-6699, jen.burkitt@usask.ca) or Lorin J. Elias (966-6670).

APPENDIX D
WATERLOO HANDEDNESS & FOOTEDNESS QUESTIONNAIRE – REVISED

PARTICIPANT QUESTIONNAIRE

Age: ________

Sex: **M** **F** (circle one)

Height: __________feet, inches or __________cm/m Weight __________pounds or ________kg

If you are a student, what is your major? _________________ Year of study? ____________

What was the **first** language you learned as a child? **English** **French** **Chinese** **Other: __________**

Do you have any hearing impairments? **Yes** **No**

Do you have any visual impairments (including colorblindness)? **Yes** **No** **Yes (corrected)**

What colour are your eyes? **Blue** **Brown** **Green** **Hazel** **Violet** **Other:_____**

What is your natural hair colour? **Blond** **Brown** **Black** **Red** **Auburn** **Other:_____**

Do you have any primary **biological** relatives (i.e. mother, father, brother, or sister) who are left-handed?
Yes **No** **Don't Know**

Do you have any **biological** extended family members (i.e grandparents, biologically related aunts and uncles) who are left-handed? **Yes** **No** **Don't Know**

Please list any medications (including oral contraceptives) that you are currently taking:

Instructions: Please indicate your hand preference for the following activities by circling the appropriate response. If you **always** (i.e. 95% or more of the time) use one hand to perform the described activity, circle **Ra** or **La** (for **right always** or **left always**). If you **usually** (i.e., about 75% of the time) use one hand circle **Ru** or **Lu,** as appropriate. If you use both hands **equally often** (i.e., you use each hand about 50% of the time), circle **Eq.**

1. With which hand would you use a pair of tweezers?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
2. With which hand would you use a paintbrush to paint a wall?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
3. Which hand would you use to pick up a book?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
4. With which hand would you use to eat a bowl of soup?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
5. With which hand would you use the eraser on the end of a pencil?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
6. Which hand would you use to pick up a piece of paper?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
7. Which hand would you use to draw a picture?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
8. Which hand would you use to hammer a nail?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
9. Which hand would you use to insert a plug into an electrical outlet?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
10. Which hand would you use to through a ball?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
11. In which hand would you hold a needle while sewing?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
12. In which hand would you use to turn on a light switch?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
13. Which hand do you use for writing?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
14. Which hand would you use to saw a piece of wood with a hand saw?	**La**	**Lu**	**Eq**	**Ru**	**Ra**

15. Which hand would you use to open a drawer?	**La**	**Lu**	**Eq**	**Ru**	**Ra**

16. Is there any reason (e.g., injury) why you have changed your hand preference for any of the above activities?
YES **NO**

17. Have you been given special training or encouragement to use a particular hand for certain activities?
YES **NO**

18. If you have answered YES to either Questions 16 or 17, please explain.

Instructions: Please indicate your foot preference for the following activities by circling the appropriate response. If you **always** (i.e., 95% or more of the time) use one foot to perform the described activity, circle **Ra** or **La** (for **right always** or **left always**). If you **usually** (i.e., about 75% of the time) use one foot circle **Ru** or **Lu** (for **right usually** or **left usually**). If you use both feet **equally often** (i.e., you use each hand about 50% of the time), circle **Eq**. Please do not simply circle for all questions, but imagine yourself performing each activity in turn, and then mark the appropriate answer.

19. Which foot would you use to kick a stationary ball at a target straight ahead?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
20. If you had to stand on one foot, which foot would it be?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
21. Which foot would you use to smooth sand on a beach?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
22. If you had to step up onto a chair, which foot would you place on the chair first?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
23. Which foot would you use to stomp on a fast moving bug?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
24. If you were to balance on one foot on a railway track, which foot would you use?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
25. If you wanted to pick up a marble with your toes, which foot would you use?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
26. If you had to hop on one foot, which foot would you use?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
27. Which foot would you use to help push a shovel into the ground?	**La**	**Lu**	**Eq**	**Ru**	**Ra**
28. During relaxed standing, most people have one leg fully extended for support and the other slightly bent. Which leg do you have fully extended first?	**La**	**Lu**	**Eq**	**Ru**	**Ra**

29. Is there any reason (i.e. injury) why you have changed your foot preference for any of the above activities?
YES **NO**

30. Have you ever been given special training or encouragement to use a particular foot for certain activities?
YES **NO**

31. If you have answered YES for either question 29n or 30, please explain:

APPENDIX E

JEN BURKITT'S FACE STUDY PROTOCOL - REVISED

Jen Burkitt's Face Study Protocol - Revised

Before the Participant arrives:

1. Turn on the iView camera (remove lens cap), the Subject PC, and the Experimenter PC
2. Subject PC -- open the appropriate E' script
3. Subject PC – move the mouse to where it can be reached while seated at the Experimenter PC
4. Experimenter PC – open the iView 3.01 program
5. Experimenter PC – if there is data in the buffer, clear it (Ctrl-B)

When the Participant arrives:

1. Give them the consent form, briefly outlining the purpose of the study!
2. Give them a general explanation of the apparatus:
    a. The chinrest is used to help them hold their head still
    b. The camera is not recording pictures of them or their eye
    c. We will be able to tell where they were looking during the test
3. Give them the demographics questionnaire, stressing that any questions they don't the answer to or don't feel comfortable revealing the answer to, to skip and leave blank!
4. Assess eyedness:
    a. Ask them to lace their fingers together leaving a small space between their thumbs.
    b. Have them bring their hands to their face as if they were looking into the microscope.
    c. Record the eye they brought their hands to!
5. Run the script, entering their demographics information from their questionnaire
6. Start calibration (be sure to record which eye you calibrated)
    a. Focus on the eye at this point
        i. Adjust Zoom, Focus & Iris if required
        ii. Make sure the crosshair sliders are all the way to the top before trying to get a good track on the eye
    b. After the eye is focused and centered on the screen (the eye should be the entire width of the screen)
        i. Adjust the crosshairs
            1. Pull first crosshair ~ 1/3 the way down, until the pupil is bright white with minimal white elsewhere
                a. If you are getting a lot of white elsewhere open the iris of the camera to let more light in (this works well if the person is wearing eye makeup)
            2. Pull the second crosshair down just a touch
7. Press F5 (or the button that has 9 dots on it)

    a. You must accept the first point manually (by pressing the green checkmark)
    b. The next 8 are automatic; click the subject mouse to advance the red square after the dot has been turned into a checkmark!
8. ENSURE THAT CALLIBRATION WAS SUCCESSFUL!
9. After calibration, they will advance to the instruction screen! Press the red button to begin recording! The buffer should be at 0 at this point!
    a. If the buffer is not at 0 clear it or record the set number at this time!
    b. Make sure the set numbers are increasing with each trial!
10. After each block, the participant will notify you!
    a. Stop recording!
    b. Save the data the files should be saved in the folder named JenB located on the C drive.
        i. File names should be JB(subject #)bl(block number)
            1. Each participant will have 5 blocks!
    c. Clear the buffer, Ctrl-B!
    d. Start recording again, tell participants they can begin the next block!
    e. Repeat step 9 for each of the 5 blocks!
11. Upon study completion thank the participant and debrief them!
    a. Make sure they leave with their copy of the consent and debriefing forms!

APPENDIX F

ETHICS CERTIFICATE OF APPROVAL STUDY 2: ATTRACTIVENESS AND GAZE

UNIVERSITY OF SASKATCHEWAN

Behavioural Research Ethics Board (Beh-REB)

Certificate of Approval

PRINCIPAL INVESTIGATOR
Lorin J. Elias

DEPARTMENT
Psychology

BEH#
07-257

INSTITUTION(S) WHERE RESEARCH WILL BE CONDUCTED (STUDY SITE)
University of Saskatchewan
Saskatoon SK

STUDENT RESEARCHERS
Jennifer Burkitt-Hiebert

SPONSOR
NATURAL SCIENCES & ENGINEERING RESEARCH COUNCIL OF CANADA (NSERC)

TITLE
Does your gaze appeal to me?

APPROVAL DATE	EXPIRY DATE	APPROVAL OF:
04-Dec-2007	03-Dec-2008	Ethics Application Consent Protocol

CERTIFICATION
The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http://www.usask.ca/research/ethical.shtml

[redacted]

Dec 7/07
Signature Date

Please send all correspondence to:

Ethics Office
University of Saskatchewan
Room 306 Kirk Hall, 117 Science Place
Saskatoon SK S7N 5C8
Telephone: (306) [illegible]   Fax: (306) [illegible]

APPENDIX G
CONSENT FORM STUDY 2: ATTRACTIVENESS AND GAZE

CONSENT FORM

You are invited to participate in a study entitled *Attractiveness and Gaze (F36).* Please read this form carefully, and feel free to ask questions you might have.

Researcher(s):	Jennifer Burkitt, Department of Psychology	966-6699
	Lorin J. Elias, Department of Psychology	966-6670

Purpose: The current study will investigate what stimulus properties are related to people's judgments of attractiveness. Properties will include the complexity and biological relevance of the stimuli.

Procedure: Participants will complete a general demographics questionnaire to assess handedness. Following completion of the questionnaire participants will first view single images and will assign attractiveness judgments. Participants will then view images in pairs and select the image they prefer. Participation should take no more than 1 hour.

Potential Risks: There are no known risks associated with participation in this study. However, you may receive no personal benefit from participation in the study. At the end of the study you will be given a sheet that better explains the nature of the study and you will be given a chance to ask chance to ask any further questions you might have.

Potential Benefits: Participants will gain experience with experimental psychology and if they wish they will be given an opportunity to learn the results of the study (only group results will be released). Each participant will receive two credits for their participation.

Storage of Data: All data will be stored in Arts 147 for a minimum of 5 years.

Confidentiality: Although the data from this study will be published and presented at conferences, the data will be reported in aggregate form, so that it will not be possible to identify individuals. Moreover, the consent forms will be stored separately from all testing materials (i.e. questionnaires, response scores & latencies), so that it will not be possible to associate a name with any given set of responses. Please do not put your name or other identifying information on the testing materials.

Right to Withdraw: Your participation is voluntary, and you may withdraw from the study for any reason, at any time, without penalty of any sort. You may withdraw without loss of relevant entitlements, for example your decision to withdraw will not affect your access to services, grades in Psychology 110 and without loss of the research credit for this session. If you withdraw from the study at any time, any data that you have contributed will be destroyed at the time of your request to withdraw.

Questions: If you have any questions concerning the study, please feel free to ask at any point; you are also free to contact the researchers at the numbers provided above if you have questions at a later time. The University of Saskatchewan Behavioural

Research Ethics Board has approved this study on ethical grounds on (12/07/07. Any questions regarding your rights as a participant may be addressed to that committee through the Ethics Office (966-2084). Out of town participants may call collect. Also, indicate how participants may find out about the results of the study.

Consent to Participate: I have read and understood the description provided above; I have been provided with an opportunity to ask questions and my questions have been answered satisfactorily. I consent to participate in the study described above, understanding that I may withdraw this consent at any time. A copy of this consent form has been given to me for my records."

______________________________	______________________________
(Name of Participant)	(Date)
______________________________	______________________________
(Signature of Participant)	(Signature of Researcher)

APPENDIX H
DEBRIEFING FORM STUDY 2: ATTRACTIVENESS AND GAZE

Attractiveness & Gaze (F36)
Debriefing Form

Thank you for participating in the study!

Past research has demonstrated that people will look longer at stimuli they prefer or consider to be more attractive. This can be observed using human faces, abstract stimuli or even with simple shapes. When using abstract or unfamiliar stimuli briefly seeing an object can increase preference for an object. Whereas, there are several factors that can influence the attractiveness of facial stimuli, these factors include gaze direction (where the face is looking) and symmetry (how similar both sides of the face). Specifically, faces that are gazing towards you or that are highly symmetrical are preferred and chosen as more attractive. The primary goal of the current study was to replicate this gaze bias and to observe how gaze direction affects it.

Additionally, the observed gaze bias increases as you near the point of decision. This has been interpreted as an exposure effect and has been termed the ‘gaze cascade effect’. Simply stated we look at what we prefer longer and what we look at longer we prefer. The secondary goal of the study was to investigate how gaze direction affected the gaze cascade effect. Gaze direction is known to shift an individual’s attention, perhaps resulting in faces with a deviated gaze being looked at and preferred less. The gaze cascade effect was expected to be mediated by gaze direction in that participants were more likely to look at and select the face that was looking at them!

Finally, the gaze cascade effect is stronger when the decision was more difficult (i.e. the objects had very similar attractiveness ratings). The current study also investigated how gaze direction affected task difficulty.

If you have any questions or concerns about this study, do not hesitate to contact the investigator (Jennifer Burkitt, Phone: 966-6699, E-mail: jen.burkitt@usask.ca). Alternatively, you may contact the faculty supervisor, Dr. Lorin Elias, by phone at 966-6670 or by e-mail at Lorin.elais@usask.ca.

APPENDIX I
CONSENT FORM STUDY 3: JUDGING BRIGHTNESS AND SHAPE

CONSENT FORM

Judging Brightness and Shape

Researchers: Dr. L. Elias, Department of Psychology, phone: 966-6670
Farzana Karim-Tessem, Department of Psychology, phone: 966-6699

Purpose and objectives of the study: Previous studies have suggested that people judge the brightness of objects differently depending on where they are presented on a computer screen and where the source of the light is located. This study is meant to test whether this is the case. Further, we will also be testing whether the differences are consistent across different types of judgment tasks.

Possible benefits of the study: This project should help clarify whether the differences in how people make these judgments actually exist. Participants will gain experience with experimental psychology, and if they wish, they will be given opportunity to learn of the results of the study (only group results will be released). Each participant will receive one credit for their participation.

Procedure: Participants will complete a brief demographic questionnaire, followed by the following tasks: (1) making judgements about brightness for objects (2) making judgements about the appearance of spheres lit from different locations. The entire session should take less than 1/2 hour.

Possible Risks: There are no known risks associated with this procedure.

I, ______________________________, have read the above description and agree to participate. The procedure and its possible risks have been explained to me by the researcher, and I understand them. I understand that I am free to withdraw from this study at any time without penalty of any type and I will not lose credit for the session. I also understand that although the data from this study may be published in a research article, only aggregate data will be described and that my identity will be kept confidential. I also confirm that I have received a copy of this consent form for my records.

__________________________________ ____________________
(signature) (date)

____
(researcher)
Department of Psychology
University of Saskatchewan

If you have any concerns about this study or your rights as a participant, please contact the Office of Research Services (306) 966-4053.

APPENDIX J
DEBRIEFING FORM STUDY 3: JUDGING BRIGHTNESS AND SHAPE

<u>DEBRIEFING FORM</u>

Study Title: **<u>Judging Brightness and Shape</u>**

Thank you for participating in the study!

Previous studies have shown that people judge objects differently depending on which side of a computer screen they are presented on. One way of testing this effect is by presenting two equivalent objects on each side of the screen and asking people top make judgements about the objects. For example, when identical (but mirrored) objects are presented on each side of the screen and people are asked to indicate which object is darker, they usually (66% of the time) indicate that the object on the left is darker. The cause of this strange effect is unknown. One possibility is that people tend to scan the objects from left to right (as in normal reading). Another possibility is that people pay more attention to complex visual objects on their left side.

In the second part of the experiment, we were investigating the assumptions people make about the source of light when presented with ambiguous stimuli. You were presented with pictures of the same black and white sphere in different orientations. When the source of light is portrayed as coming from above, people tend to perceive the object as being convex (i.e. sticking out). Conversely, when the object is portrayed with the light source coming from the bottom, people tend to perceive the object as being concave (i.e. sticking in). In addition to looking for this effect, the present investigation also varied the left-right direction of the light. It was predicted that people would assume that the light source was to the left and from the top.

If you have any questions or concerns about this study, do not hesitate to contact Lorin Elias by phone: 966-6670. Alternatively, you can contact the Head of the Department of Psychology at 966-6701 or the Office of Research Services at 966-4053.

Thanks again for participating in the study!

APPENDIX K
DESCRIPTION OF STIMULI EXPERIMENTS 1 & 2

Description of Stimuli

The images used for object trials in experiments 1 & 2 were downloaded from the TARR lab website (http://www.cnbc.cmu.edu/tarrlab/stimuli.html). Descriptions of each stimulus set can be found below.

Greeble

The notorious Greeble object set. Scott Yu designed these objects as a control set for faces - discriminating among them requires attention to subtle variations in shape and they are hierarchically organized into "genders" and "families," as well as individuals. See the readme.txt file for an explanation of the current naming scheme. Images are TIFFs generated from the new 3DS Max versions of the Greebles (they correspond to the included MAX or 3DS files). The 3D file format is 3D Studio Max which should be importable into many different 3D modeling programs (extension .max). Each Greeble should contain the same camera positions and have a standard textured purple shading. The archive includes two viewpoints for each Greeble, plus the .max and .3ds files (thanks to Jeff Munson, University of Washingtoh, for converting the MAX files to the more portable 3DS format).
http://www.cnbc.cmu.edu/tarrlab/stimuli/novel-objects/greebles-2-0-symmetric.zip/view.html

"String" Objects

This image set was created by Marion Zabinski using a program written by Volker Blanz and contains 40 (actually 39) objects composed of 5 parts per an object. Each object is composed of a linear chain of Geons. Objects were inspired by Poggio, Edelman & Bülthoff's work, as well Biederman and Gerhardstein's (1993) variation. The set (STANDARD COLORS only) include rotations in depth around the vertical axis of -90, -60, -30, 0, 30, 60, and 90 deg. There are actually 4 sets of 10 objects - as a default all parts are composed of "tubes." The sets vary in how many of the parts are unique Geons rather than tubes. Set 0 has no unique Geons in each object, Set 1 has 1 unique Geon in the middle of each object, Set 3 has 3 Geons in the middle of each object, and Set 5 has 5 Geons (and no tubes; an error resulted in only 9 objects in this set). File names are coded as: Set#.Object#.View. See Tarr, et al.'s (1997) Psychological Science article for experiments using these objects and more on this topic.
http://www.cnbc.cmu.edu/tarrlab/stimuli/novel-objects/string-objects.zip/view.html

Geons

This image set contains 10 single part objects ("Geons"). Each object is qualitatively different from the others in the set. Objects were modeled after those in Biederman and Gerhardstein's (1993) JEP:HPP article. The set includes

rotations in depth around the vertical axis of 0, 45, and 90 deg (labeled A, B, and C). One nice property is that the 0 to 45 deg rotations show the same visible image features, but the 45 to 90 deg rotations show qualitatively different image features. This allows a comparison between equal magnitude rotations with differing degrees of qualitative change. See Hayward and Tarr's (1997) JEP:HPP article for an experiment using these objects and more on this topic.
http://www.cnbc.cmu.edu/tarrlab/stimuli/novel-objects/geons.zip/view.html

Chairs
Grayscale pictures of 31 chairs garnered from various sources by Bruno Rossion at the Universite Catholique de Louvain. Bruno has scaled all of the images to the same size, orientation, and brightness. Bruno asks that if you are going to use the chairs, please contact him at rossion@neco.ucl.ac.be and let him know what you are up to.
http://www.cnbc.cmu.edu/tarrlab/stimuli/objects/chairs.zip/view.html

VITA

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Evening - (306) 374-5240
Jen.burkitt@usask.ca

Education:

2004-Present	Ph.D. Candidate (ABD), University of Saskatchewan
2004	B.A. Honours Psychology, University of Saskatchewan
2000	High School Graduate, Winston High School, Watrous, SK.

Honours or Awards:

2005-2008	Summer Scholarship, University of Saskatchewan
2004-2008	Graduate Teaching Fellowship, University of Saskatchewan
2004	First Prize in Session at the 11th Annual Life Sciences Research Conference
2001	Leadership Award, Augustana University College
2001	Academic Excellence Award, Augustana University College
2000	Watrous Hospital Auxiliary Scholarship

Professional Work Experience:

Quality Improvement Consultant
August 2008- Present
Supervisor: Karen Barber, Health Quality Council
Duties: Assisted in designing focus group interviews, conducted focus groups, analyzed focus group data, prepared summary report, actively participate in team meetings & projects (Quality Improvement Consultant School, Clinical Practice Redesign School, Physician Engagement, Chronic Disease Management Collaborative (I & II))

Research Assistant
June 2008-August 2008
Supervisor: Gary Teare, Health Quality Council
Duties: Assisted in conducting qualitative interviews with office managers, nurse practitioners, physicians and collaborative facilitators for the Chronic Disease Management Collaborative, completed qualitative content analysis of interview transcripts

Research Assistant
May 2003- August 2004

Supervisor: Carl Gutwin. Department of Computer Science, University of Saskatchewan
Duties: Assisted in the research design of multiple experiments, recruited and tested participants for experiments, formulated consent forms and questionnaires specific to individual studies, assisted in writing of publications as well gained experience in use of the statistical program SPSS.

Research Assistant
May 2003- August 2004
Supervisor: Deb Saucier Ph.D. Department of Psychology, University of Saskatchewan.
Duties: Completed literary searches, located and retrieved journal articles, completed data entry tasks using the statistical program SPSS, recruited and tested participants for experiments, formulated consent forms and questionnaires specific to individual studies, handled rat subjects, as well completed Testosterone assays.

Research Assistant
September 2002 – September 2003
Supervisor: Michael MacGregor Ph.D. Department of Psychology, University of Saskatchewan.
Duties: Coded semi structured interviews for hostility as well as Constructive Verbal Behaviour, also attended research meetings as well as be able to witness all steps of the research process.

Student Parole Officer
May 2002- August 2002
Saskatchewan Penitentiary, Prince Albert, SK.
Duties: Interviewed inmates, received and responded to inmate requests, researched past experiences and wrote reports regarding inmate requests, investigated inmate complaints as well presented information to a panel of parole officers, Warden and Deputy Warden

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Publications/Presentations:

Burkitt, J.A. & Elias, L.J. (2008). Gazing at attractiveness: Looking times and Control Stimuli. *A talk at the 18th Annual Meeting for Canadian Society for Brain, Behaviour and Cognitive Science.*

Burkitt, J.A. & Elias, L.J. (2008). Gazing at attractiveness: Looking times and Control Stimuli. Published abstract from poster presentation at the Theoretical and Experimental Neuropsychology (TENNET) 18th Annual Meeting, June 2007. *Brain and Cognition* (in press

Thomas, N.A., **Burkitt, J.A**., Patrick, R.E. & Elias (in press). The lighter side of advertising: Investigating Posing and Lighting Biases. *Laterality*.

Burkitt, J.A., Thomas, N.A., Patrick, R.E., & Elias, L.J. (2007). The lighter side of advertising. Published abstract from poster presentation at the Theoretical and Experimental Neuropsychology (TENNET) 17th Annual Meeting, June 2007. *Brain and Cognition* (in press).

Thomas, N.A., **Burkitt, J.A**., Patrick, R.E., & Elias, L.J. (2007). Put your best shoulder forward: An investigation of posing bias in advertising. Published abstract from poster presentation at the

Theoretical and Experimental Neuropsychology (TENNET) 17th Annual Meeting, June 2007. *Brain and Cognition* (in press).

Burkitt, J., Widman, D. & Saucier, D.M. (2007). Evidence for the influence of testosterone in the performance of spatial navigation in a virtual water maze in women but not in men. *Hormones and Behavior, 51*, 649-654.

Thomas, N.A., **Burkitt, J.A**., & Saucier, D.M. (2006). Photographer preference or image purpose? An investigation of posing bias in mammalian and non-mammalian species. *Laterality 11*(4), 350-354.

Burkitt, J.A., Saucier, D.M., Thomas, N.A., & Ehresman, C. (2006). When advertising turns cheeky. *Laterality, 11*(3), 277-286.

***Burkitt, J**. & Saucier, D. (2006). The effects of cue manipulation on performance in a virtual water maze. A poster at the 16th Annual Meeting for Canadian Society for Brain, Behaviour and Cognitive Science.*

*Andersen, D., **Burkitt, J**., & Desorcey, D. (2006). Assessment of prosodic functioning in two hemispherectomy cases. A talk at the 16th Annual Meeting for Canadian Society for Brain, Behaviour and Cognitive Science.*

Burkitt, J., Saucier, D. & Widman, D. (2005). Testosterone and the Virtual Water Maze. *A Talk given at 17th Annual Canadian Spring Meeting on Behaviour and Brain, Fernie, BC.*

Burkitt, J., Saucier, D., & Green, S. (2004). Targeting in men, but not women, exhibits a relation to fine motor control with the non-dominant hand. *A Talk given at 2004 Canadian Society for Psychomotor Learning and Sport Psychology, Saskatoon. SK.*

Burkitt, J. & Saucier, D. (2004). Testosterone and the Virtual Watermaze. *A Poster presented at The 11th Annual Life Sciences Research Conference, Saskatoon, SK.*

Burkitt, J. & Saucier, D. (2004). Testosterone and the Virtual Watermaze. *A talk at the 17th Annual Psychology Undergraduate Research Conference, Saskatoon, SK.*

Gutwin, C., Dyck, J., and **Burkitt, J**. (2003) Using Cursor Prediction to Smooth Telepointer Jitter. *Proceedings of the 2003 ACM Conference on Group Work (Group'03), Sanibel Island, Florida,* 294-301.

Teaching Experience:

Psy 343	Laboratory in Behavioural Neuroscience
Psy 347	Advanced Human Neuropsychology
Psy 348	Research in Human Neuropsychology

Graduate Course Experience:

ANAT 898	Advanced Functional Neuroanatomy
GSR 989	Introduction to University Teaching
GSR 985	Ethics and Integrity
KIN 804	Perception and Action
PSY 805	Statistics I Univariate Linear Models
PSY 807	Statistics III Multivariate Statistics
PSY 809	Qualitative Statistics (AUDIT)
PSY 837	Seminar in Language Processing
PSY 844	Advanced Seminar in Behavioral Pharmacology
PSY 846	Advanced Seminar in Human Neuropsychology

Educational Workshops:

Coach Approach

Mini-TLQIT

Measurement TLQIT

QI 302