The Role of Visual Attention in Preference Formation for Food

Ji Xu, Kyushu University, Japan
Noha Mohsen Zommara, Kyushu University, Japan
Johan Lauwereyns, Kyushu University, Japan

The Asian Conference on Psychology and the Behavioral Sciences 2016
Official Conference Proceedings

Abstract
Although several important theories have suggested that the length of looking time correlates with decision-making on preference, previous research has not considered the effect of visual attention (cueing) on preference formation. In the present study, we aim to explore whether attentional and emotional cues influence the preference decision-making among different food choices. A strictly controlled spatial cueing paradigm was applied: a 50 ms onset cue was presented prior to a stimulus display that consisted of two clearly visible food images and the cue could appear at either side. Participants were asked to choose the food image they preferred. To investigate the effect of visual attention (cueing) and emotional priming respectively, a neutral symbol (dot) or an emotional symbol (face logo with a smile or with a sad expression) was presented with 100 ms and 300 ms stimulus onset asynchrony (SOA) in different sessions, in order to either facilitate or inhibit attention to the cued option. The results showed that people tended to choose the cued image more often with short SOA than with long SOA in the neutral symbol sessions. Additionally, it was found that the face logo images with a smile were chosen more often than those with a sad expression in the case of long SOA, though not in the case of short SOA. The results provide important implications for our understanding of the interaction of visual attention and evaluative decision-making.

Keywords: decision-making, visual attention, preference, cueing, emotion, attention-shifting.

Introduction

Preference has been explained as an individual's attitude towards a set of objects, especially reflected in the process of decision-making (Lichtenstein & Slovic, 2006). The process of giving the evaluative judgment in the sense of liking or disliking has been typically defined as preference formation, which has been also studied in various aspects (e.g., Scherer, 2005). Generally, preference formation, in other words, the comparative evaluation of decision-making, depends on not only an individual's experience and memory (Stevens, 2008), but also the current environment. Several important studies have proven that the different way of presenting choice options influences human decision-making (e.g., context effects, framing effects); however, most of the previous studies have focused on the processing of perceptual decision-making (e.g., with the requirement of detecting a target), instead of decision-making on preference.

On the other hand, recent studies of preference formation conducted by Shimojo and colleagues have generated a "Gaze Cascade Effect" hypothesis to explain how subjects construct decision-making on preference (Shimojo et al., 2003). In an experiment involving the free choice of the more attractive face from a pair of face pictures, the researchers found that the selected face was fixated longer than the unselected face, especially in the period of 600 ms leading up to the actual choice. The researchers referred to this phenomenon of gaze shifting and gaze bias to the ultimate preference choice as a gaze cascade effect. Not only the study done by Shimojo and colleagues, but also several subsequent studies have demonstrated that the subjects indeed made more gaze fixations toward the option they eventually chose (Nittono & Wada, 2009; Glauckner & Herbold, 2011; Glaholt & Reingold, 2012). In addition, as a follow-up study, Bird and colleagues developed the paradigm further and found an exposure effect on preference formation (Bird et al., 2012), in line with the classic study by Zajonc (1968). On the basis of those previous studies on preference formation, it is clear to state that the gaze is actively involved in the preference formation and one could conclude that people tend to gradually commit towards a choice by spending more time looking at it.

In parallel, in the area of research on visual attention, the spatial-cueing paradigm has been a very successful approach to study how different types of cues may influence the allocation of attention (Posner, 1984). For instance, with simple peripheral stimuli as cues (e.g., a flash of light, or the outline of a square), subjects tend to respond faster and more accurately to subsequent targets at the location of the cue than at an uncued location. This kind of cueing effect particularly happens with short time delays between the cue and the target, which is also described as stimulus onset asynchrony (SOA). Nevertheless, the effect from peripheral cueing would turn to inhibitory when the time interval is longer (i.e., response to the cued targets becomes slower and less accurate; see Posner & Cohen, 1984; Handy, Jha, & Mangun, 1999). This kind of function has been defined as inhibition of return (IOR), and is often attributed to a process of re-orienting, away from the originally attended location (Klein, 1988 & 2002; Pratt, Kingstone, & Khoe, 1997; Tipper, Weaver, Jerreat, & Burak, 1994). In other words, our visual attention would be withdrawn from the cued location after it has been captured by the peripheral cue in a long SOA condition, which demands an additional process (and extra effort) when the task requires to return to the previous location, in spite of a facilitation caused by the attention residing in short SOA condition. Thus, the effect of peripheral cueing on the orienting of attention should be divided in opposing mechanisms of facilitation and inhibition, occurring at different moments in time. By manipulation the SOA, then, it should be possible vary the extent of visual attention to different portions of the visual field.

Considering the finding of a relationship between preference formation and looking time, on the one hand, and Posner's study on visual attention, on the other hand, it is reasonable to question the interaction between visual attention, particularly with respect to the orienting of attention by different cueing, and preference formation. One could argue that, if the length of looking time correlates with the likelihood of choosing a certain option (Shimojo et al., 2003; Bird et al., 2012), and if visual attention works on the attentional duration via cueing effects, it should be possible to manipulate people's preference choice through manipulating their orienting of attention. To explore the role of visual attention of cueing in preference formation, we therefore conducted our experiment based on the well-established Posner spatial-cueing paradigm, using food images as our stimuli for evaluative decision-making. Since the different cueing effects occur in perceptual decision-making tasks through attentional shifting, and given the possible relationship between cueing and looking time, we speculate that a similar cueing effect might occur on the processing of evaluative decision-making (i.e., preference formation). Consequently, we applied an attentional cueing condition with a neural symbol (filled white dot) with different SOA of 100 ms and 300 ms (i.e., short and long time delay) to test whether a cue influences the subjects' preference. We predicted a similar result as in perceptual decision-making tasks, that is, people would tend to choose the cued food images more than uncued images in the short SOA condition, but would tend to choose the uncued images in the long SOA condition, when they are required to make preference choices. Furthermore, we used a second type of cue to investigate whether an emotional priming effect might be observed in the preference formation. We used a pair of face logos (smiley and sad) as cues in both short and long SOA conditions. Besides the same predictions with respect to the cued versus uncued choice tendency as in the neutral dot cueing condition, we anticipated a higher probability of choosing images cued by a smiley face, whereas images cued by a sad face would have a lower probability of being chosen.

Materials and Methods

Participants. A total of 43 undergraduate students (ages of 17 to 27, mean: 21.3) from Kyushu University participated in this study. Subjects received either course credits for their participation or a participation fee of 1000 yen. All participants were naïve to the purpose of the experiment and had normal or corrected to normal vision. Written informed consent was obtained before the experiment. Four participants' data were excluded from the data analysis; the remaining 39 participants consisted of 23 Japanese and 16 non-Japanese (mainly from China, Korea and Indonesia), with 20 females and 19 males. Three of the participants were left-handed but giving mouse responses by their right hand, same as the right-handed participants.

Apparatus. The experiment was programmed by using Matlab Psychtoolbox software and was displayed on a (32 cm × 54.5 cm) monitor with resolution of 1920 × 1080. Participants were seated at a viewing distance of approximately 60 cm, and were required to respond by clicking a wired mouse.

Stimuli Sets. The stimuli conditions are presented in Table 1. To assess the influence from different cueing conditions on preference formation, we applied two types of cue stimulus: the white dot (as neutral cue) and the face logo including smiley and sad face (as emotional cue). In both of cueing experiments, two kinds of stimulus onset asynchrony (SOA) were used to either facilitate attention to the cued option (i.e., short SOA: 100ms) or inhibit attention to the cued option (i.e., long SOA: 300ms), respectively, based on the Posner cueing effect and IOR (inhibition of return) phenomena. The different experimental conditions were marked as dot-100, dot-300, face-100 and face-300.

The target stimuli consisted of a total of 480 food images cropped from digital images, including pictures of sweets (i.e., cake, cupcake, donut, ice-cream, muffin, parfait), and main dishes (i.e., bread, fried rice, hamburger, hotdog, Japanese lunch box, pizza, ramen, sandwich); the sets of images were counterbalanced in each experimental session. To minimize the visual differences between choice options, the pair of food images in each trial were always imported from the same category (e.g., two simultaneously presented images were from cake category in the first trial, and hamburger category in the second trial).

Experiment	Dot-100	Dot-300	Face-100	Face-300
Cue type	Dot	Dot	Face logo (smile & sad)	Face logo (smile & sad)
SOA	100ms	300ms	100ms	300ms
Onset Cue time	50ms	50ms	50ms	50ms
Number of Trials	40	40	80 (40 / 40)	80 (40 / 40)
Prediction	C > U	C < U	C > U P > N	C < U P > N

Table 1. Experiment design. A total of four experimental sessions included two types of cueing and two different SOAs, referred to as dot-100, dot-300, face-100 and face-300. The number of trials applied for each type of cue was kept the same. The predictions are listed in the bottom row, indicating which image would be more likely chosen. "C" means cued; "U", uncued; "P", positive (i.e., smiley face); "N", negative (i.e., sad face). In general, cued images were predicted to be chosen more than uncued in short SOA conditions, whereas the opposite result was predicted in long SOA conditions. Positive emotional cues would enhance choice as compared to negative emotional cues.

Task Design. A within-participants design with two SOAs (100ms and 300ms) × two cueing conditions (cued and uncued) × two cueing valence (dot and face) was employed. Through the entire set of experimental sessions, participants were asked to compare a pair of food images and choose their preferred one as the goal for each trial. In total, participants were required to make 240 choices (i.e., 80 trials from dot experiments, and 160 trials, including 80 trials with sad face cues and 80 trials with smiley face cues). The order of the experimental sessions was counterbalanced across participants (i.e., half of participants started from the dot-100 session and the other half started from the face-300 session).

Procedures. Participants were instructed to refrain from eating and drinking (except for water) for 1h before the experiment to ensure that food was a relevant stimulus. A self-reported pre-questionnaire was obtained from the participants about their physical conditions. Before starting the actual experiment, the instructions were explained in detail and a training session was performed to ensure that the participants understood the experiment procedure.

The experiment consisted of four sessions; the trial sequence in each session is presented in Figure 1a. Participants clicked the mouse button to initiate each experimental session. In the experiment, a white cross fixation was always shown on the center of the black screen and participants were asked to lock their gaze on the fixation cross all the time except when the food images were showing. Each trial began with 500 ms of fixation, and subsequently a cue was presented for 50 ms, with a variable cue-target SOA of 100 ms or 300 ms (i.e., time delay of 50 or 250 ms), until the presentation of the target display with two food images. The participants were required to make a preference choice between the two food images by clicking the mouse. The pair of food images was displayed in one of four possible patterns (i.e., up-down, left-right, upper right-lower left, lower right-upper left; see Fig. 1b); the cue was presented with equal probability at either of the two food images (e.g., if the food images would appear to left and right side of fixation, the cue could be either on left or right side, but with the same probability throughout the session). The maximum duration for decision-making was 5 s. A questionnaire was also presented after each experimental session.

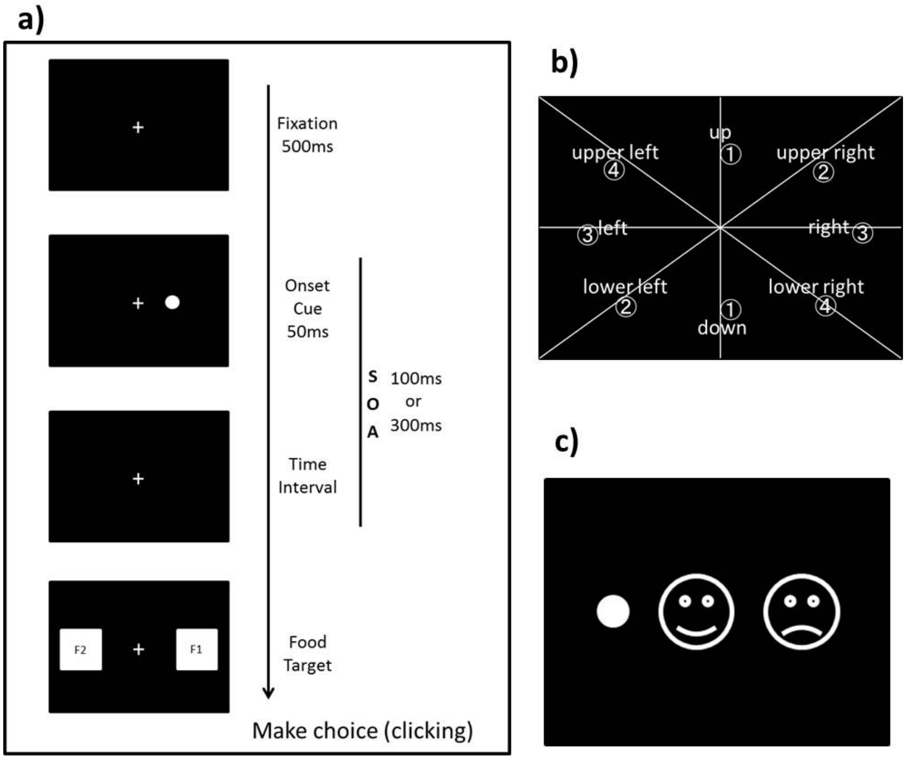

Figure 1. Task design of the experimental sessions. a) Experimental procedure of the trial sequence, based on Posner's spatial cueing paradigm. Two different time intervals were used between onset cue and target stimulus. The maximum duration for making the choice was 5s. b) The position of target stimulus: a total of four patterns to display a pair of food images (up-down, left-right, upper right-lower left and lower right-upper left). c) Design of cues: filled white dot (for neutral cueing); smiley versus sad face logo (for emotional cueing).

Data analysis

To examine the cued choice rate in each session experiment, we divided the number of trials in which the cued image was chosen by the total number of trials. This index ranged from 0 to 1; the higher, the more choices for cued images.

$$\text{Cued Choice Rate} = \frac{\text{N(Trials choosing the cued image)}}{\text{N(all performed trials)}}$$

In addition, to analyze the effect of emotional cueing, we used the following equation to calculate cued choice rate for smiley versus sad face respectively:

$$\text{Smiley Face Cued Choice Rate} = \frac{\text{N(Trials choosing the smiley face)}}{\text{N(all performed trials)}}$$

$$\text{Sad Face Cued Choice Rate} = \frac{\text{N(Trials of choosing the sad face)}}{\text{N(all performed trials)}}$$

Results

Attentional Cueing Experiment. As indicated in Figure 2, in the dot cueing experiment, the cued image (i.e., the image presented at the same side as the dot cue) was chosen in 51.7% of all the performed trials in the short SOA condition (i.e., Dot-100 session), and with 47.7% cued choice rate in the long SOA condition (i.e., Dot-300 session), respectively. A one-way repeated measures ANOVA was conducted on cued choice rate using a within-subjects factor of SOA (100 vs. 300 ms), which revealed a statistically significant effect of SOA, F (1, 38) = 4.785, MSE = 0.031, $p < 0.05$, indicating a higher choice rate of cued image in 100 ms (vs. 300 ms) SOA condition. No significant difference between the cued and uncued choice rate was found within each experimental session experiment ($p > 0.1$).

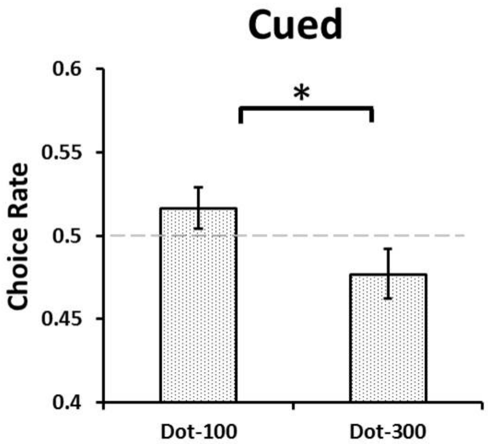

Figure 2. The probability of cued choice in the attentional cueing experiment. The choice rates are shown for the cued image in the dot-100 session (mean ± SE = 0.517 ± 0.012), and in the dot-300 session (mean ± SE = 0.477 ± 0.015). A one-way repeated measures ANOVA showed a statistically significant effect of SOA in sessions, F (1, 38) = 4.785, MSE = 0.031, $p < 0.05$.

Emotional Cueing Experiment. In the face cueing experiment, a statistical analysis from all trials, regardless of the different types of faces, revealed that the choice rates to cued images were almost equal to each other in both the short and long SOA conditions: 49.8% in the 100 ms SOA session and 49.7% in the 300 ms SOA session. There was no significant main effect in each condition, nor between the two conditions (see Fig. 3).

On the other hand, to investigate the effect from different face cues, we divided all performed trials on cued images to smiley cued and sad cued trials to calculate the choice rate of each face logo. As indicated in Figure 4, the result of the cued choice rate on different face logos showed an interaction effect between conditions, from a two-way ANOVA with factors of SOA (100 ms vs 300 ms) and types of face logo (smiley vs. sad), F (1, 37) = 5.606, MSE = 0.001, $p < 0.05$. Additionally, a student *T-test* was conducted on different face logos in each condition, and we found a significant effect of face logos in the long SOA session, which indicated that the choice rate of smiley cued images was higher than that of sad cued images (smiley: M = 52.1%, SE = 1.1; sad: M = 47.9%, SE = 1.1; $p < 0.05$). No difference on choice rate between smiley and sad faces was found in the 100 ms SOA condition (smiley: M = 50.2%, SE = 1.0; sad: M = 49.8%, SE = 1.0; $p > 0.1$).

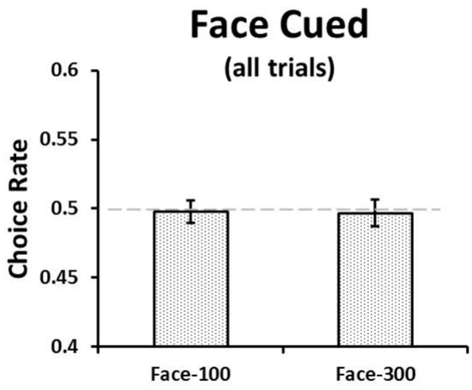

Figure 3. The probability of cued choice from all trials in the emotional cueing experimental sessions. The choice rates of all cued images are presented in the face-100 session (mean ± SE = 0.498 ± 0.008), and the face-300 session (mean ± SE = 0.497 ± 0.010). No significant effect was found from one-way ANOVA analysis; $p > 0.1$.

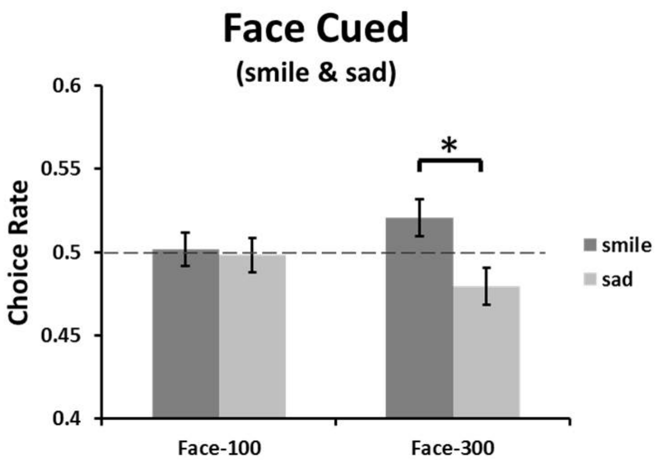

Figure 4. The probability of cued choice varied by different face logos in the emotional cueing experimental sessions. In the face-100 session, no significance was found between the choice rate of smiley cued images (mean ± SE = 0.502 ± 0.010) versus sad cued images (mean ± SE = 0.498 ± 0.010). In the face-300 session, the choice rate of smiley cued images (mean ± SE = 0.521 ± 0.011) was higher than that of sad cued images (mean ± SE = 0.479 ± 0.011), as confirmed by student T-test analysis. A two-way ANOVA revealed an interaction effect between the face-100 and face-300 conditions; $p < 0.05$.

Discussion

The current study addressed the question of whether our preference decision-making could be affected by manipulating the orienting of attention. To this aim, we presented neutral dot and emotional facial cues in a strictly controlled spatial cueing paradigm, by asking for a preference choice between a pair of same categorized food images. As per the findings of Shimojo et al. (2003) and the principle of the Posner cueing paradigm, it was expected that images presented at the same side as the cue in a short time interval (SOA) condition would be more likely to be preferred; the opposite result would hold true in the long SOA condition. The present finding from the dot cueing experiment clearly showed the expected trend: the choice rate of cued images was particularly reduced in the long SOA condition. It indicated a possibility of bias from visual attention to preference decision-making, and the bias happened most likely because of "*inhibition of return*" (IOR) effect. Since the initial discovery of "*inhibition of return*" by Posner & Cohen (1984), the inhibitory function has often been thought of as a useful phenomenon to explore the effect of peripheral cueing in recent years (e.g., Fox, Russo, & Dutton, 2002; Taylor & Therrien, 2005; Theeuwes, & Van der Stigchel, 2006; Stoyanova, Pratt, & Anderson, 2007; Weaver, Aronsen, & Lauwereyns, 2012). Different from old studies, we applied the IOR effect on evaluative decision-making in the present experiment, instead of the typical perceptual decision-making tasks from previous papers. Considering the principle of IOR described in early studies (e.g., Klein, 1988 & 2002; Pratt, Kingstone, & Khoe, 1997; Tipper, Weaver, Jerreat, & Burak, 1994), the result of the present study gave an important implication for the relationship between visual attention and evaluative decision-making; that is, the effect of IOR affects our decision-making not only in perceptual processing but also in evaluative processing, via attention shifting. Moreover, our result may also indirectly associate to the explanation of likelihood and looking time in the gaze cascade hypothesis, namely, more orienting of attention may influence the looking time to the cued target, which in turn affects the preference choice. Interestingly, our result suggest that the influence would be mainly negative, with longer SOA: The cues effectively turn people off the cued images, by inhibiting the return of attention there.

With respect to the result from emotional cueing experiment, however, no significant difference in choice rate was observed from analysis of all performed trials, regardless of face type. It indicated an emotional cueing influences the evaluative decision-making not only by attention shifting. The fact that the face-logo cue contains more meaningful features than a neutral dot cue may explain the reason of non-difference result, that is, an emotional cueing plays a role in both processing of attention shifting and emotional priming. In other words, visual attention can be affected by emotion, to be more specific, our orientation of attention correlates with emotional expression. Indeed, the relationship between emotion and decision-making has been studied in many aspects since long time ago and it is believed that emotion interacts with evaluation and motivation, irrespective of its own characteristic decision process (Ortega y Gasset, 1957; Strongman, 1978; Toda, 1980). Moreover, the impact could either be positive or negative (Tomkins, 1970). Accordingly, the different findings between the two kinds of experiments could be due to difference in path of processing in general, since it is reasonable to have a more complex conscious processing in the face-logo cueing experiment, with both of attentional and emotional factors.

Another interesting finding from the emotional cueing experiment is the different ratio of choosing cued images with different types of face logo in the face-300 condition. The result revealed a higher choice rate of cued images with smiley face cued than with sad face cued, even though no similar trend was observed in the face-100 condition. The possible explanation for the different result in these two sessions could be the less time for detecting or recognizing the face logo in face-100 condition, which has a shorter time delay (50 ms) in the paradigm. Unlike the case of face-300, in the face-100 session it is more difficult to realize the cue or the content of the cue owing to an extremely short time interval, resulting in insufficient time to complete a recognition process; participants may have realized the cue but in a very rush processing which brought a conflict with the task processing. In addition, compared to face-100, face-300 showed a significant difference between smiley and sad face logo. This observation is in line with previous studies (e.g., Tomkins, 1970), suggesting that people tend to choose positive options rather than negative options; in the present study, the positive options were the images cued by the smiley face logo. Additionally, taking into account the IOR effect, it appears that this mechanism of emotional processing interacted the IOR in evaluative decision-making; namely, a positive expression counteracted against the effect of IOR, leading to a higher result compared to the choice rate of smiley cued images in face-100; a negative expression, however, exacerbated the effect with IOR. Thus, the strongest effect observed in the present study is that of a sad face cue at long SOA, effectively a strong negative influence, driving people away from choosing the cued image.

In summary, in light of the results of the present study, we suggest that visual attention plays an active role to influence the preference decision-making; furthermore, the "*inhibition of return*" mechanism prominently affects the evaluative decision-making in both attentional and emotional cueing. Several questions remain open for future research, such as whether different types of cue capture different levels of visual attention, and to what extent this would influence the preference decision-making; also, it remains unclear what is the relationship between the first fixation and preference choice. To address these issues, an eye-tracking system and more controlled paradigm are warranted. This future work can build on the present study to further our understanding of the mechanisms of visual attention in evaluative decision-making.

References

Bird, G. D., Lauwereyns, J., & Crawford, M. T. (2012). The role of eye movements in decision making and the prospect of exposure effects. *Vision Research, 60*, 16-21.

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16*, 355–379.

Glaholt, M. G., & Reingold, E. M. (2009). Stimulus exposure and gaze bias: A further test of the gaze cascade model. *Attention, Perception, and Psychophysics, 71,* 445-450.

Glauckner, A., & Herbold, A. K. (2011). An eye-tracking study on information processing in risky decisions: Evidence for compensatory strategies based on automatic processes. *Journal of Behavioral Decision Making, 24,* 71-98.

Handy, T., Jha, A., & Mangun, G. (1999). Promoting novelty in vision: Inhibition of return modulates perceptual-level processing. *Psychological Science, 10,* 157–161.

Klein, R. (1988). Inhibitory tagging system facilitates visual search. *Nature, 334,* 430–431.

Klein, R. M. (2000). Inhibition of return. *Trends in Cognitive Sciences, 4,* 138-147.

Lichtenstein, S., & Slovic, P. (2006). *The Construction of Preference*. New York: Cambridge University Press.

Ortega y Gassett, J. (1957). *On Love*. Cleveland: world.

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology, 32,* 3-25.

Posner, M. I., & Cohen, Y. (1984). *Components of Visual Orienting.* Nillsdale, NJ: Erlbaum.

Pratt, J., Kingstone, A., & Khoe, W. (1997). Inhibition of return in location- and identity-based choice decision tasks. *Perception and Psychophysics, 59,* 964–971.

Scherer, K.R. (2005). What are emotions? And how can they be measured? *Social Science Information, 44,* 695-729.

Shimojo, S., Simion, C., Shimojo, E., & Scheier, C. (2003). Gaze bias both reflects and influences preference. *Nature neuroscience, 6,* 1317-1322.

Stevens, J. R. (2008). *The Evolutionary Biology of Decision Making*. Faculty publications, Department of Psychology, University of Nebraska.

Stolz, J. A. (1996). Exogenous orienting does not reflect an encapsulated set of processes. *Journal of Experimental Psychology: Human Perception and Performance, 22,* 187–201.

Stoyanova, R. S., Pratt, J., & Anderson, A. K. (2007). Inhibition of return to social signals of fear. *Emotion, 7,* 49–56.

Strongman, K. T. (1978). *The Psychology of Emotion*. 2nd edition. New York: Wiley.

Taylor, T. L., & Therrien, M. E. (2005). Inhibition of return for faces. *Perception & Psychophysics, 67,* 1418–1422.

Theeuwes, J., & Van der Stigchel, S. (2006). Faces capture attention: Evidence from inhibition of return. *Visual Cognition, 13*, 657–665.

Tipper, S., Weaver, B., Jerreat, L., & Burak, A. (1994). Object-based and environment-based inhibition of return of visual attention. *Journal of Experimental Psychology: Human Perception and Performance, 20,* 478–499.

Tomkins, S. S. (1970). Affect as the primary motivational system. In: M.B. Arnold (ed.), *Feelings and Emotions: The Loyola Symposium*. New York: Academic Press.

Toda, M. (1980). Emotion and decision making. *Acta Psychologica, 45,* 133-155.

Weaver, M.D., Aronsen, D., & Lauwereyns, J. (2012). A short-lived face alert during inhibition of return. *Attention, Perception & Psychophysics, 74,* 510-520.

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology, 9,* 1-27.