INDIVIDUAL DIFFERENCES IN EMOTIONAL AND MOTIVATIONAL SALIENCE FOR COMPLEX SCENES

by

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ABSTRACT

Attention to elements in complex scenes is determined, in part, by the physical characteristics of stimuli. However, the ability of objects to capture visual attention is also subject to emotional and motivational influences. The present study investigates how positive mood and individual differences influence attention to complex, ecologically-valid scenes containing multiple motivational stimuli. Participants (*N*=41) viewed 15 scenes containing various motivationally relevant stimuli (food, alcohol, and tobacco) under neutral and happy moods while having their eye movements recorded with an eye-tracker. While past research has demonstrated that positive moods broaden attention and affective state can change the order in which participants view stimuli, the results of the current study found that mood did not increase fixation count and gaze order varied significantly regardless of mood. Further, though positive moods tend to increase the salience of rewarding stimuli (e.g., alcohol and food), creating differences in gaze behaviors, attention to food did not vary as a function of mood and alcohol received less attention after mood manipulation amongst participants that drink alcohol. Additionally, the incentive value of appetitive stimuli was not affected by the presence of other stimuli; alcohol and food attracted more fixations faster and for longer durations than stimuli without incentive salience. Current results suggest that motivationally salient content, and not mood, may be more influential when viewing complex scenes.

CHAPTER I

INTRODUCTION

Attention is the act of focusing and selectively processing aspects of one's environment (Anderson, 1990). Without attention, navigating and interpreting the complex environment in which we live would be impossible. Visual attention allows us to focus on individual items or regions for further processing. How our attention is directed depends on the physical and motivational characteristics of objects (Connor, Egeth, & Yantis, 2004). To describe it simply, Humphrey, Underwood, and Lambert (2012) state that an object is salient when attention is drawn to it more so than other, nearby objects. Essentially, the greater the salience an object has within a scene, the more likely that object is to capture attention. Salience influences attention in a pre-attentive, automatic fashion where object detection may be emphasized over object recognition or interpretation (Ohman, Flykt, & Esteves, 2001). Bottom-up, stimulus characteristics attract attention through physical qualities, such as contrast, saturation, and orientation, otherwise known as visual salience. In contrast, motivational or emotional salience is the importance of stimuli relative to one's motivational goals or affective state (Humphrey, et al., 2012). Together, these properties of salience determine which objects or elements in a scene capture attention.

The salience of stimuli also has an observable effect on subsequent cognitive processes, such as memory. In addition to receiving increased attention, salient stimuli receive increased preference during encoding (Everaert, Tierens, Uzieblo, & Koster, 2013), the process of storing information in short and long term memory (Watson & Breedlove, 2012). The probability of stimuli being encoded into memory increases as a stimulus becomes more salient (Everaert et al., 2013). Therefore, salient stimuli receive attention early and will be recalled more easily during memory retrieval.

Salience can be studied with a variety of methods; eye tracking, dot probe tasks, and flanker tasks are three of the most common approaches. These methods are non-invasive, accurate, and are not likely to alter viewing patterns as much as other techniques such as scleral coils (lenses with coils placed one the eye) and electrooculography (electrodes placed on the face to measure eye movements; for a review, see Young & Sheena, 1975). In eye tracking research, gaze patterns (order and duration of fixations) are monitored while a participant views a scene and gaze patterns are used to determine which objects in a display receive attention (Poole & Ball, 2005). In a dot probe task, attentional biases (a tendency to fixate on certain objects, either innately or through learning; Field, Duka, Tyler, & Schoenmakers, 2009) are inferred via reaction times. Reaction times are also used to infer attentional processes in Flanker tasks, wherein a target is displayed with incongruent stimuli (distractors) or with congruent stimuli and reaction times to identify the target are measured. While useful for certain questions, behavioral tasks such as dot probe and flanker tasks are limited in their generalizability to real-world contexts, where many different items compete for limited attentional resources.

Recent studies have utilized eye-tracking methodologies to examine fixations (Ohman et al., 2001; Tamir & Robinson, 2007) and order of saccades (Itti & Koch, 2000; Humphrey et al., 2012) towards particular stimuli, with the assumption that earlier fixations and longer fixation durations are a marker of attentional biases (Birch et al., 2008; Bradley, Field, Mogg, & De Houwer, 2004). A strength of eye-tracking methodologies is that they allow for the quantification of gaze patterns to complex scenes where multiple objects compete for attention. In eye-tracking studies, salience is often inferred through scan patterns and fixation data (e.g., Humphrey et al., 2012; Itti et al., 1998; Itti & Koch, 2000). As participants view a scene, the eye-tracker captures their scan patterns, recording data such as duration / order of fixations, number of fixations, time to first fixation, saccades, and other variables. This data allows researchers to make inferences about which stimuli are salient; the most salient stimuli are those receiving earlier, longer, and/or more repeated fixations (Poole & Ball, 2005). The eye-tracker can then display the resulting gaze data using a thermal graph or line segments (depicting saccades) linking together "hot spots" that correspond to the order and duration of fixations to different objects.

The data obtained from eye-tracking provide precise information about different aspects of gaze behavior, which can then be used to infer the deployment and maintenance of attention. For example, determining the order of fixations across objects in a scene can be used to determine extent of change in overall fixation patterns across viewing conditions. Examining how quickly participants fixate on an object (duration to first fixation) provides information about how quickly different stimuli capture attention (Poole & Ball, 2005). Total fixation duration corresponds to the length of time that attention is directed towards a single stimulus or category of stimuli across the entire viewing time of a scene (Jacob & Karn, 2003). Longer durations indicate difficulty disengaging from the stimulus (Poole & Ball, 2005). Similarly, repeated fixations on an object, or group of objects, provides an index of attentional engagement over the course of viewing a scene (Jacob & Karn, 2003). Further, an increase in the total number of saccades is representative of attentional broadening wherein viewers spend more time scanning a scene (Wadlinger & Isaacowitz, 2006). Thus, eye-tracking methodologies yield a wealth of data that can be used to infer the relative salience of multiple objects in a complex scene.

Visual salience refers to the observation that attention is attracted to the objects with the most physical prominence within a scene. For example, if a person were to view a grid of blue horizontal lines that contains a single red, vertical line, this red line deviates from the other lines due to its contrasting color and orientation which increases its visual salience. Studies in which participants view such stimuli (grid of lines with one differing in orientation or color) have reported increased attention to the unique stimulus in comparison to other stimuli (Itti , Koch, & Neibur, 1998). Itti et al. (1998) were among the first to offer a thorough explanation of how visual salience guides attention by examining how elementary properties in complex scenes elicit gaze patterns to create a visual salience map. Their salience map utilized the physical features (color, contrast, intensity, etc.) in an image to predict visually important regions of interest (ROIs). Itti et al. (1998) generated their salience map based on the assumption that ROIs will attract attention based on their levels of visual salience. The visual salience of each ROI was estimated from a feature map which prioritized areas according to intensity, color, and orientation. The result of these computations yielded a salience map which objectively defined the most visually salient ROIs in a scene. If the physical properties of objects in a scene determine gaze patterns, then these maps should be predictive of fixation patterns in human observers.

Itti and Koch (2000) tested the ability of their map to predict actual gaze patterns by comparing the visual behavior of humans viewing both simple (varying forms of one visual stimulus) and complex scenes (scenes involving several stimuli and multiple ROIs) to behavior predicted by their map. The salience map mimicked human visual behavior in simple scenes, predicting the ROIs that would actually receive the most attention from participants. The efficacy of this model was demonstrated by its ability to replicate human visual behavior by identifying the most informative regions of a scene and ignoring unimportant details. The model was fairly accurate in most instances, but Itti et al. (1998) admit that viewers' opinions of which visual information was most important did not always correspond to predictions. Essentially, the research by Itti et al. (1998) and Itti and Koch (2000) highlights the efficient nature of visual attention in guiding eye-movements and the utility of eye-tracking methodology as an objective way to investigate visual salience and model human visual behavior. However, these studies also suggest that low-level stimulus properties may not be entirely sufficient to explain complex gaze patterns to scenes.

One weakness of the Itti and Koch (2000) model is that it fails to take emotional and motivational influences into account, including the emotional relevance of objects in a scene and the motivation or dispositional inclinations of the observer. Although the map was able to predict areas high in visual salience, their map was limited by a relatively high variance due to individual differences across gaze patterns (Itti et al., 1998). In order to test the efficacy the salience map to predict human visual behavior when viewing scenes with emotional objects, Humphrey et al. (2012) attempted to replicate Itti and Koch's (2000). More specifically, Humphrey et al. (2012) examined how the observed viewing patterns of participants would differ from those predicted by Itti and Koch's (2000) salience map when motivationally relevant objects were present in a scene.

Utilizing predictions generated by the Itti and Koch (2000) salience map, Humphrey et al. (2012) had participants view 30 images of complex scenes and compared their behavior to that predicted by the model. Each image included one emotion-eliciting stimulus that was either positively valenced (e.g., happy, pleasant, etc.), negatively valenced (e.g., disgusting, sad, etc.), or neutral. In addition to the emotional stimuli, one stimulus high in visual salience (e.g., large or colorful) was included in each scene. For images with a neutral theme, there were proportionally more fixations towards ROIs higher in visual salience (Humphrey et al., 2012), consistent with predictions generated by the Itti and Koch (2000) model. However, analyses of the positive- and negative-themed scenes revealed significant differences between actual viewing patterns and those predicted by the model. Instead, Humphrey et al. (2012) found that the emotionally salient ROIs received proportionally more first fixations compared to visually salient ROIs.

In summary, low level stimulus properties are an accurate predictor of how an observer might view a scene devoid of emotional content (e.g., Itti & Koch, 2000). However, the primacy of visual salience is reduced when emotional or motivational stimuli are present in a scene. Humphrey et al.'s (2012) findings illustrate that although stimulus-driven processes like visual salience guide attention, human viewing behavior is also influenced by the presence of an emotionally-charged object in a scene. In addition, Humphrey et al. (2012) only utilized one affective object per scene; however, in real life, there are often multiple objects with motivational properties in a scene. To date, our understanding of visual attention does not adequately investigate how behavior may also be dependent upon the emotional state of the viewer, as well as the motivational properties of objects in a complex scene. Thus, the effect of the emotional state of the viewer on gaze patterns requires further elucidation. Another consideration is how gaze behavior changes when viewers are presented with multiple affective stimuli in a complex scene.

The previously discussed research has demonstrated that while the stimulus-driven aspects of visual attention are objectively influenced by the physical properties of a scene, these properties alone cannot account for human gaze behavior. According to Ohman et al. (2001), emotional stimuli are processed in a pre-attentive manner wherein evolutionarily- (e.g., threat) relevant stimuli are processed rapidly and automatically. The importance of emotional stimuli then results in increased attention to these stimuli (Ohman et al., 2001). Pre-attentive processing is also influenced by the motivational state of viewer and has been shown to alter visual attention in a number of studies (e.g., Ohman et al., 2001; Rowe, Hirsh, & Anderson 2007; Tamir & Robinson, 2007). The following paragraphs will outline how positive affective states influence visual behavior and examine how mood is thought to affect attention to motivationally-relevant stimuli (e.g. food, alcohol).

Fredrickson (2001) describes a “broaden and build theory” which states that positive mood states tend to promote an increase in attention to peripheral information, heightened awareness of one’s surroundings, and continued scanning of the environment. Wadlinger and Isaacowitz (2006) examined the broaden and build theory using eye tracking procedures. Participants were presented with slides, each containing three images (one central and two peripherally located), in either a neutral or positive mood. Results showed an increase in percentage of fixations to peripheral stimuli, as well as an increase in total number of saccades, for the positive mood induction (PMI) condition. While Wadlinger and Isaacowitz's (2006) emphasize that their results are due to stimuli with a positive valence receiving increased attention, their findings are consistent with Fredrickson's (2001) theory that positive moods broaden attention.

However, there are shortcomings to this increase in attention to peripheral visual stimuli. For example, Rowe et al. (2007) conducted a series of experiments wherein participants' ability to focus on a target stimuli was tested when the target was presented with multiple distractor stimuli. Rowe et al.'s (2007) findings corroborated the results of Fredrickson (2001): a positive mood elicited an increase in attention to peripheral stimuli. Rowe et al. (2007) suggested that positive mood affects information processing in a manner that promotes visual exploration. The authors noted that this increase in attention to peripheral stimuli comes at a cost, resulting in a simultaneous decline in the ability to ignore distractors and remain focused on target stimuli.

Gable and Harmon-Jones (2010) discuss further how positive mood modulates attention in their review of the extant literature on attentional broadening. More specifically, the authors describe broadening of attention as a result of positive mood as contingent upon the motivational intensity of a stimulus. When an object has low motivational intensity (i.e., is low in importance), viewers spend more time scanning scenes and attentional broadening occurs. However, if a viewer observes a stimulus high in motivational intensity (i.e., high in importance) within a scene, attention may instead be narrowed as the viewer repeatedly fixates on the motivational stimulus (Gable & Harmon-Jones, 2010).

Research on interactions between positive mood in the observer and motivationally-relevant stimuli in a scene is consistent with the conclusions of Gable and Harmon-Jones (2010). More specifically, studies on attention and motivationally salient stimuli have found that positive mood states enhance biases towards stimuli associated with reward (Tamir & Robinson, 2007). In a series of dot-probe tasks wherein word pairs were presented under multiple conditions (different types of mood induction), Tamir and Robinson (2007) found that positive mood states were associated with faster reaction times to identify reward-related words. Extending this idea to alcohol, Russell and Bond (1980) investigated whether viewing pleasant or unpleasant scenes would affect a participant's desire to drink in each setting. The majority of occasional drinkers indicated that they were more likely to drink in a positive setting. Birch et al. (2008) extended these findings by examining how mood states would affect attention by using mood induction procedures with a sample of heavy drinkers. To summarize their findings, positive mood led to increased attention to alcohol-themed words among participants who reported drinking to enhance positive moods. Birch et al. (2008) interpret these findings as evidence that positive mood increases the incentive value of alcohol and alcohol-related stimuli. Together, these studies suggest that alcohol may vary in salience as a function of consumption patterns (i.e., salience will be highest in moderate to heavy drinkers), as well as mood.

In summary, positive moods broaden attentional scope (Fredrickson, 2001). Further, this broadening of attention results in an increase in attention to peripheral stimuli and continued scanning of scenes (Rowe et al., 2007; Wadlinger & Isaacowitz, 2006). However, while positive mood promotes the broadening of attention, it is moderated by the motivational intensity of the stimuli being observed (Gable & Harmon-Jones, 2010). This modifying effect of motivational intensity has been observed in studies investigating attention to stimuli associated with reward (Birch et al., 2008; Tamir & Robinson, 2007). At present though the effects of mood on motivational salient stimuli, specifically those with incentive salience, when multiple motivationally-relevant stimuli compete for attention in complex ecologically valid scenes are relatively unknown.

A wide variety of motivationally salient stimuli capture attention, in particular those that are relevant to a viewer (Ohman et al., 2001; Sakaki et al., 2012). These stimuli differ according to whether they elicit approach- or avoidance-related tendencies. While a viewer's probable goal in the former case would be to approach and/or obtain the stimulus; in the latter, it would be to avoid unfavorable outcomes (Elliot & Covington, 2001). Approach judgments are made when a person feels that an object will satisfy their needs or meet their goals (Elliot & Covington, 2001). Berridge and Robinson (1998) propose that stimuli associated with the promise of reward develop incentive salience, which increase the likelihood that these stimuli will capture attention. Incentive salience refers to an object eliciting a "wanting", as opposed to a "liking" response, that engages an appetitive reaction (e.g., craving or consumption; Berridge & Robinson, 1998). This phenomenon is a notable feature in addiction, wherein users associate addiction-related cues with subsequent use, leading to craving (Field & Cox, 2008). Once cravings have been satiated, addiction-related cues become associated with positive outcomes and the behavior is reinforced. Stimuli likely to acquire or possess incentive salience are appetitive in nature such as food (Werthmann et al., 2013), alcohol (Birch et al., 2008; Russel & Bond, 1980), and tobacco (Bradley, Field, Mogg, & De Houwer, 2004). These are discussed further, in turn, below.

Food is an appetitive stimulus which is often associated with an approach orientation, although this may vary with a number of factors (weight, dieting history, food preferences, etc.). For example, hunger is associated with increased attention to images of high-fat foods, especially in overweight participants (Castellanos et al., 2009; Graham, Hoover, & Ceballos, 2011; Werthmann et al., 2011). Hunger and perceived reward are also correlated with delayed attentional disengagement from both appetitive and plain food images (Tapper, Pothos, & Lawrence, 2010). In general, food has been found to elicit an attentional bias in both healthy and unhealthy adults in comparison to neutral stimuli such as office supplies and other non-food stimuli (Werthmann, et al. 2013). However, the incentive salience of food in the context of other motivationally relevant stimuli (e.g., alcohol) requires further investigation. Furthermore, a systematic investigation of how the emotional state of the viewer affects the incentive salience of multiple appetitive stimuli (e.g., food and alcohol) present in complex scenes is also lacking.

Experiments examining the incentive salience of alcohol have yielded similar findings in drinkers. Field, Mogg, Zetteler, and Bradley (2004) examined how alcohol images capture attention in social drinkers using a visual probe task. Pairs of pictures were presented (one alcohol-related, one non-alcohol-related) for 200, 500, and 2000 ms, after which time, an arrow appeared in the location of one of the two images. Reaction times to identify the direction of the arrow were longer in heavy drinkers compared to light drinkers at 500 and 2000 ms when the arrow appeared in the location of non-alcohol images. This delay was believed to occur because attention was focused on alcohol images (Field et al., 2004). Further, the attentional bias for heavy drinkers at the 2000 ms display positively correlated with both higher cravings (before and after viewing the images) and higher levels of current alcohol consumption. These findings attest to the incentive salience of alcohol-related stimuli, especially in heavier drinkers.

The incentive salience of tobacco has also been demonstrated in smokers. Bradley et al. (2004) presented smokers and nonsmokers with smoking-related and control images in a visual probe task for durations ranging from 17 ms to 2000 ms and examined reaction times to identify the images. Participants also rated the stimuli on pleasantness. Similar to alcohol, smokers were slower to respond to probes appearing in the location of control images, indicative of an attentional bias toward images of cigarettes regardless of presentation duration (although when stimuli were masked, the effect was no longer present at short durations). The findings of Bradley et al. (2004) and the review of addictive substances by Field and Cox (2008) implicate tobacco products as a stimulus with high incentive salience in smokers. However, in nonsmokers, tobacco stimuli may have aversive properties. Nevertheless, the salience of tobacco relative to other emotionally relevant stimuli and how this varies as a function of the emotional state of the viewer are less understood.

The research discussed above illustrates the effects of food (Castellanos et al., 2009; Graham et al., 2009; Werthmann, et al., 2013), alcohol (Birch et al., 2008; Field et al., 2004), and tobacco (Bradley et al., 2004; Field & Cox, 2008) on attention and describes each of these stimuli as biasing attention when they are associated with reward.

As such, these findings converge with the conclusions drawn by Gable and Harmon-Jones (2010) and Ohman et al. (2001) in that attention is preferentially allocated to motivationally salient stimuli. However, there is a lack of inquiry on whether multiple stimuli with motivational salience would narrow attention, as discussed by Gable and Harmon-Jones (2010), or result in a broadening of attention.

To summarize, while the low level properties of stimuli are a powerful predictor of attention to objects in complex scenes, visual salience alone cannot predict fixation scenes. Rather, gaze patterns are also affected by the affective and motivational states of the viewer as well as the presence of motivationally relevant stimuli. Exactly which stimuli will capture attention on any given occasion should vary widely across individuals, dependent not only on individual differences in the relative significance of goal-related stimuli, but also on transient emotional and motivational states (e.g., mood, hunger/cravings). In order to understand visual attention to natural environments rather than images of an isolated stimulus, studies should employ more ecologically valid methods to examine visual attention to complex scenes.

Overall, the literature highlights three influences on object salience: the physical features of stimuli, the emotional state of the observer, and the relative importance of the stimuli. While visual salience has been extensively examined as a predictor of attention (Itti et al., 1998; Itti & Koch, 2000), it does not provide a complete explanation of visual behavior in response to complex scenes (Humphrey et al., 2012). Furthermore, while the effects of emotion on attention have been examined, such studies are narrow in scope and do not investigate how the presence of multiple motivational stimuli influence attention. Additionally, studies assessing the motivational salience of stimuli have used techniques such as dot probe paradigms with food (Werthmann et al., 2011), alcohol (Field et al., 2004), or tobacco (Bradley et al., 2004) and paired the stimulus of choice with a single, neutral stimulus rather than present multiple stimuli in natural environments. Notably, none of the aforementioned studies regarding appetitive stimuli or stimuli with incentive salience (e.g., Bradley et al., 2004; Field et al., 2004; Tapper et al., 2010) utilized eye tracking to determine how those stimuli actually affect gaze behavior. Similarly, research examining the effects of emotional states (e.g., Koster et al., 2005; Birch et al., 2008; Hepworth et al., 2014) on attention has not employed eye-tracking methodology to examine gaze behavior while viewing scenes containing a variety of motivationally-relevant objects.

Purpose of the Current Study

Research has demonstrated that the physical characteristics of stimuli direct attention (Itti et al., 1998; Itti & Koch, 2000); however, there is more to salience than physical stimulus properties (Humphrey et al., 2012). Findings by Fredrickson (2001) and Wadlinger and Isaacowitz (2006) emphasize positive moods as having a broadening effect on attention that promotes continued scanning of one’s environment. Further, motivationally-relevant stimuli can capture attention due to the rewards associated with subsequent consumption, a phenomenon known as incentive salience (Tamir & Robinson, 2007). Positive mood states then create biases towards viewing particular stimuli (e.g., attention biases towards alcohol, Birch et al., 2008). However, the focus of many experiments has been on stimuli presented in isolation rather than in complex, ecologically-valid scenes. In order to understand human visual behavior, stimuli must be presented and recorded in a manner than is consistent with real-life conditions.

The primary objective of this study was to determine whether a positive mood will induce attentional broadening when viewing complex scenes with multiple stimulus types. To this end, participants viewed scenes that included a number of different motivationally-relevant stimuli such as alcohol, food, and tobacco while their eye movements were monitored. While these stimulus types have received preferential attention in past research, their relative salience has not been assed using natural scenes in which many stimulus types are presented together. Participants were separated into two groups; a PMI group that completed the viewing task twice in a randomized order, once after PMI and a second time with no mood induction; and a control group that completed the viewing task twice without PMI in either condition. Similar to past research, (e.g., Wadlinger & Isaacowitz, 2006), positive mood was expected to produce an increase in the number of fixations as well as a change in order of fixations (Humphrey et al., 2012). Relative to the control group, the PMI group was expected to display an increase in the number of fixations, specifically in the PMI condition. Generating a Kendall's tau for order of fixations provided an index for the extent of change in visual behavior across viewing conditions. Tau scores offer a measure of concordance with respect to the order of fixations across two sessions; therefore the tau scores of the PMI group were expected to show a greater dissimilarity (lower tau scores) in fixation orders across conditions relative to the control group.

A secondary objective of this study was to investigate how a positive mood influences attention to motivationally-relevant objects in complex scenes. Studies have shown that positive mood may bias attention towards motivationally salient stimuli (Gable & Harmon-Jones, 2010; Ohman et al., 2001). It is likely that stimulus types receiving an increase in attention would also be stimuli with incentive salience (Berridge & Robinson, 1998). To this end, participants viewed scenes that included a number of different motivationally-relevant stimuli such as alcohol, food, and tobacco. Changes between mood conditions were observed by examining the fixation data (count, duration to first fixation, and total fixation duration) to each of the stimulus categories as a function of mood. Positive mood is associated with increased attention to rewarding stimuli (Tamir & Robinson, 2007) and alcohol has increased salience when consumers are in a happy mood state (Birch et al., 2008). Therefore, it was hypothesized that attention to alcohol would be moderated by drinking status and increase more for consumers in the PMI condition than non-consumers relative to those in the control group. It was predicted that the increase in attention would be manifested by lower durations to first fixation, longer total fixation duration, and a greater number of fixations to alcohol stimuli. With regard to food stimuli, results were more difficult to predict. If the incentive value of food (as rewarding stimuli) increases as a function of PMI, food should elicit more fixations and be fixated upon earlier and for longer durations than other stimuli.

The results of this study are relevant to several domains of research, as well as clinical practice. The area of study that will garner the most benefit from this thesis is attention research. More specifically, how positive emotions, such as happiness, may influence attention to scenes with the stimuli used in this study (e.g., alcohol and food). It is understood that happiness broadens attention (Fredrickson, 2001) but that the presence of motivational stimuli may conversely narrow attention when in a positive mood (Gable & Harmon-Jones, 2010). Thus far, little emphasis has been placed on understanding the impact of ecologically valid scenes on our attentional processes. This thesis will offer new insights into how multiple rewarding stimuli influence attention when simultaneously presented and whether attention is broadened, or narrowed, in such instances. Further, results will elucidate whether any individual differences may play a role in the allocation of attention to complex scenes.

Additional benefits of this study involve implications for clinical research and practice. For example, it will enrich our understanding of how attention for each of the stimulus categories presented in the scenes, and how appetitive, rewarding stimuli like food, tobacco, and alcohol compete for attention as a function of mood and individual differences in consumption patterns. Such findings could have implications not only for understanding biases in attention, but could also inform treatment for disorders like addiction and obesity. There are currently cognitive therapies based on altering attentional biases to cigarettes and alcohol (Field et al., 2009; Schoenmakers, et al., 2010). Attention-bias modification therapy (ABM) is one such method where patients learn to actively diminish their attentional bias to visual phobic or substance triggers by focusing on control stimuli over several trials (see Bar-Haim, 2010 for review). However, while therapies such as ABM have shown promising results in altering attentional biases toward addictive substances, their utility could be increased by using methods that are more generalizable to complex, real-world environments. Data from this study would provide a background from which cognitive based therapies like ABM could begin to improve their ecological validity.

CHAPTER II

METHOD

Participants

A total of 50 participants were recruited through the Psychology Research Experience (SONA subject pool) in the Department of Psychology. This approach provided diversity in both age and ethnicity among potential participants. Undergraduate participants signed up through the SONA system and received one extra credit hour for their first visit to the lab and another when they for their second visit. Participants were screened for normal or corrected to normal vision and were at least 18 years of age. There were no other exclusionary criteria. A total of nine participants were excluded from analyses: four due to attrition, one for age, one for poor eye-tracking data, and three who did not show an increase in mood after to the mood induction task. The final data set consisted of 41 participants (30 female, 11 male) aged 18 – 26 years (M = 19.76, SD = 1.91) with a total of 22 participants in the control group and 19 in the PMI group.

Intake Questionnaire

In addition to demographic information, an intake questionnaire was used to collect data on participants' recent use of alcohol and tobacco as well as levels of hunger, thirst, and fatigue. The data from the survey was then used for exploratory correlations to examine possible covariates as well as to observe how consumer status (drinkers vs. non-drinkers) affected gaze behaviors, such as time to first fixation, fixation duration, or fixation count to objects in these complex scenes. (see Appendix A for full intake questionnaire)

Mood Induction and Assessment

In order to induce a positive mood, participants completed an adaptation of the Prkachin Anger Interview (Prkachin, Williams-Avery, Zwaal, & Mills, 1999). This 5-minute interview required participants to verbally recall and answer questions about a situation that made him/her happy (see Appendix B for the adapted script).

In order to assess mood states, the Positive and Negative Affect Schedule (PANAS, Watson et al., 1988) was administered before and after scene viewing/mood induction. The PANAS scale is a pair of two, ten-item scales that are used to index positive and negative affective states (Watson, Clark, & Tellegan, 1988). The scales are simple to administer, take only a few minutes to complete, and are shown to have fairly good internal reliability and stability over time, with Cronbach's alphas ranging from .86 to .90 for positive affect and.84 to .87 for negative affect (Watson et al., 1988).

Stimuli

The stimuli consisted of 15 color images of complex scenes (1280 x 960 pixels). Each image depicted an indoor scene containing 15 items (± 2). Objects of interest include alcohol (beer, liquor, and wine), food (snack, meal, and dessert food items), tobacco products (cigarettes), non-alcoholic beverages (soda, water, juice, coffee, tea), and miscellaneous filler objects (see figure 1 on the following page for a representative image).

Figure 1. Representative image of stimuli used.

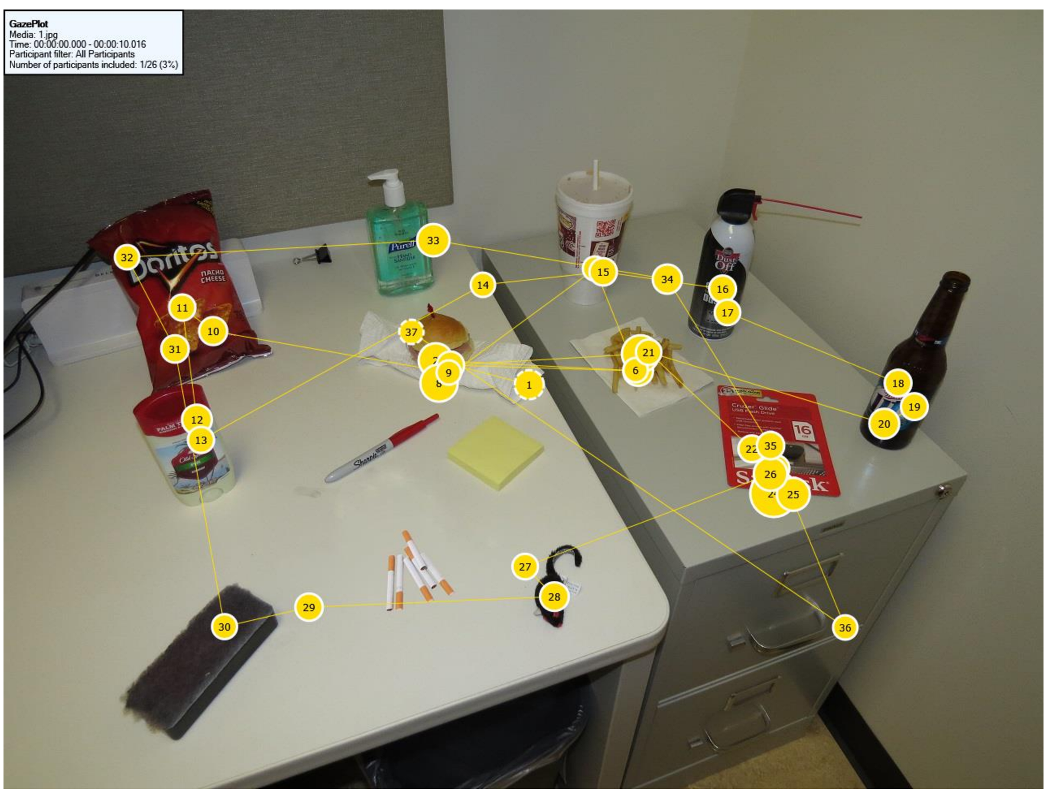


Figure 2. Representative image depicting the order of fixations with repeated fixations to food and alcohol ROIs. Each circle represents one fixation.

Eye Tracking Methods

A Tobii Eye Tracker X120 (Tobii Technology, Inc., Falls Church, Virginia) was used to record gaze behavior. The Tobii utilizes a non-invasive technique; infrared binocular tracking with a sampling rate 120 Hz. The eye-tracker was connected to a desktop PC and situated under a 19” computer monitor approximately 50 cm in front of the participant. A chin rest was used to maintain viewing distance.

The eye tracking task consisted of 15 images that were each presented for 10 seconds. A fixation cross appeared for four seconds before each image followed by a pause after each image allowing participants to verbally recall the items in the scene. To control for order effects, images were presented in one of four orders, with each participant viewing a different order on each visit. Viewing order was then counterbalanced across participants.

In order to track eye movements, ROIs were drawn for each object within a scene for all images. The eye tracker uses the ROIs to record the fixation data (count, duration, and time to first fixation) for each item viewed. The ROIs were then grouped according to one of the five stimulus types (alcohol, food, and tobacco as well as non-alcoholic beverages and miscellaneous items). Non-alcoholic beverage ROIs acted as control stimuli for alcoholic beverages. Due to the number of ROI groups, each scene had roughly 15 (± 2) ROIs. The data exported from the eye tracker included the order of fixations to each of the items, total fixation count to all images and total fixation count to each ROI category, as well as the average time to first fixation (ms), and average total fixation duration (ms) for each ROI category. Because the analysis software (Tobii Studio) did not did not quantify saccades, total fixation count was used as a proxy for saccades. In order to generate a representational index of attention for each type of stimulus in a scene, the total fixation count to each ROI group was divided by the number of objects in that particular ROI group and the average total fixation duration to each ROI group was divided by the average number items per ROI category. In contrast, the average time to first fixation for each ROI group was generated by averaging the time to first fixation across the objects in an ROI group in a scene.

Procedure

Participants completed two visits to the lab spaced approximately one week apart. For each visit participants completed either the PMI condition, if in the experimental group, or the control condition. During the PMI condition, the PANAS was administered before, immediately after the PMI as a manipulation check, as well as after the viewing task. In the control condition, participants completed a PANAS assessment before and after the viewing task (for further clarification, see timeline below). Participants in the experimental group completed one visit with the PMI procedure and a second visit without the PMI procedure (counterbalanced across participants).

Upon coming to the lab, participants were told that they were volunteering in a visual memory task. After signing informed consent, participants were assigned to either the PMI group or the control group. The PMI group had one visit in which they completed the PMI condition consisting of a survey, the PANAS, the PMI task, the PANAS, the viewing task (with free recall), and the PANAS (see Table 1). The other visit (order counterbalanced across participants) consisted of the control condition: intake survey, the PANAS, the viewing task (with free recall after each slide), and the PANAS.

Participants in the control group completed the control condition twice; once per visit (see Table 1).

Table 1

Order of tasks for the control and PMI conditions.

Condition	Order of Tasks					
Control:	Survery	PANAS	-	-	Viewing Task	PANAS
PMI:	Survey	PANAS	PMI	PANAS	Viewing Task	PANAS

After completing the intake survey and initial PANAS (and PMI, depending on the session), participants then completed the viewing task. After situating their chins in the chinrest, the eye-tracker was calibrated and was followed by the viewing task. Participants were instructed to observe a series of complex scenes and told that their memory for each scene would be recorded in order to encourage attention to items in the scenes. Between each scene, participants verbally described, in as much detail as possible, their memory for the objects in that scene. After the viewing task, the PANAS was then re-administered.

Participants were debriefed after their second visit to the lab unless they chose to discontinue their participation in the study. Those who elected to not return were sent the details of the study via email.

Analytic Strategy

The data extracted from the eye-tracker included the following variables: the total number of fixations (to all scenes), the corrected total number of fixations (per ROI group), the average duration to first fixation (per ROI group), the corrected total duration of fixations (per ROI group), and the order of fixations to each ROI. The efficacy of the mood induction was assessed via a mixed ANOVA using the PANAS scores (positive and negative scores from the PANAS surveys) as within subjects variables and condition as a between subjects variable. Interactions between the aforementioned variables were assessed using post-hoc t-tests.

The primary hypothesis that positive mood would elicit a broadening in attention used total fixation count to determine whether there was a change in the number of fixations between visit (visit 1 and visit 2 for each group) and across groups (control and PMI), where an increase in the number of fixations across conditions would indicate attentional broadening. The order of fixations was then examined across the ROIs as a function of condition and group. To this end, the order of fixations from visit one were compared to that from visit 2 (both groups). The concordance between viewing order were quantified with Kendall's tau and tau scores were in turn used to determine whether there were differences in the order of fixations across visits or between groups.

To determine which of the ROI groups received preferential processing and were more salient, the total number of fixations, mean duration to first fixation, and mean total fixation duration to each ROI group were each assessed by an omnibus ANOVA using visit and ROI group as within subjects variables and participant group as a between subjects variable. Self-reported demographic variables (age, hunger, thirst, and fatigue) from the survey were correlated with the aforementioned variables as possible covariates; however, no significant relationships were noted.

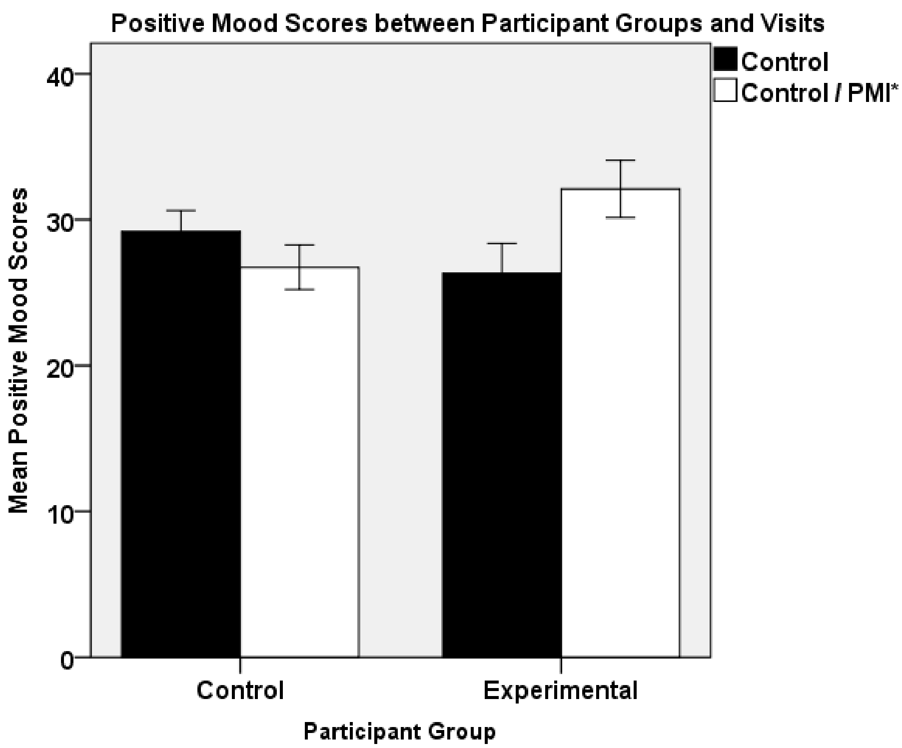
Secondary hypotheses that alcohol and food would receive increased attention were also examined by a series of ANOVAs that focused on specific ROI groups. Three ANOVAs examining gaze behavior to alcohol ROIs (fixation count, time to first fixation, and total fixation duration) were conducted, which used visit as a within subjects variable and consumer status (consumer vs. non-consumer of alcohol based on self-report, yes or no answers provided in survey) and participant group as between subjects variables. Attention to food ROIs was also examined with three ANOVAs (with fixation count, time to first fixation, and total fixation duration as dependent variables), using visit as a within subjects factor and participant group as a between subjects factor. Where applicable, degrees of freedom were adjusted with Greenhouse-Geisser corrections to protect against Type I error due to violations of sphericity.

CHAPTER III

RESULTS

Manipulation Check

A mixed ANOVA was conducted to determine whether the within subjects variables of visit (visits 1 and 2) and mood (positive and negative) varied as a function of the between subjects variable of participant group (control and PMI). The ANOVA revealed a three-way interaction between time, mood, and condition, $F(1, 39) = 139.73$, $p < .001$, partial $\eta^2 = .301$. Post-hoc *t*-tests (see Table 2 for average positive and negative mood scores) confirmed that the mood induction generated significantly higher positive mood scores for the PMI group after mood induction, $t(39) = -2.187$, $p < .05$.



*Condition depends on participant group.
Figure 3. Average positive mood scores as a function of condition (error bars represent the standard error of the mean).

Attentional Broadening

A mixed ANOVA was conducted to determine whether fixation count varied as a function of the within subjects variable of visit (visits 1 and 2) and the between subjects variable of participant group (consumer vs PMI). Tau scores (an index of the correspondence between fixation orders across visits) were generated by comparing the order of fixations between visits for each scene; the average tau score for all 15 scenes was then used to represent the gaze similarity between visits. An independent samples *t*-test was then used to determine whether there were significant differences in tau scores between groups. Table 2, shown on the following page, displays the mean and standard deviations (*SD*) for total fixation count and mean tau score according to condition. It is apparent that, on average, the PMI group had fewer total fixations for each visit compared to the control group and fewer fixations for visit 2 than for visit 1, suggesting that there was likely no attentional broadening present. Further, tau scores for both groups are comparable to one another and are both near 0, indicating discordance in the order of fixations on different objects across visits.

Table 2
Total mean fixation count and mean tau scores with standard deviations for visits 1 and 2 between participant groups.

Metric	Group	N	Mean	*SD*
Fixation Count Visit 1	Control	22	432.55	42.92
	PMI	19	428.11	50.16
Fixation Count Visit 2	Control	22	438.68	46.36
	PMI	19	416.58	66.09
tau Scores	Control	22	0.049	0.053
	PMI	19	0.046	0.050

The mixed ANOVA that examined differences in overall fixation counts between visit and group revealed that there were no significant effects of either time, F (1,39) = .186, $p > .05$, or group, F (1,39) = .79, $p > .05$. An independent samples *t*-test then examined differences in tau scores across groups, which indicated that fixation orders were equally discordant for both the PMI and the control groups across visits, $t(39) = .23$, $p > .05$. Furthermore, the tau scores of each group were examined separately using 2, one-sample *t*-tests and a critical value of 1 (indicative of perfectly concordant fixation orders across visits). Tau scores were significantly lower than 1 for both groups, $t(21) = -84.40$, $p < .001$ for the control group and $t(18) = -82.54$, $p < .001$ for the PMI group. Thus, gaze patterns between visits varied regardless of PMI.

Allocation of Attention across ROI Groups

Attention to the ROI groups was examined to determine whether any ROI group received preferential processing. Three mixed ANOVAs were conducted to determine whether fixation count, time to first fixation,or total fixation duration varied as a function of the within subjects variables of visit (visits 1 and 2) and ROI (alcohol, beverage, food, miscellaneous, and tobacco) and the between subjects variable of participant group (control vs PMI). In addition, paired-samples *t*-tests were used to examine differences in the aforementioned variables as a function of ROI group and conditions. Where indicated, degrees of freedom were adjusted with Geisser-Greenhouse corrections for violations of sphericity.

To determine whether total fixation count to each ROI group varied as a function of mood, a mixed ANOVA examined the total fixation count to each ROI group using visit and ROI group as within subjects variables and participant group as a between subjects variable. While there was no significant effect of visit, $F(1, 39) = .54$, $p > .05$, there was a main effect of ROI group, $F(2.93, 114.41) = 6.34$, $p < .001$, partial $\eta^2 = .140$. Further, group assignment had no significant effect on the total fixation count across the different ROI groups, $F(1, 39) = 1.91$, $p > .05$.

Paired-samples *t*-tests were used to examine differences in the average fixation count between visits for each of the ROI groups using a critical value of $p < .005$ (Bonferroni-corrected alpha, to correct for multiple comparisons). Significant differences for four pairs of ROI groups were observed. Alcohol ROIs ($M = 1.65$ fixations) were shown to have elicited significantly more fixations than miscellaneous ROIs ($M = 1.45$ fixations), $t(40) = 4.36$, $p < .001$. Beverage ROIs ($M = 1.53$ fixations) elicited significantly fewer fixations than food ROIs ($M = 1.65$ fixations), $t(40) = - 3.00$, $p < .005$. Further, food ROIs had significantly more fixations than miscellaneous ROIs ($M = 1.45$ fixations), $t(40) = 6.48$, $p < .001$, and tobacco ROIs ($M = 1.47$ fixations), $t(40) = 3.94$, $p < .005$. The results of these *t*-tests show that alcohol and food ROIs attracted significantly more fixations compared to the miscellaneous ROIs while tobacco was only viewed significantly less compared to food ROIs.

In order to assess whether time to first fixation on any ROI group varied as a function of mood, a second mixed ANOVA, using visit as a within subjects variable and participant group as a between subjects variable, examined whether there were differences in time to first fixation as a function of ROI group or of condition and/or group. Results of this ANOVA showed a significant main effect of ROI group, $F(2.36, 535.93) = 25.45$, $p < .001$, partial $\eta^2 = .395$, as well as an interaction between visit and participant group, $F(1, 39) = 4.67$, $p < .05$, $\eta^2 = .107$. Post hoc t-tests investigated the interaction and found that tobacco was fixated on significant faster in the control group's control visit relative to the experimental group's control visit ($M = 4.18$ compared to $M = 7.29$, respectively) $t(39) = -2.25$, p¸< .05. Paired-samples t-tests were then used to examine which ROIs elicited first fixations significantly faster using the average time to first fixation for each ROI group between visits and $p < .005$ (Bonferroni-corrected) as a critical value. A total of six pairs of ROIs were found to have elicited significant differences in average time to first fixation. Miscellaneous ROIs ($M = 1.22$ s) attracted attention significantly faster than alcohol ROIs ($M = 3.43$ s), $t(40) = 5.82$, $p < .001$, beverage ROIs ($M = 2.73$ s), $t(40) = 4.41$, $p < .001$, and tobacco ROIs ($M = 6.31$), $t(40) = -7.80$. $p < .001$. Conversely, tobacco ROIs were fixated on significant slower than alcohol ROIs, $t(40) = -3.92$, $p < .001$, beverage ROIs, $t(40) = -5.07$, $p < .001$, and food ROIs ($M = 2.01$ s), $t(40) = -5.89$, $p < .001$.

The final ANOVA examined total fixation duration across ROI groups using visit and ROI group as within subjects variable and participant group as a between subjects variable. There was once again a main effect of ROI group, $F(2.49, 97.17) = 10.00$, $p < .001$, partial $\eta^2 = .204$, as well as a main effect of participant group, $F(1,39) = 6.67$. $p < .05$, partial $\eta^2 = .146$. Examination of the marginal means show a significant difference of participant group on overall average fixation duration such that participants in the control group have longer average fixation durations ($M = 8.35$ s) compared to the PMI group ($M = 7.30$ s). To further examine the main effect of ROI and how total fixation duration varied as a function of ROI, paired samples t-tests were conducted on the average total fixation duration to each ROI between visit 1 and visit 2 and $p < .005$ (Bonferroni-corrected). Paired samples t-tests revealed significant differences between six pairs of ROIs. Alcohol (*M* = 8.94 s) had significantly longer durations of attention compared to the ROI groups of beverage (*M* = 7.53 s), *t*(40) = 3.70, *p* < .001, miscellaneous (*M* = 7.31 s), *t*(40) = 4.65, *p* <.001, and tobacco (*M* = 7.22 s), *t*(40) = 4.74, *p* < .001. Food ROIs also had longer average total fixation durations relative to beverage, *t*(40) = 3.91, *p* < .001, miscellaneous, *t*(40) = 6.50, *p* < .001, and tobacco ROIs, *t*(40) = 3.484, *p* < .001.

Table 3

Aggregate Means and SDs for Average Fixation Count, Average Time to First Fixation, and Average Total Fixation Duration between visits.

		Metric					
		Fixation Count		Time to 1st Fixation		Total Fixation Duration	
Group	ROI	*M*	*SD*	*M*	*SD*	*M*	*SD*
All Participants	Alcohol	1.65	0.38	3.43	2.62	8.94	2.60
	Beverage	1.53	0.34	2.73	2.29	7.53	1.71
	Food	1.65	0.29	2.01	2.24	8.33	1.60
	Misc	1.45	0.23	1.22	1.08	7.31	1.44
	Tobacco	1.47	0.34	6.31	4.17	7.22	2.03
Control	Alcohol	1.69	0.42	3.20	2.39	9.59	2.79
	Beverage	1.57	0.31	2.28	1.27	7.91	1.45
	Food	1.70	0.23	1.85	1.98	8.70	1.20
	Misc	1.48	0.25	1.12	0.79	7.63	1.09
	Tobacco	1.55	0.31	5.77	4.42	7.86	2.19
PMI	Alcohol	1.60	0.32	3.70	2.92	8.20	2.19
	Beverage	1.48	0.36	3.25	3.04	7.08	1.91
	Food	1.58	0.33	2.19	2.55	7.91	1.60
	Misc	1.41	0.22	1.33	1.35	6.93	1.37
	Tobacco	1.38	0.36	6.94	3.88	6.49	1.59

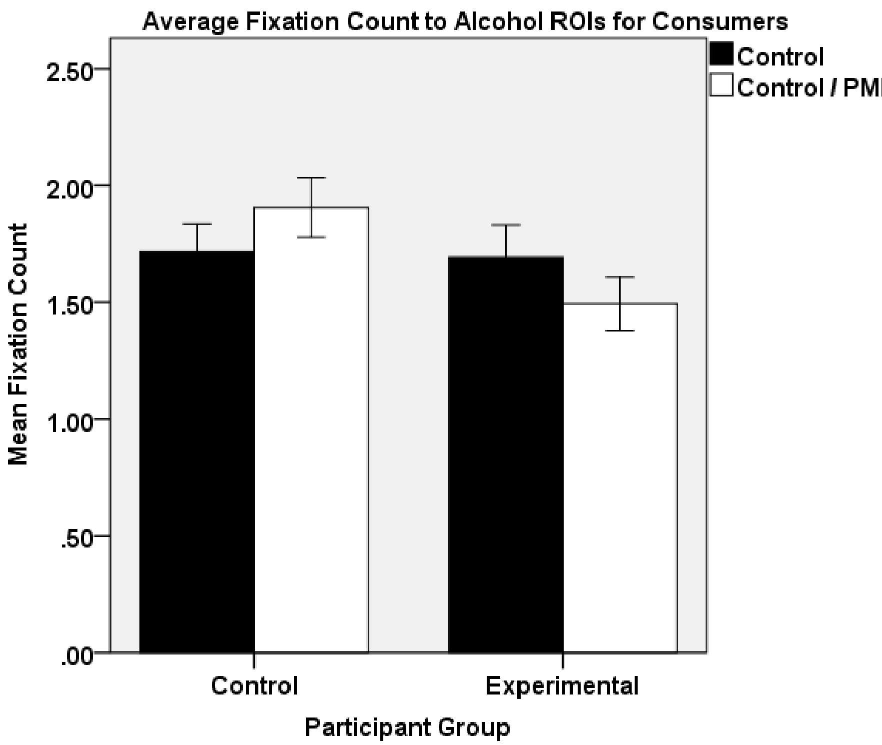
Attention to Alcohol

In order to examine the secondary hypothesis that being a consumer of alcohol affected attention to alcohol. Three mixed ANOVAs were used to determine how total fixation count, average time to fixation, and average total fixation duration to alcohol ROIs varied as a function of the within subjects variable of visit and the between subjects variables of participant group and consumer status. Table 4 displays the means and SDs for each of the eye-tracking metrics for both consumers and non-consumers of alcohol across visits.

Table 4
Mean and SD for Total Fixation Count, Average Time to First Fixation, and Average Total Fixation Duration between visits for consumers and non-consumers of alcohol.

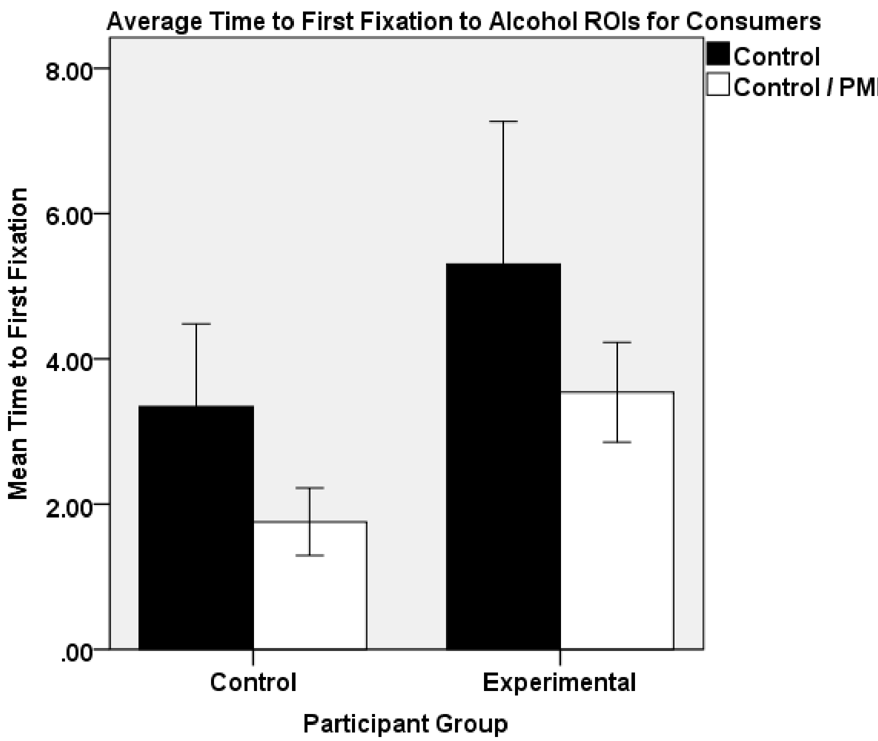
			Fixation Count		Time to First Fixation (s)		Fixation Duration (s)	
Consumer Status	Group	Visit	M	*SD*	M	*SD*	M	*SD*
Consumers	Control	1	1.72	0.43	3.34	4.10	10.92	2.87
		2	1.91	0.46	1.75	1.68	10.85	3.13
	PMI	1	1.69	0.50	5.30	7.08	8.38	2.69
		2	1.49	0.41	3.54	2.48	7.62	3.48
Non-Consumers	Control	1	1.55	0.62	2.43	1.82	8.22	2.49
		2	1.38	0.43	5.84	5.21	7.00	2.24
	PMI	1	1.48	0.37	1.69	1.27	8.67	2.25
		2	1.60	0.31	3.54	2.48	8.50	1.38

The first ANOVA examined total fixation count to alcohol ROIs as a function of the within groups variables of visit and the between groups variables of participant group and consumer status (consumer and non-consumer). The ANOVA found no significant main effects of visit, participant group, or of consumer status but did reveal a significant three-way interaction between these variables, $F(1, 37) = 4.17$, $p < .05$, partial $\eta^2 = .101$. To examine this interaction, two mixed ANOVAs examined the total fixation count on alcohol ROIs for consumers and non-consumers separately using visit as a within subjects variable and participant group as a between subjects variable. The mixed ANOVA for non-consumers found no significant differences in fixation count as a function of mood. The ANOVA for the consumers however did reveal a marginally significant interaction between visit and participant group, $F(1, 24) = 3.95$, $p = .058$, partial $\eta^2 = .141$. Post-hoc *t*-tests examining this marginal interaction revealed that the total fixation count for consumers in the control condition had significantly more fixations to alcohol ($M = 1.91$) relative to consumers in the PMI condition ($M = 1.49$), $t(27) = 2.62$, $p < .05$. Thus, drinkers in the PMI condition were less likely to fixate on alcohol ROIs in the PMI visit relative to drinkers in the control condition.



*Condition depends on participant group.
Figure 4. Mean fixation count to alcohol ROIs for consumers between participant groups (error bars represent standard error).

A second mixed ANOVA then examined whether time to first fixation to alcohol ROIs varied as a function of the within subjects variable of visit and the between subjects variables of participant group and consumer status. The ANOVA revealed no significant main effects for consumer status, visit, or participant group. However, there was an interaction between visit and participant group that approached significance, $F(1, 37) = 3.48$, $p = .07$, partial $\eta^2 = .086$. Post-hoc t-tests showed that consumers in the PMI condition took significantly longer to fixate on alcohol ROIs than consumers in the control condition (mean times to first fixation: $M = 3.54$ s and $M = 1.75$ s, respectively), $t(24) = -2.15$, $p < .05$.



*Condition depends on participant group.
Figure 5. Mean time to first fixation to alcohol ROIs for consumers between participant groups.

A final ANOVA then examined whether total fixation duration to alcohol varied as a function of mood. The ANOVA, which used visit as a within subjects variable and participant group and consumer status as between subjects variables, revealed no main effects. However, there was a significant interaction between consumer status and participant group, $F(1,37) = 6.58$, $p < .05$, partial $\eta^2 = .151$. To examine this interaction, consumers and non-consumers were separately analyzed with two ANOVAs. While the ANOVA for non-consumers revealed no significant effects, the ANOVA for consumers revealed a main effect of participant group, $F(1, 24) = 8.89$, $p < .01$, partial $\eta^2 = .270$. Post-hoc *t*-tests showed that the effect of participant group was such that drinkers in the control group spent significantly more time viewing alcohol ROIs in both visit 1, $t(24) = 2.33$, $p < .05$, and visit 2, $t(24) = 2.49$, $p < .05$. The means for the control group average total fixation duration for visits 1 and 2 were $M = 10.92$ s and 10.85 s, respectively, while the means for the PMI group were 8.31 s for the control visit and 7.56 s for the PMI visit.

Attention to Food

A brief examination of fixation data to food (see Table 5 on the following page) shows minor differences between visits with the exception of apparent differences in time to first fixation between conditions in the PMI group. Prior to examining attention to food as a function of mood, correlations between self-reported hunger (presented in Table 6 on the following page) and each of the eye-tracking metrics were conducted and no significant correlations between hunger and eye-tracking data for food ROIs were noted.

Table 5
Mean and SD for Total Fixation Count, Average Time to First Fixation, and Average Total Fixation Duration to food ROIs between groups.

		Fixation Count		Time to First Fixation (s)		Fixation Duration (s)	
Group	Visit	M	*SD*	M	*SD*	M	*SD*
Control	Control	1.72	0.31	1.27	1.07	8.68	1.49
	Control	1.69	0.33	2.43	3.36	8.64	1.68
PMI	Control	1.62	0.38	2.52	3.70	8.05	1.75
	PMI	1.56	0.39	1.87	3.12	7.68	2.14

Table 6
Correlations between self-reported hunger and attention to food between visits.

	Metric		
Visit	Fixation Count	Time to First Fixation	Total Fixation Duration
Control	-.056	-.096	-.140
PMI / Control*	-.195	.064	.204

* Condition depended on whether participants were in the control or PMI group.
Note: No correlations were significant at $p < 0.05$.

Following the same analytic method used for examining attention to alcohol, a series of ANOVAs were used to examine total fixation count, average time to first fixation, and average total fixation duration as a function of visit and / or condition. Analyses for food found no significant results for any of the aforementioned metrics as a function of mood, despite the apparent decline in time to first fixation amongst participants in the PMI condition.

CHAPTER IV

DISCUSSION

Research regarding how attention is deployed while viewing complex scenes has placed little emphasis on understanding how mood and motivationally salient stimuli interact to direct attention. The effects of emotional and motivational salience on attention to several categories of stimuli (e.g., alcohol and food) have been empirically proven in a multitude of studies (e.g., Birch et al., 2008; Field & Cox, 2008; Werthmann et al., 2013). Positive mood has been implicated in broadening attention (Fredrickson, 2001) but such findings have not been replicated when multiple motivationally salient stimuli are present (Gable & Harmon-Jones, 2010). Further, past research investigating the motivational salience of several types of stimuli is limited. More specifically, studies often display target and control stimuli in isolation rather than in natural scenes where multiple objects compete for attention. The present study attempted to examine visual attention during the viewing of ecologically-valid, complex scenes and how attention to different stimuli in those scenes are influenced by positive mood states and individual differences. The current study assessed 41 participants' attention to 15 complex scenes with five categories of stimuli present in each scene (alcohol, beverage, food, miscellaneous, and tobacco items) under neutral and positive mood states. The fixation data and gaze patterns of participants' were then compared to determine how attention to the scenes changes as a function of mood and ROI type.

In addition to examining general allocation of attention, this study also examined individual differences in how specific motivationally-relevant stimuli influence attention. Stimuli associated with reward often receive preferential processing during encoding

(Gable & Harmon-Jones, 2010), and positive mood has been shown to increase this effect for some stimuli (Tamir & Robinson, 2007). Alcohol is one stimulus that elicits increased attention when participants are in positive moods (Birch et al., 2008) but this effect has yet to be examined when other rewarding stimuli are present. Food also receives preferential processing (Werthmann, et al. 2013) but the cumulative influence of both mood and presence of other stimuli on attention has also not been investigated. The present study also examined how being a consumer of alcohol influences attention to alcohol stimuli between neutral and positive mood states, as well as how attention to food varies as a function of mood.

Results from the present study revealed no significant effects of mood on total fixation count, suggesting that attentional broadening did not result from positive mood induction. Further, positive mood did not lead to significant differences in how participants fixated on different objects in a scene; fixation orders were highly variable across visits and did not change systematically after PMI. Overall, attention was directed toward alcohol and food ROIs. Food ROIs received preferential processing regardless of visit or participant group. Further, alcohol ROIs received fewer fixations, took longer to fixate on, and had a shorter average fixation duration in the PMI condition for consumers indicating that positive mood resulted in a decrease in the attention capturing and maintaining properties of alcohol stimuli. Last, attention to food was not directly influenced or moderated by mood. These results are discussed in further detail below.

Attentional Broadening

It was hypothesized that positive mood induction would elicit an increase in the total fixation count relative to the control condition. The results of the current study do not support this hypothesis, showing no differences in the number or the order of fixations as a function of mood induction. In past research, positive mood has elicited a broadening in attention (e.g., Fredrickson, 2001; Wadlinger & Isaacowitz, 1996). However, this study is markedly different in its use of complex scenes and the inclusion of multiple stimuli. One explanation for the finding of no attentional broadening as a function of mood may be that food and alcohol ROIs were high in motivational salience and minimized the effects of mood. Gable and Harmon-Jones (2010) describe content high in motivational intensity as receiving increased attention and reducing the attentional broadening effects of positive mood. Additionally, alcohol and food have incentive salience (Birch et al, 2008; Werthmann et al., 2013) due to their association with reward that increases their tendency to receive increased attention (Berridge & Robinson, 1998). In the current study, alcohol and food received proportionally more attention in both PMI and control conditions. While the lack of attentional broadening is inconsistent with expectations, it is consistent with past research describing motivationally salient stimuli as inhibiting the broadening effects of positive mood (Gable& Harmon-Jones, 2010).

In addition to total fixation count, comparing the fixation data between stimuli may also offer insight into whether attention broadened or narrowed. The current study defines attentional broadening as an increase in fixation count but, for comparison, attention can also broaden when there is increased attention to peripheral stimuli (e.g., Frederickson, 2001) or motivationally irrelevant stimuli (Gable & Harmon-Jones, 2010). For example, Gable & Harmon-Jones (2010) examined attentional breadth (i.e., the extent to which continued scanning of a scene occurs) and found that participants were slower to fixate on motivationally irrelevant stimuli when motivationally relevant stimuli are present; they concluded that such fixation data is indicative of attentional narrowing rather than attentional broadening. In the current, study food repeatedly drew attention significantly faster and both food and alcohol held attention longer and were fixated on more frequently than non-motivationally salient stimuli. The finding that food ROIs captured attention faster than other ROI groups (e.g., alcohol and tobacco in the current study) is more characteristic of attentional narrowing than attentional broadening by Gable & Harmon-Jones' (2010) methodology. In addition, the finding that alcohol and food were fixated on more frequently and for more time than other ROIs also suggests that less attention was narrowed rather than broadening as other stimuli consequently received less attention. If broadening had occurred, less motivationally stimuli would likely have received more fixations or longer fixation durations, however no such changes were found as a result of positive mood. Thus, findings in the current study are consistent with the notion that in the presence of motivationally relevant stimuli, attentional broadening is not an inevitable consequence of positive mood. Rather, the inclusion of motivationally salient stimuli receiving preferential attention.

Nevertheless, results of the current study demonstrate that attentional broadening did not occur as a result of PMI, which may have been due to the inclusion of motivationally salient stimuli. Instead of an overall increase in fixations as a results of PMI, alcohol and food stimuli received more fixations overall, and were fixated on faster than other stimuli which limited the broadening effects of mood. Improvements in methodology may affect the outcome of similar studies. Foremost, ensuring the quality of sample size, mood manipulation, and visual stimuli could help to resolve the issue of whether or not positive mood elicits a broadening of attention to the elements in complex scenes. In addition, indexing saccades directly (vs. using fixations as a proxy) may have produced different results with respect to attentional broadening. Replicating the current study using mood induction procedures for the neutral condition, as well as examining saccades and systematically manipulating the number and presence of motivationally-relevant stimuli in a given scene, would help to establish whether motivationally salient stimuli limit the influence of mood during attentional processes. Further, the effects of other moods, such as sadness or anxiety, and other samples (e.g., comparing light and heavy drinkers or healthy-weight and overweight participants) may be beneficial to examine with similar procedures.

Mood and Gaze Order

The hypothesis that mood would produce significant differences in how participants viewed elements in each scene was not supported in the current study. When examining the tau scores of each group of participants, they were not significantly different from one another and no evidence of concordance across gaze patterns was observed across visits, regardless of group. This suggests that mood did not affect the order in which participants viewed objects in scenes across visits. Furthermore, tau scores for both groups were significantly less than 1 (perfect concordance of fixation orders across visits) indicating that regardless of mood, participants fixated on different objects in different orders across visits. Though the mean tau score for the PMI group was slightly lower than that of the control group (M = .046 compared to M = .049, respectively), there was no indication that positive mood was a significant factor in the order in which participants fixated on objects in complex scenes.

Previous literature places less emphasis on differences in gaze order as a measure of gaze stability and more emphasis on which stimuli received preferential processing. Humphrey et al. (2012) reported that emotional content led to greater dissimilarity in the order of how participants viewed scenes containing emotional items compared to what visual salience alone would suggest. Further, Tamir & Robinson (2007) found that positive mood increases attention to stimuli associated with rewards. Changes in mood were thus hypothesized as capable of eliciting changes in gaze behavior to scenes with content associated with rewards (e.g., food and alcohol). However, gaze orders in the present study were significantly different across visits regardless of condition.

One explanation for the difference in gaze behavior that occurred regardless of PMI is that novel stimuli are more likely to capture attention relative to familiar stimuli (Biggs et al., 2012). Participants in the current study had 10 seconds to view each scene, each of which contained 15 (± 2) items, which likely resulted in some items not being encoded. Further, the instructions to view and remember items in each scene may have encouraged participants to attend all items in each scene rather than allow their attention to focus and encode specific items. This increase in attention to stimuli would likely result in decreased memory for multiple stimuli. As a result, many items would seem unfamiliar in a follow up visit, have increased attention capturing qualities due to novelty, and subsequently lead to changes in gaze behavior. This could be examined by comparing attention to individual stimuli between visits to determine whether stimuli that received increased attention during a first visit received less attention in a second visit. Participants could also be surveyed to determine whether their familiarity to stimuli correlate with their gaze behavior after their second visit, with less familiar stimuli receiving increased attention.

In summary, positive mood manipulation had little influence on order of fixations between visits. Taken into context of other research, it is possible that motivational content or the novelty of objects not encoded during a participant's first visit had greater effects on order of fixations than the mood state of the observer. Replication of the current study, with inclusion of negative, positive, and neutral stimuli, may provide insight to the veracity of this conjecture. The current findings that mood did not influence gaze order are consistent with literature that the motivational and emotional salience of items direct attention (Humphrey et al., 2012) and might have a greater influence on cognitive processes than mood when motivationally salient stimuli are present (Gable & Harmon-Jones, 2010). Replication of the present experiment would further confirm that content high in motivational salience directs attention and subsequently lessens the effects of mood.

Allocation of Attention across ROI Groups

One aim of the present study was to examine how attention would be allocated to scenes with multiple types of motivationally salient stimuli. While no firm hypotheses were made regarding how attention would be allocated toward the different categories of ROIs, there were some expectations that selective attention would not be equally distributed across the different ROI categories. Analyses investigating allocation of attention as a function of mood and ROI category between visits determined that ROI category was the only significant variable in determining where and how attention was directed. Concerning the proportion of fixations for all ROIs, alcohol and food consistently received more fixations and had longer average fixation durations than miscellaneous and tobacco ROIs. Further, fixation count to alcohol was moderated by an interaction between participant group, consumer status, and condition such that mood led to a decrease in fixation count for consumers in the PMI condition. Beverage ROIs received fewer fixations than alcohol or food but more fixations than miscellaneous and tobacco ROIs. Regarding time to first fixation, miscellaneous ROIs tended to be fixated on the fastest followed by beverage, alcohol, food, and tobacco. Miscellaneous ROIs were fixated on significantly faster than alcohol, beverage, and tobacco ROIs. Further, there was a significant delay in attending to tobacco ROIs compared to alcohol, beverage, and food ROIs. Considering these findings, alcohol and food appeared to be drawing attention more often than other ROI categories while tobacco was the least appealing to the current sample of university students.

The current finding that alcohol and food consistently drew attention more than other stimulus types is consistent with past research. Alcohol and food have each been associated as having both motivational and incentive salience that attracts increased attention relative to neutral stimuli (Berridge & Robinson, 1998; Birch et al., 2008; Wethmann et al., 2013). In regards to alcohol, 24 members of the current sample were self-reported drinkers and alcohol was generally attended to more than other ROIs by most participants. Food received the same number of fixations as alcohol ROIs but participants attended to alcohol for less time than food ROIs (M = 8.94 s for alcohol compared to M = 9.33 s for food). Regarding these motivationally salient stimuli, food was faster to capture attention and but held attention for less time than alcohol. The finding that alcohol and food ROIs received preferential processing serves to further illustrate their motivational and incentive salience relative to other stimuli (e.g., beverage and miscellaneous ROIs). However, the finding that attention to alcohol decreased amongst consumers in the PMI condition is contrary to previous findings that positive mood elicits increases in attention to alcohol for consumers (Birch et al., 2008). In contrast to alcohol and food stimuli, tobacco has been implicated as attracting attention as well but such results are limited to smokers (Bradley et al., 2004). The fact that tobacco received the least attention across all metrics can likely be attributed to the lack of smokers (current sample had seven cigarette smokers, based on yes / no self-report responses, which prevented direct examination of smoking status) that might have found tobacco to be an appetitive stimulus in the current study.

Taking all metrics of attention into account, alcohol and food were the most salient ROIs according to nearly every metric. Further, these two ROI groups were very similar in both their influence on attention and the amount of attention received. Thus, food and alcohol maintain their incentive and motivational salience when miscellaneous items are present and, to some extent, when other motivationally salient stimuli are present. Successful replication of the current findings would demonstrate the veracity of this claim. Further investigation would also aid in understanding why attention to alcohol was diminished amongst consumers in the PMI condition as well as corroborating the notion that content high in motivational salience might have more influence on attention to complex scenes than a positive mood.

Attention to Alcohol

A secondary objective of the current study was to determine whether individual differences such as mood and consumer status influenced attention to alcohol stimuli.

Fixation count, duration to first fixation and total fixation duration to alcohol ROIs were analyzed to determine whether consumer status (drinker vs. nondrinker) and mood interacted to direct attention to scenes with multiple stimuli. It was expected that attention to alcohol would be increased for consumers, in particular after PMI; however, this hypothesis was only partially supported. Consumers in the control condition had more fixations to alcohol compared to consumers in the PMI condition while non-consumers showed no effects of mood between conditions. Further, consumers in the PMI condition showed greater delay in time to first fixation and shorter total fixation durations to alcohol ROIs relative to consumers in the control condition. Such results suggest that alcohol is less likely to capture attention and hold attention for consumers in positive moods; however, motives and the influence of quantity and frequency of consumption of alcohol also require examination in future studies. Though alcohol ROIs received more attention relative to other ROI groups, alcohol stimuli were less salient in complex scenes to consumers after PMI.

The present finding that consumers attended to alcohol stimuli less in the PMI condition relative to consumers in the control condition is inconsistent with past research. Alcohol has been shown to draw attention among consumers (Field et al., 2004) and positive mood has been shown to increase the reward salience associated with alcohol (Birch et al., 2008; Tamir & Robinson, 2007). However, there are numerous possibilities that might explain why alcohol received less attention among consumers relative to non-consumers. One consideration is that Field et al. (2004) found that increased consumption results in greater attention to alcohol. One limitation of the current study was that alcohol consumption patterns were not directly assessed, leaving the role of consumption an open question. Another explanation that cannot be assessed in the current study are individual differences in motives for consumption, which in turn, can influence attention to alcohol. For example, while some consumers might drink to complement a positive mood, others might drink to cope with negative mood states; such motives can drastically affect the circumstances under which alcohol-related stimuli become salient. Consumers who drink to enhance a positive are more responsive to alcohol stimuli than consumers in negative moods (Birch et al., 2008). Replication and extension of the current study to include the assessment of consumption patterns and motives for drinking should confirm present findings as well as clarify the role of individual differences in consumption motivations and quantity and frequency of consumption in attentional biases to alcohol-related objects in complex scenes.

The finding that alcohol ROIs were less salient for consumers in positive moods can also be related to cognitive efficiency. Cognitive efficiency is defined as the ability to remain on task and research has shown that heavy consumption of alcohol can lead to declines in cognitive efficiency (Nixon, Paul, & Phillips, 1998). The specific instructions provided to participants in the current study were to look at each scene and recall as many items as possible to encourage attention to all items. The finding that attention to alcohol decreased for consumers (fewer fixations and shorter fixation durations) could indicate that consumers had increased cognitive efficiency as they were less likely to fixate on, and had less difficulty disengaging their attention from, alcohol-related stimuli. Such findings have implications for clinical practice: if the same decline in attention to alcohol were to be found for individuals with alcohol use disorders, then cessation programs would benefit from emphasizing the importance of mood states and risk of relapse.

While mood had no effect on attention to alcohol for non-consumers, consumers showed a decrease in attention to alcohol when in a positive mood which is contradictory to what previous literature would predict (e.g., Birch et al., 2008; Tamir & Robinson, 2007). Present findings could indicate that alcohol stimuli in complex scenes lose their ability to capture and maintain attention when in a positive mood. Confirmation that alcohol receives less attention in positive moods would warrant further investigation to determine how other moods or the presence of other motivationally salient stimuli might influence visual behavior to similar complex scenes. Further, if neutral moods elicit decreases in attention to alcohol, such effects may be intensified by more negative moods (e.g., depression or anxiety). However, it would be beneficial to replicate the current study with additional mood states to directly compare how attention to alcohol changes as a function of mood within the context of a similar experiment.

Attention to Food

The final objective of the current study was to understand how mood positive mood influences attention with the presence of multiple stimuli. Hypotheses concerning the interaction of mood and the motivational salience of food were less precise. It was uncertain whether a positive mood or a neutral mood would increase the incentive salience of food. Results of the current study showed that attention to food was not influenced by positive mood. The lack of a main effect of mood is surprising considering that food has both motivational and incentive salience (Berridge & Robinson, 1998; Werthmann et al., 2013) and incentive salience has been shown to bias attention when participants are in more positive moods (Tamir & Robinson, 2007).

One possibility for the lack of variability in attention to food could be the lack of control for food stimuli used in the present study. While an attempt was made to include a variety of food items, no screening was used to determine the degree to which participants found each item appetizing. Hunger was not significantly correlated with attention to food ROIs and no emphasis was placed on dietary preferences between participants. Improvements in methodology (e.g., increasing sample size and using consistent lighting conditions and size / placement of stimuli within scenes) could elicit results that would contradict current findings that attention to food in complex scenes does not vary as a function of mood.

Despite null findings with respect to PMI, food still received significantly more attention than all ROIs except for alcohol. Such findings further emphasize the idea that the content in a scene may affect selective attention to a greater degree than mood. Implications of the findings for food are similar to those for alcohol. The lack of emotional effects necessitates corroboration and extension to understand when, and how, different moods influence attention to food while other motivationally relevant stimuli are present.

CHAPTER V

CONCLUSION

Past research has revealed that attention to individual stimuli is influenced by a number of variables, such as mood and individual motivations. However, little emphasis has been placed on the interaction of mood and motivations for scenes containing a variety of salient stimuli. The lack of empirical evidence surrounding attention to complex scenes prompted further investigation. The current study sought to investigate an apparent gap in research by examining how attention is allocated to complex, natural scenes as a function of mood.

Participants in the current study viewed a series of images containing multiple salient stimuli while in positive and neutral mood states to determine whether attention was broadened by positive mood for complex scenes. Fixation data between participants in the positive and neutral moods were then compared to determine how mood and stimulus type directed attention between conditions. The PMI group did not differ from the control group in regards to attentional broadening as indexed by the number of fixations to scenes or gaze order stability. In addition, there were minimal effects of mood on the direction of attention to salient stimuli. Rather, alcohol and food stimuli consistently captured and held attention regardless of PMI condition, with attention to alcohol decreasing for consumers when in positive moods. Past research has implicated positive moods as broadening attention (Fredrickson, 2001) and increasing the incentive salience of rewarding stimuli (Tamir & Robinson, 2007) but data in the current study suggests that such mood effects may be attenuated in the presence of multiple, motivationally salient stimuli.

Overall, the results of the current study implicate stimuli with incentive salience as the main predictor of selective attention. Had mood truly broadened attention there would likely be less attention to motivationally-relevant stimuli as participants would continuously scan scenes and not have returned to alcohol and food stimuli for repeated and longer fixations (Gable & Harmon-Jones, 2010). The lack of a specific relationship between mood and attention to ROI types serves to confirm the interpretation that motivational content directed attention and diminished the effects of positive mood to complex scenes.

Current literature on mood and emotional / motivational salience has not yet accounted for the presence of multiple motivationally salient stimuli under diverse emotional viewing conditions. Humphrey et al. (2012) examined complex scenes but included only one emotional stimulus per scene. Similarly, attention to alcohol and food stimuli is also typically assessed with the stimuli of interest being presented in pairs with one control item rather than in a realistic setting (e.g., Birch et al., 2008; Werthmann et al., 2013). Further, Gable & Harmon-Jones (2010) found that motivationally salient objects can narrow attention but the present furthers this understanding with the observation that motivationally relevant stimuli presented in complex scenes received preferential processing relative to less relevant stimuli. This increased processing subsequently negated the attentional broadening effects of positive mood and demonstrated that motivational salience of alcohol and food stimuli persist when presented in complex, natural scenes.

The present study has thus far offered findings, explanations, and support for conclusions as to how attention is cumulatively influenced by mood and motivational salience. However, it is not without limitations. Participants' mood was assessed for immediate mood states rather than over a more stable time period. As such, there is no certainty that some participants did not have recent feelings of anxiety or depression that could have influenced their attention to specific ROI groups. In addition to not controlling emotional states over time, the fact that participants believed their memory was being tested also influenced participants' gaze behavior such that gaze behavior was no longer natural but guided, to some extent, by experimenter instruction. Further, while this study emphasized ecological validity by using scenes with multiple, salient stimuli presented simultaneously, greater understanding of each target stimulus (e.g., alcohol and food) could have been gained by examination of each stimulus in isolation. More specifically, gaze data to complex scenes with only alcohol or food would have allowed for a comparison of how the salience of each stimulus is affected by the presence of the other.

Data loss and a small sample size limited the power of the analyses to detect potential effects of positive mood when examining both the total fixation count and attention to food. The lack of control for the stimuli used in the present study also presents several issues. More specifically, the number of items in each ROI varied between scenes which could result increased attention to whichever ROI group appears most. Further, lighting conditions were also not controlled between scenes. While an attempt was made to ensure that all items were clearly visible, any objects that may have been affected by differences in lighting could require increased fixation time to comprehend (Poole & Ball, 2005). The placement and size of items were also poorly controlled as individual items did not take up proportionally equal sizes within scenes and varied in placement from scene to scene. As such, larger items are more visible and likely to be observed as a result of physical size rather than as a result of motivational or emotional salience directing attention. However, analysis of this data found results that are consistent with those of Gable & Harmon-Jones' (2010) findings that the effects of positive mood may be limited by the presence of objects high in motivational relevance (e.g., alcohol and food) which receive preferential processing at the expense of examining other aspects of the scene.

In regards to future research, examination of the interplay between emotional states and motivational salience and how they work to direct attention to complex scenes requires further elucidation. Future research would benefit from observing the effects of other moods to determine the circumstances in which mood may have a greater influence on attention than object salience. Evidence from past research (Gable & Harmon-Jones, 2010) and the current study implicate object relevance as minimizing the effects of positive mood but little is known about how negative moods (e.g., anxiety or depression which were not assessed for immediate comparison or controlled for by examining recent feelings of) may affect attention to complex scenes with motivationally relevant stimuli. One example of the clinical implications are that interventions could identify the specific conditions under which dieters and recovering alcoholics are most at risk for relapse. In this manner, clinicians can better inform their patients and train them to understand and resist scenarios which risk relapse thereby improving treatment outcomes.

The current study examined how mood and motivational salience interact to guide attention to complex scenes. Overall, results suggest that the motivational salience of individual stimuli within a scene is a key factor in attentional capture and maintenance while viewing these scenes. While mood is a significant determinant of attentional allocation when stimulus pairs are employed (e.g., Birch et al., 2008; Tamir & Robinson, 2007), eye movement while viewing complex scenes in the present study depended on the motivational relevance of objects with little to no effect of mood. In the current study, there was no evidence of attentional broadening as a result of positive mood. Rather, eye movements to complex scenes that included motivationally-relevant stimuli revealed that these stimuli captured and held attention, suggestive of attentional narrowing. In addition, mood influenced attention to alcohol stimuli in drinkers wherein decreases in attentional capture and maintenance were observed in consumers in positive moods. The finding that a positive mood state modulates attentional biases to alcohol-related stimuli in drinkers has the potential to inform future research and treatment regimens for alcohol use disorders and addictive behaviors in general.

APPENDIX SECTION

Appendix A

1. Participant ID:
2. What is your age?
3. What is your gender?
4. Are you Hispanic?
5. What is your ethnicity?
   Select all that apply:
   American Indian/Pacific Islander
   Asian
   African American
   Hispanic
   White/Caucasian
   Other (please specify)
6. Do you have normal or corrected-to-normal vision?
7. Do you now wear contact lenses or glasses?
8. Do you smoke cigarettes?
   Regularly
   Sometimes
   Never
9. If you answered yes or sometimes to the question above, how often do you smoke and how many cigarettes do you have?
   a. How often?
   b. How many cigarettes?
10. Do you drink alcohol?
    Regularly
    Sometimes
    Never
11. If you answered yes or sometimes to the question above, how many times per week do you drink?
12. If you answered yes or sometimes to the question above, how many drinks do you typically have on any given occasion?
13. How many hours has it been since you last had something to drink?
14. Please rate how thirsty you are.
15. How many hours has it been since you last had something to eat?
16. Please rate how hungry you currently are.
17. Please rate your current level of tiredness.

Appendix B

Autobiographical Positive Mood Induction

The procedure is an autobiographical recall technique adapted from the Prkachin Anger Interview.

Memory Recall Prompt:

- Please recall an experience involving another person in which you felt the most happiness you had ever felt.

Talking Points:

- Imagine you are back in that experience right now.
- Where were you at the time?
- What could you see, hear, or smell while you were there?
- Who or what people were there at the time?
  - What did those people look like?
  - What were they wearing?
- What happened in this memory?
- What was said?
- What were your reactions?
- What were the sensations or feelings at the time?
- How do these things make this one of your happiest experiences?

Paraphrase:

- Interviewer summarizes the experience.
- Interviewer invites participant to provide any more details about the experience before completing a PANAS mood assessment.

Prkachin, K. M., Williams-Avery, R., Zwaal, C., & Mills, D. E. (1999). Cardiovascular changes accompanying induced emotion: An application of Lang's Theory of emotional imagery. *Journal of Psychosomatic Research*. *47*, 225-267.

Appendix C

Secure Mulibiometric Approach via Eye Movements and Iris Data

Items included in survey: Numbers 4, 5, 7, and 8

1. What is your age: ____________
2. What is your gender: __________
3. What is your race/ethnicity:_____________
4. Have you had any recent head injuries over the past 12 months? Yes No

IF YES: DATE? ________________

5. Do you now wear **contact lens** or **glasses**? Circle the answer.
6. The movement of which eye was recorded: **Right Left Both**. Circle the answer.
7. How many hours did you sleep last night? _____________
8. Please indicate if you had ANY of the following over the last 24 hours

Caffiene Yes No

Medication to aid sleep Yes No

Headache Yes No

Alcohol Yes No

On the seven-point scale with 7 as the most favorable response, 4 the mid-point and 1 the least favorable response please tell us about your experiences during this study:

Experience	**Score**
General Comfort	
Shoulder Fatigue	
Neck Fatigue	
Eye Fatigue	
Physical Effort	
Mental Effort	

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