# UNDERSTANDING HOW THE INFORMATION IN FACES INFLUENCES PERCEPTION AND ATTENTION TO MARIJUANA TARGET IMAGES

by

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## ABSTRACT

Individuals are inclined to orient their attention to locations cued by anothers' eye gaze (Dunham & Moore, 1995), which is sensitive to the emotional expression of the cue and the motivational relevance of targets (e.g. Bayliss et al., 2007; Graham, 2014; Pecchinenda et al., 2008). This may be due, in part, to associative priming reflective of implicit attitudes towards targets (Greenwald, McGhee, & Schwartz, 1998). The goal of this study was to investigate the influence of facial expressions and motivationally relevant targets on gaze-triggered orienting. A secondary objective was to determine whether attitudes towards marijuana modulate gaze cuing. Seventy-two participants completed a computerized task, in which they identified marijuana and non-marijuana target images that were validly or invalidly cued by gazing expressive faces (disgusted, surprised, happy), and an online survey asking them about marijuana-related attitudes. Participants were fastest to identify targets when gaze cues were predictive of target location, regardless of facial expression and target type. Analysis of identification accuracy revealed a facial expression x target type x validity interaction, which was due to a decrease in response accuracy when participants responded to non-marijuana targets validly cued by happy faces. For the secondary goal, survey data was used to create an index of positive/negative attitudes towards marijuana. Correlations between this index and the cuing effects to marijuana targets by different facial expressions revealed that larger cuing effects for disgusted faces and marijuana targets were associated more positive attitudes towards marijuana. Results suggest that motivationally relevant target

images, in conjunction with expressive faces, can create expectancies that may be sensitive to attitudes about the targets.

# I. INTRODUCTION

Dynamic information in faces provides an abundance of information regarding an individual's emotional state and the focus of his/her attention. A consequence of this in social contexts is the phenomenon of joint attention, in which individuals are more likely to orient their attention where others are pointing or looking (Dunham & Moore, 1995). One aspect of joint attention is a phenomenon known as the gaze-cuing of attention, which is typically examined with a computerized behavioral task similar to the Posner cuing task (Posner, 1980). In these paradigms, a face is presented centrally. Participant attention is cued by eye gaze, which can be averted in a variety of directions (up, down, left, right, or no change). A target then appears in a location, which can be congruent (valid) or incongruent (invalid) with the gaze direction of the face cue. Previous research has found that participants consistently respond faster to targets validly cued by gaze direction, even when informed that gaze is uninformative of the oncoming target location (e.g. Driver et al., 1999; Friesen & Kingstone, 1998; Mansfield, Farroni, & Johnson, 2003; Ricciardelli, Bricolo, Aglioti, & Chelazzi, 2002). The magnitude of the gaze-cuing effect can be measured by items such as participant response time to detect or identify targets, accuracy at identification of targets, or gaze behavior.

Likewise, several variables can be manipulated to investigate the factors that influence gaze-cuing of attention. One factor considered is the time that intervenes between gaze cue and subsequent presentation of the target, also known as stimulus onset asynchrony (SOA). Generally, manipulation of SOA indexes the foreperiod effect, which is the time period between the cue and target onset (Bertelson, 1967). Typically, the longer the SOA that intervenes between the face cue and the target, the faster the target is detected or identified (e.g., Friesen & Kingstone, 1998). By varying cue-target SOAs and how this modulates target identification or detection, researchers are able to understand the timing of cognitive mechanisms underlying gaze-cuing of attention. Specifically, varying SOAs allows for an understanding of when dynamic information in faces (e.g., facial expression and eye gaze) is integrated. Another key variable investigated is the facial expression of emotion displayed by the cue. Intuitively, one would expect that facial expression would relay valuable information about the environment. For example, a face displaying fear would signal a threat in the environment. Therefore, it would be advantageous for faster attentional orienting to locations cued by fearful faces. Likewise, manipulations at the target level can be investigated. Researchers may utilize a variety of targets, such as letters, target images, or symbols in order to investigate the role of target detection, target identification, or the use of targets with motivational relevance.

More recently, through modifications to the original paradigm, the cognitive mechanisms underlying visual attentional shifts triggered by gaze-directional cues and factors modulating these shifts have begun to be systematically examined. In particular, various factors associated with face cues (e.g., neutral or expressive), subsequent targets (symbols, letters, or emotionally valenced images), and task-related (e.g., identification vs. detection) factors have been shown to enhance or attenuate the gaze cuing effect. Recently, evidence has emerged that suggests that the magnitude of the gaze cuing effect may be sensitive to motivationally relevant contexts created by pairing differing expressive face cues with targets that vary in their emotional valence (e.g., Bayliss et al., 2007; Friesen, Halvorsen, & Graham, 2011; Pecchinenda et al., 2008). These preliminary results suggest that associations between cues and targets can influence the way in which individuals respond during any particular cuing task, although further investigation is required. Therefore, the primary goal of the proposed study is to examine the effects of pairing expressive gazing face cues and motivationally relevant targets on the gaze cuing effect. A secondary goal of this study was to explore whether the magnitude of the effect is associated with attitudes about target stimuli. For this study, gaze cues consisted of happy, disgusted, or surprised gazing faces, while targets will consist of marijuana-related or control images. It was predicted that participants would be faster and more accurate at identifying targets appearing in the gazed-at direction (validly cued targets) relative to those appearing in the opposite direction (invalidly cued targets). However, whether this cuing effect is sensitive to target type (marijuana versus control) and marijuana-related attitudes (e.g., attitudes about targets) remains unclear. The subsequent sections will begin with the discussion of the properties of reflexive orienting of attention, followed by an overview of methodological concerns in gaze-cuing paradigms relevant to the current study. Next, the literature examining the role of expressive gaze cues will be discussed, followed by a review of the literature discussing the role of motivationally relevant targets. Finally, the notion that gaze-cuing paradigms using expressive faces and motivationally-relevant targets can be sensitive to implicit attitudes will be explored, concluding with the rationale and hypotheses for the proposed research.

## II. LITERATURE REVIEW

As social animals, humans often engage in joint attention, a shared focus on an object or event often signaled by a shift in eye gaze, gesturing, or verbal signaling. The intention of the following literature review is to discuss the current state of research on gaze-triggered attentional orienting. The review will begin with the discussion of attentional orienting as cued through eye-gaze. Next, early studies of gaze-cuing will be discussed, followed by an examination of the literature discussing the modulation of the gaze cuing effect by facial expressions of emotion on the gaze cue. This will lead to an investigation of motivationally relevant influences at the target level on the gaze cuing effect. Next, the properties of implicit attitudes and how these underlying associations may influence participant responses in gaze-cuing paradigms will be reviewed. Finally, the utility of using a gaze cuing paradigm for investigating attitudes towards marijuana, especially at an implicit level will be argued. The literature review will conclude by providing a foundation for the rationale underlying the current study.

### Attentional Orienting in Gaze-Cuing Paradigms

Attentional orienting, as triggered by eye gaze, is typically examined using a variation of the Posner cuing task. In spatial cuing tasks, a centrally located cue signals the observers' attention. These cues can be a variety of stimuli, such as a flash or an arrow. When oncoming targets appear in the same location as the cue, participants are faster to detect these stimuli. In gaze cuing paradigms, the centrally-presented cue is a gazing face, with the targets appearing either in the gazed-at direction or in the other (invalidly) cued direction. The gaze cuing effect occurs when participants are faster and/or more accurate at detecting targets validly cued by eye gaze. This phenomenon, known as the cuing effect, occurs because observer attention was already directed to that spatial location. A cuing task allows researchers to understand the properties of attentional orienting triggered by gaze information in faces.

At this time, it is an open question if the gaze cuing effect is exogenous or endogenous. Endogenous attention (often considered akin to top-down attentional processing) requires conscious, higher level cognitive processing. This orienting process occurs at a voluntary level (Egeth & Yantis, 1997). It is typically observed through behavioral spatial cuing experiments with centralized symbolic cues (e.g. arrows, words "LEFT",) which require two stages of processing. Respondents must first process and comprehend the cue and then intentionally and willingly direct attention to the cued location. Exogenous attention, on the other hand (referred to as bottom-up attentional orienting), occurs at an automatic and involuntary level. Cues in exogenous orienting of attention elicit reflexive responses to stimuli (Egeth & Yantis, 1997). These automatic responses occur faster than responses for endogenous cuing tasks. Likewise, exogenous attentional orienting can be observed when participants are instructed that cues are not informative of the proceeding target location (Egeth & Yantis, 1997).

As it currently stands, it is unclear whether gaze-cuing paradigms and reflexive orienting elicit exogenous or endogenous orienting of attention. Participants are unable to suppress gaze-triggered orienting of attention, even when informed that the target is four times more likely to appear at the invalidly cued location (Driver et al., 1999). Therefore, it was originally posited that gaze-cuing occurred at an exogenous level (Friesen & Kingstone, 1998; Hietanen & Leppänen, 2003). However, further research has indicated higher level cognitive processes are recruited when integrating pertinent information, such as facial expression (Graham, Friesen, Fichtenholtz, & LaBar, 2010), emotionally valenced target images (Holmes et al., 2010), and motivationally relevant goals (Fichtenholtz, Hopfinger, Graham, Detwiler, & LaBar, 2009). Based on these findings, it would appear that gaze-triggered attentional orienting may not be exclusively exogenous or endogenous. However, it does appear to be reflexive, such that it occurs rapidly, even when cues do not provide information about the location of the subsequent target.

**Methodological Considerations for Gaze-Cuing Paradigms**

As mentioned, gaze-triggered reflexive attentional orienting has traditionally been investigated through gaze-cuing paradigms. In this task, a centrally presented face first appears with direct gaze, followed by an eye-gaze shift to the left or right. Subsequent targets may appear in the same spatial location as the cue (valid trials) or incongruent locations (invalid trials). The gaze cuing effect is manifested as faster reaction times (RTs) to detect or identify the target, higher accuracy to identify the target (if target identification is required), and overt shifts in the observer's gaze to the gazed-at location of the face cue. Accordingly, the magnitude of the cuing effect can be indexed with RTs, accuracy, or eye-tracking. Previous research has found a robust cuing effect for validly cued items across a variety of manipulations (e.g. Driver et al., 1999; Friesen & Kingstone, 1998; Hietanen & Leppänen, 2003; Holmes, Mogg, Garcia, & Bradley, 2010; Kuhn & Tipples, 2011). For example, when participants were informed to ignore face cues altogether or when participants were informed that the oncoming target was 4x more likely to appear in an opposite location than the cue, cuing effects were still robust. In gaze-cuing paradigms, researchers can manipulate varying aspects of the basic task, such as using different kinds of face cues (e.g., varying the identity or facial expressions) or targets (e.g., symbols, letters, or images), the task goal assigned to participants (e.g., target detection or identification), as well as the differing stimulus onset asynchronies (SOAs). The aim of this section of the literature review is to discuss methodological influences in gaze-cuing paradigms.

One of the factors manipulated for gaze cuing experiments is the type of face cue used. For example, researchers found that gaze-cuing still occurred with schematic face drawings (e.g. Friesen & Kinstone, 1998; Hietanen & Leppänen, 2003; Ristic, Friesen, & Kingstone, 2002). Gaze-cuing effects have also been found in static photographs of face cues (Driver et al, 1999) and dynamic faces (e.g., Graham et al., 2010; Friesen et al., 2011). Researchers have found that the gaze-cuing effect is robust regardless of the type of stimuli used. Nevertheless, the type of face cue used (e.g., schematic vs. real faces; static vs. dynamic faces) is an important consideration in gaze-cuing paradigm designs, especially with respect to ecological validity.

Another consideration in gaze cuing paradigms are task demands. Specifically, participants may be asked to make different kinds of responses to targets presented after the face cue. In some experiments, participants are prompted to merely detect the presence of a target via a key press. Other times, participants may be asked to categorize or identify target items. For task demands that require categorization or target identification, RTs tend to be longer, versus response times for detection tasks, which tend to be automatic. Likewise, task goals may be evaluative, in that participants are asked to rate the targets. For example, in one study, Bayliss, Frischen, Fenske, and Tipper (2007) instructed participants to evaluate how much they liked a target image of a household item based on a rating system from 1-9, with nine being very liked. Furthermore, some experimental designs require participants to initiate a response by fixating their eyes on the target image. As these different task demands likely recruit different cognitive resources and neural subsystems, they have the potential to yield important information about the nature of gaze triggered orienting and how it is modulated by task goals and the cognitive set of the observer. The effects of task demands will be explored in more detail in subsequent sections.

Another consideration in the design of gaze cuing experiments is stimulus onset asynchrony (SOA), which has provided important information regarding the timing of gaze processing and face processing in general. Varying SOAs has been especially useful for elucidating the time course of gaze and facial expression interactions at the level of the gaze cue. Gaze and facial expression both provide dynamic information and are likely involve similar neural processes (see Graham & LaBar, 2012 for a review). However, whether these two dimensions are processed separately or in an integrated manner remains an open question. The role of SOAs will be discussed further in depth in subsequent sections.

In conclusion, there are a variety of methodological factors that modulate the magnitude of the gaze-cuing effect, such as the types of face cues used, the types of targets used, task demands, and the time that intervenes between the face cue and the target. As these experimental details can vary drastically across studies, it is important to consider that gaze-cuing sequences are ecologically valid. In general, gaze cuing studies lack conformity in terms of methodological considerations, which may account for differing outcomes throughout gaze-cuing literature.

**Influence of Facial Expression**

One variable that has yielded the most inconsistent results has been the influence of facial expression in gaze-triggered attentional orienting. The emotional expression of a gazing face provides valuable information about the nature of the gazed-at environment. Intuitively, one can expect that dynamic information in faces, such as a change in facial expression, could influence attentional orienting from the observer. For example, a gazing face displaying fear should signal a threat in the environment; therefore, it would be advantageous for the observer to orient his or her attention to that spatial location faster than if the face were displaying a neutral expression. In spite of this, the literature regarding the influence of facial expression in gaze-cuing has yielded mixed results. While some research has found evidence for expressive gaze cues influencing attentional orienting (e.g. Bayless et al., 2011; Lassalle & Itier, 2013; 2015; Pecchinenda et al., 2008), others have only found this effect only after personality traits are taken into account, especially trait anxiety (Fox, Matthews, Calder, & Yiend, 2007; Holmes et al., 2010; Matthews et al., 2003). However, other studies have found no support for facial expression in gaze-triggered orienting (e.g. Fichtenholtz et al., 2007; 2009, Galfano, et al., 2011; Hietanen & Leppänen, 2003). This section of the literature review is intended to discuss and reconcile these inconsistent findings.

The effects of different expressive cues on gaze-triggered orienting have been investigated in multiple studies, but results have not converged. Some studies have found that expressive cues do not influence attentional orienting (Bayliss, Frischen, Fenske & Tipper, 2007; Fichtenholtz, Hopfinger, Graham, Detwiler, & Labar 2007; 2009; Galfano, Sarlo, Sassi, Munafo, Fuentes & Umilta, 2011; Hietanen & Leppänen, 2003; Holmes, Mogg, Monje Garcia, & Bradley, 2010). For example, in a study to investigate the influence of facial expression, Hietanen and Leppänen (2003), conducted a series of six experiments. Researchers manipulated cues to demonstrate several facial expressions (neutral, happy, angry, or fearful). Although a cuing effect was observed (i.e., faster responses to validly versus invalidly cued items), there was no evidence supporting the notion that facial expression modulated the cuing effect, leading the researchers to conclude that gaze-shift processing occurs independently of facial expression processing. As this was one of the first studies to investigate the influence of facial expression, it is important to note that the stimuli used were lacking in ecological validity. Gaze-cue and expressive face images had no transition (static photos of emotional gazing faces appeared as cues), unlike situations in real life, where the gaze cue would precede an emotional reaction. In Hietanen and Leppänen's experiment (2003), faces displaying full emotional expressions already gazing in a particular direction cued the observers. The order of stimuli presented, translated to natural settings, merely presented an emotional gazing face, as opposed to an individual responding to a signal in the environment; a dynamic sequence of events starting with a gaze shift, followed by an emotional reaction to whatever occurred in the gazed-at location.

To complicate matters further, some studies have found that facial expression only plays a role in gaze-triggered orienting in the presence of other mitigating factors, such as individual differences in trait anxiety. Several studies suggest that participants with high anxiety traits demonstrate increased cuing effects for fearful expressive cues (Fox, Matthews, Calder, & Yiend, 2007; Holmes et al., 2010; Matthews, et al., 2003; Putman et al., 2006; Tipples, 2006). The conclusion that can be drawn from these studies is that individuals with high trait anxiety may be more sensitive to expressive cues signaling a threat in the environment, whereas individuals low in trait anxiety might not be as sensitive to threat cues. For example, Putman et al. (2006) conducted a study to investigate the effects of attentional shifts cued by emotional faces (happy versus fearful) while considering the participant anxiety traits. Participant responses were significantly faster when cued by fearful faces versus happy faces and were correlated with participant anxiety traits. Participants high in anxiety were faster to respond to fearful emotional cues, whereas participants low in trait anxiety did not show these effects. Results from this study suggest that individual differences play a key role in the gaze cuing effect. However, it is important to note that some studies have not found differences in gaze-cuing effects to fearful faces across anxious and non-anxious populations (Lassalle & Itier, 2013; 2015; Neath et al., 2013).

In contrast, other research suggests that gaze-cuing of attention is influenced by facial expressions. For example, several studies have found effects were largest for fearful facial expressions versus neutral or happy expressions (Bayless et al., 2011; Graham, Kelland-Friesen, Fichtenholtz, & LaBar 2010; Lassalle & Itier, 2013; 2015; Neath et al., 2013; Pecchinenda, Pes, Farlazzo, & Zoccolotti, 2008; Tipples, 2006; Putman, Hermans, & Van Honk, 2006). Other researchers have found a larger cuing effect in surprised faces versus happy and angry faces (Bayless et al., 2011; Lassalle & Itier, 2013; Neath et al., 2013). However, it is possible that these results could be influenced by the aperture of the eyes, which are wider for surprised and fearful faces and may make it easier to detect changes in gaze direction (Graham et al., 2009; Tipples, 2005). Specifically, in fearful or surprised faces, a widening of the eyes occurs, allowing the observer an opportunity to better distinguish the contrast of the pupil of the sclera with the eye whites. Therefore, enhanced cuing for these expressions may not be due to emotion per se. However, when controlling for these changes, Graham and colleagues (2009) found that participants were faster to detect oncoming targets when expressive cues were used. These results suggest that the cuing effect is enhanced for emotional faces and are not due solely to easier discrimination of eye gaze due to a widening of the eyes.

As mentioned earlier, SOA is a methodological consideration in the design of gaze cuing studies and may be of particular importance when examining gaze and expression interaction at the level of the gaze cue. More specifically, gaze and expression may be processed independently via separate, parallel pathways (at least initially) and it may take time for these two dimensions to be integrated (e.g. Haxby, Hoffman, & Gobbini, 2000; see Graham & LaBar, 2012 for a review). If this is the case, then gaze and expression interactions may not influence attentional orienting at short SOAs if target-related processing interrupts cue-related processing (e.g., the integration of information about emotional expression and gaze) but will be observed at longer SOAs that should allow for more time to process the face cue (e.g. Bruce, Ellis, Gibling, & Young, 1987). Varying SOAs in a gaze cuing paradigm using expressive faces can inform this question. For example, if faster attentional orienting to different gazing emotional faces occurs at short SOAs, then it would indicate that facial expression and gaze processing occur conjointly at a fairly early stage of visual processing (e.g. Schweinberger & Soukup, 1998). However, if gaze and expression interactions are only observed at longer SOAs (i.e., a larger cuing effect for some expressions and not others), then this would suggest that these two dimensions are processed in separate pathways initially and are integrated at relatively later stages of visual processing. Through systematic manipulations of SOA, researchers have able to investigate the time course of cue processing and to make inferences regarding how different properties of the face cue affect gaze-triggered attentional orienting. For example, in a series of studies, Graham and colleagues (2010) tested varying SOAs to understand how we integrate dynamic information in faces. Here, researchers only found a gaze-cuing effect for expressive faces at longer SOAs (around 300ms). These findings indicate that dynamic information in faces, such as facial expression and gaze direction, might not be integrated until later stages of visual processing.

Similar to varying SOAs, the nature of the cue stimuli used also appears to play a role in understanding the effect of facial expression in gaze-cuing effects. Gaze-cuing paradigms incorporating gaze shifts and expressive faces should be as ecologically valid as possible to mimic what would be seen in typical social contexts. In natural settings, eye-gaze shifts and facial expressions occur dynamically. To validly investigate how we integrate eye-gaze and facial expressions, it is important that the sequence and timing of events reflect gaze-cuing as seen in natural social interactions. For example, many of the experiments that did not find an effect for expressive cues used a static cue sequence (Hietanen & Leppänen, 2003, Experiments 1-4; Holmes et al., 2006, Experiment 3; Hori, Umeno, Kamachi, Kobayashi, Ono & Nishijo, 2005; Tipples, 2006). On the other hand, cuing effects with expressive faces were more pronounced for dynamic cue sequences (Bayless et al., 2011; Lassalle & Itier, 2013; Putman et al., 2006; Tipples, 2006; Uono et al., 2009). Lassalle and Itier (2015) demonstrated this when they found that expressive facial cues influenced attentional orienting in dynamic experimental designs but not when static facial cues were used to convey information about gaze direction and expression. When cue sequences were ecologically valid (i.e. gaze shift, expression change, oncoming target), cuing effects were enhanced for expressive faces (fearful, surprised, and angry) compared to neutral cues.

In conclusion, the role of facial expression in gaze-triggered attentional orienting remains unclear. The lack of convergence in gaze-cuing literature could be explained by methodological differences across experiments. Studies have found different effects for facial expression based on items such as stimuli used (static vs. dynamic), differing SOAs (short vs. long), and participant task goals (identify vs. detect). Furthermore, early studies investigating the role of facial expression have exclusively focused on shifts of attention elicited by the cue. As facial expressions appear to react in response to stimuli in the environment, it may be that expectations regarding the subsequent target could also affect the magnitude of the cuing effect.

**Emotionally Valenced Target Images**

The possibility that inconsistencies with respect to the modulation of cuing effects by facial expression can be resolved by creating motivationally relevant contexts that include combinations of expressive cues and emotionally/motivationally relevant targets has received some attention (see Graham & LaBar, 2012 for a review). Therefore, as gaze-cuing paradigms have been embellished over time to include more varied cues, manipulations of the emotional valence of the targets have also been investigated. It appears that gaze-triggered attentional orienting may be influenced by the affective context or motivational relevance of the target evaluation in gaze-cuing paradigm (e.g., Bayliss et al., 2007; Graham, 2014; Pecchinenda et al., 2008). An affective component at the target level appears to modulate the gaze-cuing effects, possibly by creating cue-target contingencies between cue expression and target valence. This influence can be investigated via using motivationally relevant target images as well as expressive cues. In addition, varying participant task demands to include some affective evaluation of the targets has also yielded gaze and expression interactions at the level of the face cue. Therefore, it is possible that task parameters like cue-target contingencies and target evaluation could recruit endogenous attentional processes that interact with exogenous processes elicited by the gaze cue.

For example, Bayliss, Frischen, Fenske, and Tipper (2007) instructed participants to provide affective evaluations of neutral household items that were preceded by expressive gazing faces (happy versus disgusted). In this study, participants had stronger positive evaluations of neutral target images cued by happy faces than disgusted ones. In a similar study, Pecchinenda, Pes, Ferlazzo, and Zoccolotti (2008) examined the effects of incorporating target evaluations into a gaze-cuing paradigm using emotional face cues. For these studies, disgusted, fearful, happy, and neutral expressive cues preceded positive or negative target words. Participants were either asked to respond to the target words based on a perceptual characteristic (letter case) or affective valence. When participants were given an evaluative task (affective valence of target words), response times were significantly faster when cued by negative emotional faces (disgusted and fearful). Such cuing effects were not seen when the participant task was not evaluative (letter case). This suggests that motivational goals play an important role in the attentional processing that occurs during gaze-cuing, underscoring the importance of task demands in the design of these tasks.

Furthermore, Kuhn and Tipples (2011) investigated the influence of emotionally valenced targets using a modified visual search task and eye tracking in which participants were instructed to search for oncoming targets (either threatening or pleasant images of animals). Each trial started with a centrally presented neutral face that then gazed either right, left, up, or down, changing either into a fearful or happy expression. After an SOA of 300 ms, four images of animals (one threatening, one pleasant, two neutral) appeared to the top, bottom, left, or right of the cue location. For one block of trials, participants were asked to indicate the location of the most threatening animal via saccade; for the other, they were asked to indicate the location of the most pleasant animal. Participants were faster at indicating the location of threatening stimuli when their locations were validly cued by fearful expressive cues (e.g. when a snarling dog was presented in conjunction with a fearful face). This effect was not seen when fearful faces cued the location of pleasant target images. These results support the notion that gaze cuing is influenced by contextual factors such as the emotional expression of the cue, as well as task demands including the goals of the participants.

Through the articles reviewed here, an underlying theme that emerges is that context provided by combinations of expressive cues and valenced targets (or targets that require affective evaluation) plays a critical role in whether the facial expression of the cue has an effect on gaze-cuing. When expressive cues are presented in conjunction with the appropriately valenced target images, gaze-cuing effects are enhanced. As gaze-cuing is reflexive, individual attitudes and expectancies might therefore influence gaze-triggered attentional orienting in a manner akin to associative priming. The timing of stimulus presentation in these gaze cuing tasks, consisting of expressive cues and emotionally salient targets presented in close temporal proximity, shares similarities with concept-association priming. Associative priming occurs when exposure to one stimulus influences a response to a subsequent stimulus due to associations (e.g., semantic, affective) between the two stimuli. This is thought to occur without conscious guidance or intention, making associative priming tasks suitable for the examination of implicit attitudes (see De Houwer, 2003 for a review). Therefore, by presenting an emotionally expressive cue and a subsequent motivationally relevant target, gaze-cuing paradigms may be susceptible to associative priming, which in turn may make this paradigm sensitive to implicit/underlying attitudes.

**Implicit Attitudes and Gaze-Cuing Paradigms**

Implicit attitudes can be defined as evaluations that exist without awareness. Attitudes are formed through life experiences, which create and reinforce associations (Greenwald & Banaji, 1995). Such attitudes are shaped through experiences that are difficult to articulate and may not be consciously accessible. Because these attitudes cannot be reported, they cannot be indexed via self-report measures. This is particularly true of attitudes towards sensitive topics, such as racism, gender, drugs, or alcohol, such responses provided through self-report measures are contaminated by demand characteristics like social desirability effects, such that self-reported attitudes may not accurately reflect how an individual feels. Concept-association priming allows for implicit attitudes to be observed through a behavioral task. A prime activates one neural system, which then activates other associated concepts (De Houwer & Moors, 2007).

Therefore, if a strong association exists between a prime and a subsequent target, it should be manifested behaviorally in performance on computerized tasks (typically faster response times and/or higher accuracy in identifying the target). A typical trial in a gaze-cuing experiment with expressive face cues and motivationally-relevant targets consists of an emotional cue followed closely by an emotional target, similar to trials in priming experiments. Therefore, it is possible that some concept-association priming also occurs in these gaze-cuing tasks, which may tap into implicit attitudes about targets and influence the magnitude of the cuing effect.

As it currently stands, the most commonly used tool in implicit attitudes research is the Implicit Association Task (IAT). This test relies on concept-association priming to tap into individual's implicit biases (Greenwald & Banaji, 1995). Although it is commonly used, a large body of evidence suggests that the IAT may not validly measure implicit attitudes as originally posited (Blanton et al., 2009). If implicit attitudes influence participant responses to gaze-cuing of attention through motivationally relevant context, the gaze-cuing paradigm may be utilized as a novel measure for implicit attitude research.

Previous research supports the idea that gaze-cuing paradigms can be indicative of implicit attitudes. For example, Liuzza et. al (2013) found that gaze following can be predictive of implicit attitudes towards politicians, when the emotionally salient cue is manipulated. In their study, researchers investigated the attitudes of participants towards two candidates for an Italian election campaign. Electors were more likely to follow the gaze-cue of candidates that they had stronger positive attitudes towards. Effects of gaze-cuing were more pronounced when participants were cued by candidates they found more favorable.  Researchers found a significant relationship between behavioral data and IAT scores, indicating that participant responses were heavily influenced by implicit attitudes. In a follow up study, the participant results on the gaze-cuing paradigm were predictive of a participant's likelihood to vote for a particular candidate.

Likewise, Layton, Trefalls, Ceballos and Graham (2015) paired facial cues (neutral, happy, disgusted) with target images of prosocial (e.g., gift giving, helping behaviors) and antisocial acts (e.g., littering, pick-pocketing) and participants were asked to identify targets as prosocial or antisocial.  In this study, a pattern of cue-target interactions was found.  Researchers found a larger cuing effect when a relevant expressive cue and an affective target were presented in conjunction with each other.  For example, participants were faster to respond to when a disgusted facial cue was followed by an antisocial target.  It is possible that certain expression cues create expectations about forthcoming targets that are the result of associations between cues and targets in a manner similar to associative priming.  Therefore, implicit attitudes about targets may influence performance on gaze-cuing tasks, especially if target identification is required.

Research by Graham (2014) further supports this idea.  In Experiment 1, researchers investigated happy versus disgusted faces in conjunction with appetitive images (food versus non-food items).  A main effect for facial expression was found; participants were fastest in response to happy cues relative to disgusted cues.  However, these effects appeared to be moderated by cue-target contingencies.  No cuing effect was found when non-food targets were paired with happy facial expression cues, while cuing effects were most pronounced when disgusted facial expressions cued (disgusting) non-food targets.  In Experiment 2, researchers examined the role of participant's attitudes toward tobacco in the gaze cuing effect. Facial expressions (happy versus disgusted) were paired with tobacco versus non-tobacco images for smoker versus non-smoker participants. In spite of an overall main effect of validity, the cuing effect was only significant for targets validly cued by disgusted faces (not happy faces) and for validly cued control images (not tobacco images). Smokers were faster to identify non-tobacco images, possibly because tobacco targets captured attention, interfering with responding. Smokers also made more errors in identifying tobacco images cued by disgusted faces, and fewer errors in identifying control images cued by happy faces, suggesting that this group may have established target expectancies based on target/cue expression relationships. In a final experiment, researchers utilized images of alcohol as targets to examine the role of participant's drinking patterns and attitudes toward alcohol in the gaze cuing effect. In spite of an overall main effect of validity, the cuing effect was only significant for validly cued alcohol targets. There was a separate interaction between drinking frequency group (lighter vs. heavier social drinkers), cue expression, and target type, such that heavier social drinkers were faster to detect non-alcoholic targets cued by disgusted faces, and alcoholic targets cued by happy faces. Correlational analyses revealed that the cuing effect for happy cues/alcoholic targets decreased as a function of alcohol use, possibly because cue/target expectations were more powerful in heavier social drinkers. Together, these results are consistent with the notion that affective context can have a powerful effect on gaze and expression interactions and subsequent attentional orienting, and that attitudes toward target objects may be an important contextual factor. Other factors include motivationally relevant items, such as facial expression and target image. When these items are presented in conjunction with each other, priming effects may influence/interact with gaze-cuing effects.

The idea that priming might play a role in some cuing paradigms has yet to be systematically examined. For the current study, attitudes toward marijuana were chosen. As marijuana and the issue of legalization currently dominates the political culture, investigating attitudes that individuals hold about cannabis may be fruitful in understanding how the general population feels about legalization, which could inform and guide legislation. To date, there is a paucity of research examining explicit and implicit attitudes towards marijuana in the general population. With regard to explicit attitudes, previous research has investigated explicit attitudes towards individuals who use marijuana (Brown, 2015). Other researchers have investigated explicit attitudes towards medicinal marijuana and its legalization (Keyes et al., 2016). Other researchers have investigated marijuana use in conjunction with other drugs, such as heroin (Brown, 2015) and cocaine (Schafer & Brown, 1991). Of the studies conducted, no reliable measure to index explicit attitudes towards marijuana has emerged.

Likewise, limited research has been done to investigate implicit attitudes towards marijuana. In one study, Beraha, Cousijn, Hermanides, Goudriaan, and Wiers (2013) investigated implicit affective memory associations in marijuana users and non-users in the Netherlands using a version of the IAT. Heavy cannabis users had stronger positive-arousal associations with marijuana but weaker negative associations toward cannabis compared to non-users. Within the heavy use group, cannabis use (as indexed by weekly consumption in grams) was actually associated with stronger implicit negative associations. These results suggest that in this sample, overall attitudes towards marijuana were negative, albeit less so in heavy users. However, the positive relationship between actual consumption and negative implicit attitudes suggests that heavy users may internalize societal attitudes towards the drug, which is then manifested as an implicit attitude even though they continue to consume marijuana.

Implicit attitudes towards marijuana were also examined in an fMRI study conducted by Ames et al. (2013), in which researchers investigated the neural correlates for implicit associations for marijuana IAT in marijuana and non-marijuana users in California. In contrast to the Dutch sample in Beraha et al. (2013), IAT results were indicative of positive attitudes towards marijuana (e.g., faster response time to identify marijuana words paired with the positive effects of marijuana). In trials where marijuana words were paired with words associated with the positive effects of marijuana, increases in activity in the dorsal striatum associated with habit formation (i.e., the caudate nucleus and putamen) were found. These studies demonstrate that implicit attitudes toward marijuana can be indexed by the IAT. However, whether a gaze-cuing paradigm can also index these attitudes remains an open question. Given that marijuana use is still prohibited in Texas, it is possible that Texan college students have a wider range of attitudes regarding marijuana than in the Netherlands and California.

**Conclusion**

In conclusion, research regarding the role of cue facial expression on the gaze-cuing effect has been largely inconsistent. One possibility is that gaze-triggered attentional orienting may be influenced by motivationally relevant contexts that are created by combining emotionally expressive cues and affectively-charged targets. Specifically, to date, the role of affectively valenced targets, in conjunction with expressive cues has not yielded consistent results in the literature Therefore, the current proposed study was primarily intended to investigate the gaze-cuing effect in a task in which emotionally expressive face cues and marijuana and non-marijuana target images are used in conjunction with each other. A secondary question was to investigate whether the paradigm is sensitive to implicit attitudes towards targets. Given the similarities between gaze-cuing paradigms and concept-association priming, especially with regard to the temporal characteristics of cue/target presentation, it is possible that associations between cues and targets may affect the magnitude of the cuing effect. More specifically, when cue-target interactions align with the observers' implicit attitudes, faster attentional orienting may be observed. Therefore, the study also sought to examine whether any cuing effects for marijuana targets are sensitive to marijuana-related attitudes.

In the current study, expressive gazing faces (happy, disgusted, surprised) cued participant attention to validly or invalidly cued oncoming target images (marijuana or non-marijuana). It was hypothesized that participants would have higher accuracy and faster RTs for validly-cued trials, regardless of facial expression and target type, replicating the gaze cuing effect reported in previous gaze cuing studies (e.g. Driver et al., 1999; Friesen & Kingstone, 1998; Mansfield, Farroni, & Johnson, 2003; Ricciardelli, Bricolo, Aglioti, & Chelazzi, 2002). With respect to facial emotion, if the cuing effect is sensitive to the facial expression of the cue, irrespective of the type of target that subsequently appears, then this should be manifested as a validity by cue expression interaction. Alternatively, if participants were forming cue expression and target type associations akin to priming that do not interact with the cuing effect, this should be reflected as a cue expression x target type interaction that does not interact with the gaze direction of the cue. However, if the gaze direction and cue-target associations interact, 3-way interactions between validity, cue expression, and target type should be observed for accuracy and/or reaction times (RTs). Finally, if attitudes towards marijuana modulate the cuing effect for marijuana targets, positive attitudes towards marijuana should be associated with higher accuracy and faster RTs to identify marijuana targets cued by happy faces, and lower accuracy and slower RTs to identify marijuana targets validly cued by disgusted faces. Conversely, negative attitudes towards marijuana should be associated with higher accuracy and faster RTs to identify marijuana targets validly cued by disgusted faces, and lower accuracy and slower RTs to identify marijuana targets validly cued by happy faces. The results of this study could help to clarify the inconsistencies observed in gaze cuing studies utilizing emotional face cues.

# III. RESEARCH METHODS AND DESIGN

## Participants

Eighty-seven graduate and undergraduate students recruited from Texas State University participated in this study either voluntarily or for extra course credit (64 females, 23 males; $M_{age}$ = 22.1, $SD$ = 3.1). Due to low response accuracy or a high number of timed-out trials, 15 participants were excluded from analyses, leaving a final sample of 72 (52 females, 20 males; $M_{age}$ = 21.85, $SD$ = 2.52). All participants had normal or corrected-to-normal vision. Procedures for human subjects were approved by the Institutional Review Board at Texas State University.

## Stimuli and Apparatus

Face cues were digitized color photos of the same individual chosen from the NimStim face database (Tottenham et al., 2009). Original photographs were 9.75 cm wide and 12.2 cm high cm, consisting of one female face portraying neutral, happy, disgusted, and surprised facial expressions of emotion. To omit extraneous cues such as the ears, hairline, and neck, the faces were cropped with an ovoid mask and placed on a 75% greyscale background. The photos were equated for color, contrast, and luminance. All expressions were posed at full emotional intensity in full frontal orientations without changes in head orientation.

In order to create the appearance of motion and establish a smoother, dynamic transition to 100% emotional expressions, facial expressions of intermediate intensities (55% emotion; 50% neutral) were created using the methods outlined in LaBar, Crupain, Voyvodic, and McCarthy (2003) using MorphMan software (STOIK, Moscow, Russia). The original stimuli had direct gaze, and Adobe Photoshop (San Jose, CA) was used to manipulate gaze direction so that averted irises deviated approximately 0.4 degrees of visual angle from the centrally presented irises in the face cues with direct gaze.

Target stimuli consisted of 6 color photos found via a Google image search: 3 marijuana or marijuana-related images and 3 matched non-marijuana control images sized to 5.0 by 5.0 cm (see Figure 1). Target images were equated for luminance and contrast, matched as closely as possible for composition/complexity.

*Figure 1.* Marijuana and non-marijuana target image stimuli. The top row illustrates marijuana target images (left to right: hands holding marijuana buds, marijuana buds, and marijuana plants). The bottom row illustrates non-marijuana target images (left to right: hands holding herbs, broccoli, and pinecones)

A 17-item questionnaire was created using modified items from existing self-report measures of drug- or marijuana-related attitudes. Items from studies conducted by Keyes et al. (2016) and Lippold, Coffman, and Greenberg (2014) were used to index social perceptions of marijuana and marijuana-use. Likewise, several items were modified from previous questionnaires investigating attitudes towards alcohol and alcoholics (Kalafatellis, Magill, Stirling, & Jones, 2013; Vargas & Villar-Luis, 2008). The final items were taken from Schafer and Brown (1991) that indexed attitudes towards marijuana use (Schafer & Brown, 1991). Items selected were intended to index attitudes towards marijuana users (e.g. Marijuana users cannot be trusted), legalization (e.g. Marijuana should be legalized medicinally), and general perceptions of marijuana (e.g. Using marijuana is acceptable in some situations). Questionnaire items can be found in Appendix A.

The gaze-cuing task was administered using SuperLab 5.0 (Cedrus Corporation, San Pedro, CA). Survey data were collected via Qualtrics (Qualtrics, Provo, UT).

**Procedure**

Subjects arrived at the lab for one, 45-minute session and provided informed consent prior to participation. Participants then completed the gaze cuing task, seated approximately 57 cm from the monitor. To avoid creating any expectancies that would influence responding on the behavioral task, the task was administered before the survey. This was done to reduce the likelihood of demand characteristics/preconceived notions regarding the purpose of the experiment influencing participant responses on the gaze cuing task. The task consisted of six blocks of 72 trials. Each trial began with a 1 cm x 1 cm fixation cross horizontally centered and at the eye level of the cue face (1.5 cm above the vertical center of the screen) for 400 ms. This was then replaced by the image of a neutral face with a direct gaze for 500 ms, followed by a neutral face with averted gaze (left or right) for 50 ms. Next, a gazing face displaying 55% emotional/neutral blend (happy, surprised, or disgusted) was presented for 50 ms, followed by a gazing face expressing 100% emotion. SOAs ranged between 350-450 ms (350, 375, 400, 425, or 450 ms) to discourage anticipatory responses. Longer SOAs were chosen to increase the likelihood of finding gaze/expression interactions, as previous studies have demonstrated that gaze shift/facial expression integration might occur later in visual processing (e.g. Graham et al., 2010). Then, a target image (marijuana or non-marijuana control) appeared at the eye level of the face cue (1.5 cm above the vertical center), 7 cm from the horizontal center of the screen in either the gazed-at location or the opposite side of the face cue. Targets remained on the screen until participants responded with a key press with their right hand, categorizing the image as either marijuana or control. Across all six trials, SOAs (350, 375, 400, 425, 450 ms), facial expressions (happy, disgusted, surprised), target location (valid vs. invalid), and target images (marijuana vs. control) were equally and randomly assigned. Examples of the trial structures used are shown in Figure 2.

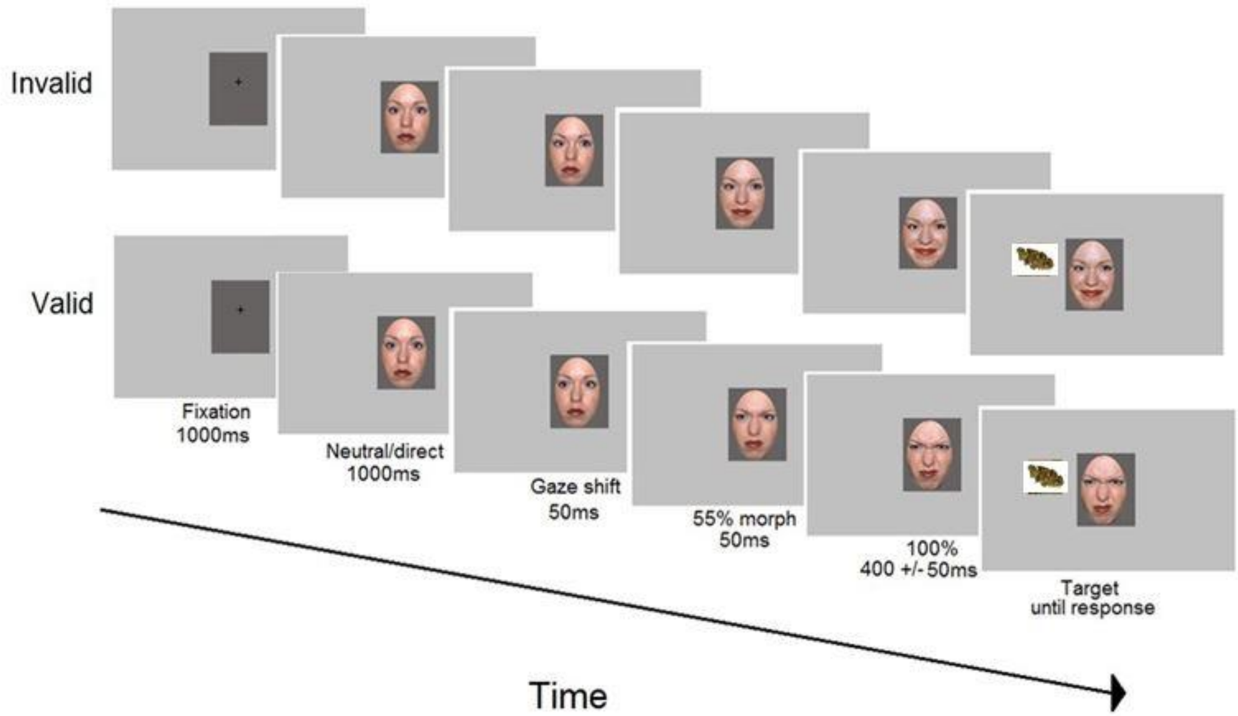



*Figure 2.* Trial structure for validly and invalidly cued trials. Example of trial structure. The top figure is an invalid trial for a happy expressive cue with marijuana target images. The bottom row displays a disgusted expressive face validly cuing a marijuana target image.

Upon completion of the behavioral task, participants completed the online survey. Following the survey, any specific participant questions or concerns were addressed. They were debriefed, thanked for their time, and compensated for their participation.

**Analytic Strategy**

Questionnaire data were analyzed using principle components analysis (PCA) to assess the dimensionality of the survey items and to identify items associated with positive/negative attitudes towards marijuana. The Kaiser-Myer-Olkin (KMO)'s Measure of Sampling Adequacy was used to ensure sampling adequacy (e.g. a large enough sample size). Likewise, Bartlett's Test of Sphericity was used to ensure no violations of sphericity. Lastly, communalities were inspected to investigate how much an item had in common with the rest of the items, demonstrating how much of the item variance is shared across other questions in the survey. The recommended cutoff of above .45 was utilized (Comrey & Lee, 1992; Tabachnick & Fidell; 2007). After completion of the PCA, items were reverse scored where necessary, and used to create a composite score for each participant reflecting positive/negative attitudes towards marijuana. For this composite score, higher scores indicated more positive attitudes towards marijuana; likewise, lower scores reflected more negative attitudes.

For the behavioral task, responses were considered correct if the correct key was pressed within 100-1500 ms after target onset. One hundred ms was chosen as the lower cut-off to avoid the inclusion of anticipatory responses due to biological time constraints associated with visual processing of the target and 1500 ms was chosen as the upper cut-off to maximize the likelihood of capturing rapid/reflexive orienting to the gaze cue and to eliminate longer RTs associated with inattention. Incorrect responses, as well as anticipations and timed-out trials, were removed from reaction time (RT) analyses.

Two separate 2 x 3 x 2 repeated-measures analyses of variance were conducted to investigate behavioral data; one for response accuracy, and the other for mean reaction times to identify targets. For both analyses, validity (valid vs. invalid trials), cue facial expression (happy vs. disgusted vs. surprised), and target type (marijuana vs. control) were included as factors. For post-hoc analyses, ANOVAs and Bonferroni-corrected paired-samples *t*-tests were utilized to investigate three-way interactions and any main effects involving facial expression. In the event of violations of sphericity, degrees of freedom were adjusted with Greenhouse-Geisser corrections. In order to examine possible relationships between marijuana-related attitudes and the cuing effect to different emotional faces, a cuing index (valid minus invalid trials) for accuracy and RTs to identify marijuana targets was computed for each facial expression. Exploratory Pearson's correlations were performed with these cuing indices and composite scores reflecting positive/negative attitudes towards marijuana derived from the PCA.

With respect to hypotheses, several potential outcomes were possible. A main effect of validity (higher accuracy and faster RTs for validly-cued trials) was expected, regardless of facial expression and target type, replicating the results of previous gaze cuing studies (e.g. Driver et al., 1999; Friesen & Kingstone, 1998; Mansfield, Farroni, & Johnson, 2003; Ricciardelli, Bricolo, Aglioti, & Chelazzi, 2002). If the cuing effect is sensitive to the facial expression of the cue, irrespective of the target, this should be manifested as a validity x cue expression interaction. If participants were forming cue expression and target type associations akin to priming that did not interact with the cuing effect, this should be reflected as a separate cue expression x target type interaction. However, if the cuing effect and cue-target associations interact, 3-way interactions between validity, cue expression, and target type should be observed. Finally, if attitudes towards marijuana modulate the cuing effect for marijuana targets, positive attitudes towards marijuana should be associated with higher accuracy and faster RTs to identify marijuana targets cued by happy faces, and lower accuracy and slower RTs to identify marijuana targets validly cued by disgusted faces. Conversely, negative attitudes towards marijuana should be associated with higher accuracy and faster RTs to identify marijuana targets validly cued by disgusted faces, and lower accuracy and slower RTs to identify marijuana targets validly cued by happy faces.

# IV. RESULTS

**Principle Component Analysis**

The factorability of the items was accessed via PCA. Fourteen of the 17 items correlated with at least one other item at a minimum of .3, indicating an appropriate level of factorability. Likewise, the KMO measure of sampling adequacy was .801, which is greater than the .6 recommended cutoff. Bartlett's test of sphericity was significant ($\chi^2(136) = 550.48$, $p < .05$). Furthermore, the communalities were above the .45 level (see Table 1). As there were no violations of assumptions, a PCA was conducted.

*Table 1.* Factor loadings and communalities from the PCA.

| Item | Loading | Communality |
|---|---|---|
| How wrong | 0.84 | 0.74 |
| Legalized recreational | 0.80 | 0.74 |
| Situationally acceptable | 0.78 | 0.69 |
| More creative/imaginative | 0.75 | 0.60 |
| Lose control | 0.72 | 0.69 |
| Legalized medicinally | 0.71 | 0.72 |
| Irresponsible | 0.69 | 0.63 |
| Immoral | 0.67 | 0.75 |
| Harm | 0.63 | 0.59 |
| Common sense | 0.61 | 0.65 |
| More fun | 0.60 | 0.75 |
| Angry/violent | 0.59 | 0.71 |

*Table 1.* Continued. Factor loadings and communalities from the PCA.

| | | |
|---|---|---|
| Cannot Trust | 0.57 | 0.67 |
| More friends | 0.38 | 0.61 |
| Everyday use | 0.33 | 0.60 |
| Look cool | | 0.90 |
| How common | | 0.83 |

Based on eigenvalues from the initial analysis, the first factor explained 38.34% of the variance. The second, third, fourth, and fifth factors explained 9.85%, 8.44%, 7.04%, and 6.01% of the variance respectively. A single latent variable solution was selected due to theoretical considerations, eigenvalues on the scree plot (see Figure 3), and reasonably large communalities for all items. The items "Smoking marijuana (pot) makes you look cool" and "In general, how common do you think it is for people to use marijuana?" had primary factor loadings less than .40 and no cross-loading of .30 or above.

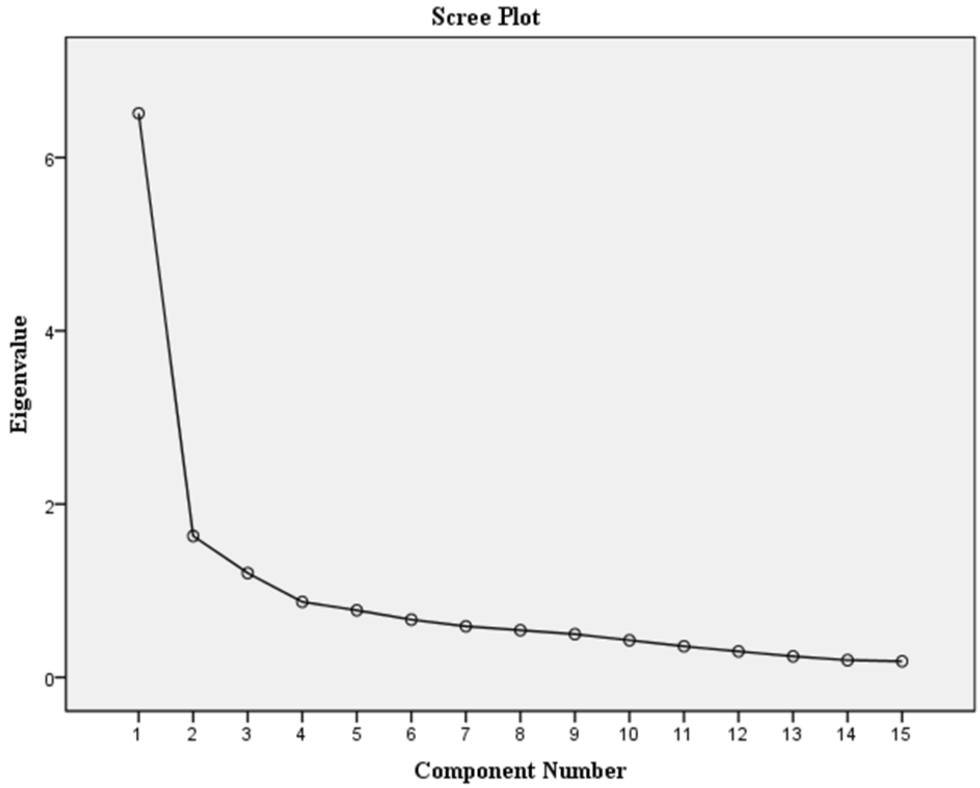



*Figure 3.* Scree plot for eigenvalues returned via PCA of the survey data.

A final PCA was conducted for the remaining 15 items with a single latent variable. From these analyses, a total of 43.4% of variance was explained by the component. Thirteen items had factor loadings greater than .05; the other two had factor loadings greater than .03 (see Table 2). The single latent variable appears to reflect a general positive or negative attitude towards marijuana. For this component, a composite score was calculated with higher scores reflecting a more positive attitude and lower scores reflecting a more negative attitude. The lowest possible score was 15; the highest possible score was 75. Descriptive statistics for the new composite score are shown in Table 2.

*Table 2.* Descriptive statistics for positive/negative attitude scores

| | *M* | *SD* | Skewness | Kurtosis | Kronbach's $\alpha$ |
|---|---|---|---|---|---|
| Composite Attitude Score | 57.99 | 9.68 | -0.79 | 0.43 | 0.76 |

**Behavioral Data**

Mean reaction times and response accuracies can be found in Tables 3 and 4 respectively.

A repeated measures analysis of variance of mean reaction times to identify targets revealed a main effect of validity, such that participant response time was faster for validly ($M$ = 745.97, $SD$ = 60.31) versus invalidly ($M$ = 763.61, $SD$ = 63.77) cued items, $F(1, 71) = 52.41$, $p < .001$. No other results were significant (effect of facial expression, target type, validity; $p$s > .05).

*Table 3.* Mean reaction times (and standard deviations) to identify targets as a function of cue expression and validity

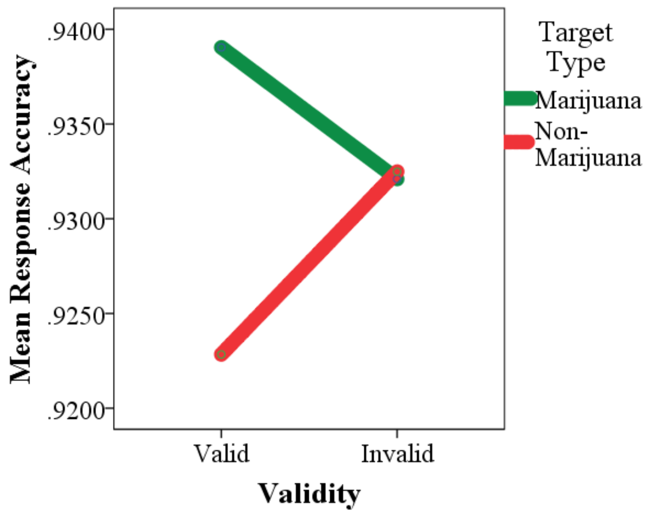
| Cue | Target | Valid | Invalid | Cuing Effect |
|---|---|---|---|---|
| | | *M (SD)* | *M (SD)* | *M (SD)* |
| Happy | Marijuana | 746.47 (70.59) | 762.51 (69.70) | 16.04 (43.46) |
| Happy | Control | 743.42 (64.63) | 762.81 (64.08) | 19.39 (34.13) |
| Disgust | Marijuana | 751.01 (71.99) | 762.29 (68.91) | 11.27 (40.04) |
| Disgust | Control | 749.29 (66.01) | 763.98 (61.78) | 14.70 (37.78) |
| Surprise | Marijuana | 744.22 (73.07) | 765.04 (78.58) | 20.82 (42.77) |
| Surprise | Control | 741.40 (58.75) | 765.04 (78.58) | 23.65 (55.24) |

*Table 4.* Mean response accuracies (and standard deviations) in percentages to identify targets as a function of cue expression and validity

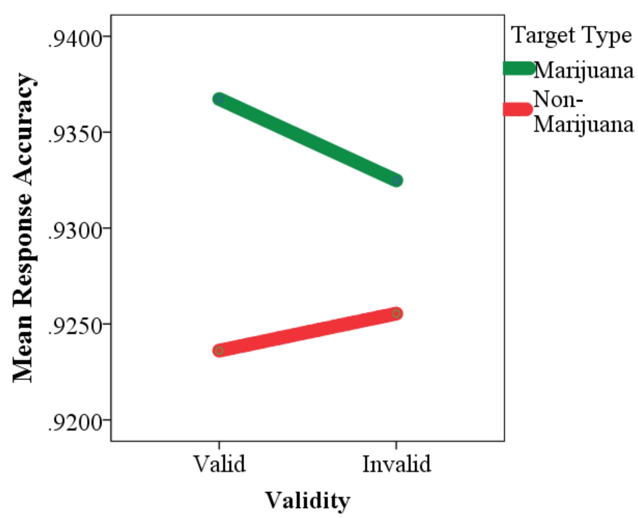
| Cue | Target | Valid | Invalid | Cuing Effect |
|---|---|---|---|---|
| | | *M (SD)* | *M (SD)* | *M (SD)* |
| Happy | Marijuana | 93.90 (10.11) | 93.21 (11.20) | -.69 (3.89) |
| Happy | Control | 92.28 (12.07) | 93.25 (11.94) | .96 (3.59) |
| Disgust | Marijuana | 93.67 (10.28) | 93.25 (11.09) | -.42 (4.44) |
| Disgust | Control | 92.36 (12.41) | 92.55 (12.38) | .19 (4.13) |
| Surprise | Marijuana | 92.94 (11.29) | 93.56 (10.77) | .62 (4.20) |
| Surprise | Control | 92.94 (11.62) | 93.17 (12.23) | .23 (3.84) |

A repeated measures ANOVA for response accuracy revealed no main effects, although an interaction effect for target type x validity was marginally significant, $F(1,71) = 3.77$, $p = .056$. This was mitigated by a significant facial expression x target type x validity interaction, $F(1.83, 129.9) = 3.23$, $p < .05$. Subsequent repeated measures ANOVAs were then conducted for each facial expression (n = 3, Bonferroni-corrected critical *p*-value = .017) revealed no significant difference for response accuracy for disgust or surprised (effect of target type, validity, or target type x validity, $p > .05$). For happiness, a significant interaction effect for target type x validity was found, $F(1,71) = 9.24, p = .003$. Charts showing accuracy results for valid and invalid trials for each emotion can be found in Figure 4. Bonferroni corrected post-hoc pairwise comparisons revealed a significant difference in valid versus invalid response accuracy for control items, such that validly cued control images ($M = .92$, $SD = .12$) were marginally significantly lower than invalidly cued ($M = .93$, $SD = .12$), $t(71) = -2.28$, $p = .025$.

*Figure 4.* Interaction plots for happy, disgust, and surprise expressive cues.

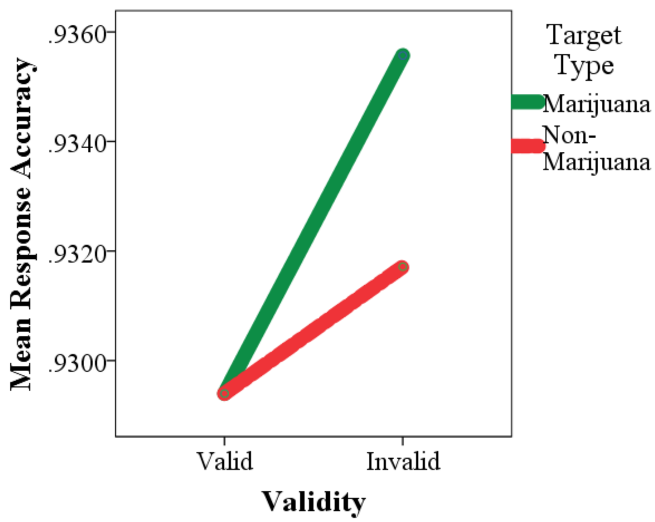



Happy




Disgust

*Figure 4.* Continued. Interaction plots for happy, disgust, and surprise expressive cues.




Surprised

Cuing effects for each facial expression x marijuana target interaction were calculated. To do this, mean valid response times were subtracted from mean invalid response times. Similarly, mean valid response accuracies were subtracted from mean invalid response accuracies. Cuing effect descriptive statistics can be found in Table 3.

**Cuing Effect Correlations**

Cuing effect (invalid minus valid trials) descriptive statistics for response times can be found in Table 3; likewise, cuing effect descriptive statistics for response accuracies can be found in Table 4.

The relationship between cuing effect scores and positive/negative attitude scores was examined using Pearson's correlation. Results can be found in Table 5. There was a weak significant relationship between attitude scores and the disgusted cuing effect scores, $r(68) = .27$, $p < .05$. As positive/negative attitude scores increased, the magnitude of the disgusted cuing effect increased as well.

*Table 5*. Cuing effect correlations.

| Facial Expression | *r* | *p* |
|---|---|---|
| Happy (RT) | 0.18 | 0.15 |
| Disgusted (RT) | 0.27 | 0.02* |
| Surprised (RT) | -0.02 | 0.90 |
| Happy (acc) | -0.21 | 0.08 |
| Disgusted (acc) | -.068 | 0.58 |
| Surprised (acc) | -0.22 | 0.06 |

## V. DISCUSSION

The face is a rich source of both static and dynamic information, including information about an individual's age, identity, emotional state, and focus of attention. Eye gaze and emotional expressions convey dynamic information about attention and emotion and it intuitively makes sense that these dimensions would be processed in an integrated fashion by the visual system. However, interactions between these two kinds of information have been inconsistent in gaze cuing studies to date. The current study investigated attentional orienting as triggered by eye-gaze and whether the cuing effect is modulated by the facial expression of the cue, the motivational relevance of the target, and self-reported attitudes about the targets. In a spatial-cuing paradigm similar to the Posner cuing task (Posner, 1980), differing facial expressions (happy, disgusted, surprised) either validly or invalidly cued marijuana or non-marijuana target images. It was predicted that gaze cuing of attention would be faster for validly versus invalidly cued target images. It was also predicted that the magnitude of the gaze-cuing effect would differ depending on the facial expression of the cue, as demonstrated through response times or response accuracy. Lastly, it was hypothesized that cue-target interactions would be related to participant attitudes towards marijuana. The first hypothesis was supported, in that participant times were faster for validly versus non-validly cued items across all facial expressions and target types. However, no interactions between the cuing effect, the facial expression of the cue, or the type of target image were observed for reaction times. In contrast, an interaction was found for response accuracy to targets cued by happy expressive cues, such that validly cued non-marijuana images had lower response accuracy relative to marijuana targets. Our third hypothesis was partially supported, in that positive attitudes to marijuana were correlated with the magnitude of the cuing effect for disgusted faces. Further investigation of results, implications, and future directions will be discussed in more detail in subsequent sections.

**Cuing Effect**

Consistent with previous gaze cuing studies, a cuing effect (e.g., faster RTs to identify validly cued targets relative to invalid targets) was observed, regardless of cue facial expression and target type. Early studies consistently reported a small, but significant cuing effect for validly cued items (Driver et al., 1999; Friesen & Kingstone, 1998, 2003; Hietanen, 1999; Kingstone, Friesen, & Gazzaniga, 2000; Ristic, Friesen, & Kingstone, 2002), even when participants are informed that the cue is not spatially predictive of oncoming target location. Because gaze-triggered shifts of attention are difficult to suppress even when gaze direction does not predict the location of subsequent targets, the gaze cuing effect was thought to reflect rapid, reflexive attentional orienting (Driver et al., 1999; Friesen & Kingstone, 1998; Friesen et al., 2004; Langton & Bruce, 1999). As gaze-cuing research has progressed and the paradigm embellished to include manipulations of the gaze cue (e.g., differing facial expressions), target types, and task demands, the cuing effect is still robust (Graham, Friesen, Fichtenholtz, & LaBar, 2010; Hietanen & Leppänen, 2003; Hori et al., 2005; Kuhn & Tipples, 2011). Collectively, results from this study and previous literature support the existence of reflexive gaze-triggered attentional orienting, which is hard to suppress.

A secondary objective of this study was to examine modulating factors, specifically interactions between gaze, facial expression, and emotionally salient cues.

No interactions of these variables with the cuing effect were observed in reaction times to identify targets. It is interesting to note that reaction times did not vary based on the facial expression of the cue, which converges with some studies in the area, but not with others.

Contrary to results of this experiment, several previous studies have found that facial expression can influence gaze-triggered attentional orienting. For example, Lassalle and Itier (2013) investigated the role of facial expression in gaze-triggered attentional orienting. For this experiment, researchers utilized a dynamic stimuli sequence and a target localization task. Participants responded by determining the spatial location of oncoming targets (asterisks). Researchers found enlarged RT cuing effects for expressive cues of surprise and fear, compared to neutral cues [Experiment 1]. Researchers also found faster gaze-triggered attentional orienting for angry versus happy or neutral expressions [Experiment 2]. Similarly, Bayless and colleagues (2011) found an effect for facial expression on gaze-cuing when participants were given a target localization task. Although in that study, researchers found faster cuing-effects for different emotions (Bayless et al., 2011). Response times were faster when expressive cues were fearful and surprised versus happy and angry. Collectively, these studies illustrate a role of expressive cues, regardless of the specific emotion, based on the task goal assigned.

As mentioned in the literature review, not all gaze-cuing studies have reported variations in the cuing effect as a function of cue facial expression. As such, findings from the current study are in line with other studies that have failed to find an influence of facial expression on the cuing effect (e.g. Galfano, Sarlo, Sassi, Munafo, Fuentes &

Umilta, 2011; Holmes, Mogg, Monje, Garcia, & Bradley, 2010; Bayliss, Frisehn, Fenske & Tipper, 2007). Therefore, it is possible that facial expression does not affect the magnitude of the cuing effect. However, given that previous studies have found cuing effects for emotion (Graham et al., 2010; Lassalle & Itier, 2015), this possibility seems unlikely. More recent work suggests that interactions between expressive cues and drug-related targets vary as a function of the drugs used as targets.

In a related study conducted by Graham (2014; Experiment 2), smokers did not have larger cuing effects for tobacco images cued by happy faces (versus control images), as expected. In spite of an overall main effect of validity, the cuing effect was only significant for targets validly cued by disgusted faces and validly cued control targets. A related study using images of alcohol as targets (Graham, 2014; Experiment 3) also yielded an overall main effect of validity; however, post hoc analyses revealed that the cuing effect was only significant for validly cued alcohol targets. A separate interaction between drinking frequency group (lighter vs. heavier social drinkers), cue expression, and target type was also observed, such that heavier social drinkers were faster to detect non-alcoholic targets cued by disgusted faces, and alcoholic targets cued by happy faces. This finding is consistent with the notion that heavier drinkers were forming cue-target associations that affected the cuing effect and this might not have been true of lighter drinkers. Furthermore, the cuing effect for happy cues/alcoholic targets decreased as QFI increased, possibly because cue/target expectations were more powerful in heavier social drinkers. Although these studies did provide evidence of complex interactions between drug use, cue expression, and target type, the exact results varied depending on the types of targets used (tobacco vs. alcohol), in spite of the fact that task parameters (e.g., cue duration, cue identity, cue expressions, SOAs) were otherwise identical across experiments and identical to those used in the current study. However, in the current study, no such interactions were observed. Although no ready explanation can be offered to reconcile these inconsistencies, taken together, these results underscore the sensitivity of the cuing effect to task parameters, especially the drug targets used across the different experiments.

In contrast to reaction times, response accuracy was influenced by cue facial expressions and marijuana/control targets, although effects failed to reach significance after Bonferroni-correction. Specifically, an interaction between validity, happy expressive faces, and control target type was observed for response accuracy. Post hoc analyses revealed that this interaction was driven by accuracy to identify targets cued by happy face cues, such that response accuracy was lower for validly cued control targets versus invalidly cued control targets, but only when these were preceded by happy expressive cues. Similar results were found by Bayless, Shuch, and Tipper (2010). Researchers found a marginally significant relationship for facial expression x validity, for happy expressive cues for RTs. This relationship was mitigated by a three-way interaction for happy expressive cues, validity, and subsequent targets. When happy cues were presented with pleasant targets, participant RT cuing-effects were faster than neutral cues. Alternatively, this effect was not found for disgusted faces presented with unpleasant, negatively valenced target stimuli.

Likewise, Pecchinenda and Petrucci (2016) investigated the modulating role of facial expression in gaze-cuing under cognitive load. Regardless of load task (high or low), happy expressive faces had significantly larger RT gaze-cuing effects. Response time cuing effects were larger for happy expressive cues than neutral and angry expressive cues. Likewise, happy cuing effects were not influenced by cognitive load. Alternatively, under high cognitive load, RT cuing effects were enhanced for angry faces, indicating exogenous attentional orienting. These behavioral findings may be indicative of the fact that happy facial expressions are processed more efficiently than other facial expressions. Previous research on the happiness superiority effect has shown that happy facial expressions are identified faster and more accurately than other expressions (e.g., Kirouac & Doré, 1983), are detected faster in visual searches (e.g., Becker, Anderson, Mortensen, Neufeld, & Neel, 2011), and are more emotionally salient than other facial expressions (e.g., Miyazawa & Iwasaki, 2010).

An alternative explanation is that happy expressive faces recruit more attentional processing resources. If this is the case, this could potentially interfere with processing for oncoming targets, leading to higher error rates. Participants may have been more likely to incorrectly identify oncoming targets as marijuana when they were invalidly cued. The notion that happy faces recruit more visual processing resources is supported by research conducted by Lassalle and Itier (2013). In a study investigating event-related potentials (ERPs) associated with the cuing effect, researchers found higher P1 amplitudes in response to happy expressive cues compared to angry ones. These physiological findings may indicate that happy face processing requires more attentional resources in comparison to other expressions, such as anger.

Another consideration may be that participants do not have strong enough attitudes about cannabis to elicit robust concept-association priming. Ambivalent attitudes towards marijuana may have prevented the formation of cue-target associations so that attitudes toward targets may not have been strong enough to influence reflexive attentional orienting. The potential role of ambivalence regarding marijuana will be discussed in subsequent sections.

Finally, it is worth noting that these results regarding target identification accuracy did not reach significance after Bonferroni-correction and may be further limited by ceiling effects in accuracy to identify marijuana/control targets. As mean response accuracy differences for invalidly cued control images (*M* = 93.25%; *SD* = 11.94) versus validly cued targets (*M* = 92.28%; *SD* = 11.94) were within 1%, results should be interpreted with caution. Furthermore, it is unknown whether differences in response accuracy were due to cue-target expectancies or inattention, although reaction times did not differ as a function of facial expression or target type. At this time, we are unable to distinguish between these two possibilities. For these reasons, future replication is necessary before any definitive conclusions can be made regarding the three-way interaction between validity, cue expression, and target type for accuracy observed in the current study.

**Attitudes**

A secondary aim of this study was to examine the relationship between direct self-reported attitudes and performance on gaze-cuing paradigms. A positive relationship was found between the gaze-cuing effect for disgusted cues with marijuana targets and positive attitudes. Results were counterintuitive, in that as participant attitudes towards marijuana were more positive, cuing effects for disgusted faces increased. There may be several explanations for these results. One plausible explanation for these findings may be that participants were ambivalent with respect to their opinions and attitudes about the subject of marijuana. If participants did not have strong enough opinions for or against marijuana, this would prevent the formation of cue/target expectancies. This possibility can be explored via participant responses to the 17-item self-report questionnaire. As the highest possible score was 75, and the lowest possible score was 15, participant mean scores was 57.99 (*range* = 27-74; *SD* = 9.68). Although this is trending towards more positive attitudes about marijuana, participant responses did not appear to be extremely polarized, with the exception of a few extreme outliers. Future studies may benefit from using samples with extremely positive and negative attitudes towards marijuana or using targets more likely to be associated with extremely positive or negative attitudes. For example, if extremely tabooed substances (such as heroin or methamphetamine) are used as targets, this may provide more insight into whether gaze-triggered attentional orienting is modulated by cue-target expectations and drug-related attitudes.

Another possibility could be that because marijuana is such a controversial subject and is still illegal in the state of Texas, participant associations may be formed based on the social culture surrounding marijuana rather than their own individual feelings about the drug. Therefore, regardless of how an individual may personally feel about marijuana, he or she could have negative associations with marijuana because of his/her perceptions about what others think about the drug. It is possible that the relationship between the magnitude of the gaze-cuing effect and marijuana-related attitudes for disgusted cues occurred because participants formed cue-target expectancies that reflected their perception of societal attitudes towards marijuana, not necessarily their own personal attitudes. Although implicit attitudes towards marijuana are understudied relative to other drugs like alcohol or tobacco, this idea receives some support from the results of Beraha et al. (2013) who found that among marijuana users, the amount of cannabis use was associated with stronger implicit negative associations using a marijuana-related IAT. These results were found in spite of the fact that heavy users had more positive attitudes towards marijuana relative to non-users. The finding of positive relationship between marijuana consumption and negative implicit attitudes gives rise to the possibility that heavy users may have internalized societal attitudes towards the drug, or perhaps feel guilty about their cannabis use and that these negative attitudes are affecting their responses on implicit tasks. The current study did not include information about actual marijuana use due to practical and ethical limitations; however, future studies that include information about participant marijuana use may help to confirm or eliminate this possibility.

Another consideration may be the identity of the individual displaying the gaze cue and facial expression. As gaze-cuing is a manifestation of joint attention, the identity of the individual cuing the observer may be another important methodological consideration in the design of gaze-cuing experiments. The importance of cue identity is supported by previous research by Liuzza et. al (2013). Electors were more likely to follow the gaze of candidates that they had stronger positive attitudes towards and the gaze-cuing effect was enhanced when cued by candidates that participants found more favorable. The cuing effect was positively correlated with IAT scores, indicating that participant responses were heavily influenced by implicit attitudes. Furthermore, the cuing effects elicited by different politicians were predictive of a participant's likelihood to vote for a particular candidate. In the current study, the cues were of the same Caucasian female, who was unknown to participants. Therefore, to further investigate if gaze-cuing paradigms are sensitive to the identity of the cue and that particular cue's attitudes towards marijuana, future research would benefit from manipulating the identity of the individual used as the gaze cue. For example, it may be informative to compare cuing effects for well-known public figures that have strong positive attitudes towards marijuana (e.g. Snoop Dogg) versus strong negative attitudes towards marijuana (e.g. Jeff Sessions).

Although further research is required, gaze-cuing paradigms using expressive cues and motivationally relevant targets may be sensitive to attitudes toward target objects. As such, these paradigms may have utility in understanding phenomena such as eating disorders, phobias, racial biases, and substance abuse/addiction.

**Limitations and Future Directions**

This study offers valuable insight into the factors that modulate gaze-triggered orienting, it is not without limitations. As this was the first study to investigate the relationship between gaze-triggered attentional orienting, expressive cues, marijuana/control targets, and implicit attitudes towards marijuana, there are many open questions and opportunities for future research.

One major limitation of the current study was that no scale exists to investigate explicit attitudes towards marijuana; therefore, a questionnaire had to be created to examine participant attitudes. In order to effectively establish a measure of attitudes, external validity, construct validity, and reliability must all be confirmed. The process of creating and validating scales requires time, large sample sizes, and other considerations, which were beyond the scope of the current study; therefore, the psychometric properties of the self-report questionnaire used are unknown. Further research in establishing a valid and reliable measure of marijuana-related attitudes is necessary to ensure that participant attitudes are being indexed veridically. A stronger understanding of participant attitudes towards marijuana will better inform future investigation of relationships between attitudes and gaze-cuing paradigms. Furthermore, for practical and ethical reasons, we were unable to examine participant use of marijuana. As participant use holds valuable insight to attitudes towards marijuana, this is a major limitation of this study. It would be informative to conduct this experiment for marijuana users versus non-users.

Future studies would also profit from utilizing physiological measures during a gaze-cuing task. Investigating neural correlates would inform researchers of underlying attentional processes in relation to behavioral data. As behavioral evidence may not demonstrate reflexive attentional orienting in its entirety, physiological evidence can detect effects (e.g. attentional capture) at a neural level before participant responses are made. For example, information regarding attentional resources for happy expressive cues was found by Lassalle and Itier (2013), despite the lack of behavioral evidence. Future studies using ERP methodology may help to shed light on outstanding questions regarding gaze and expression interactions beyond that provided by behavioral studies of gaze cuing. They may also assist in informing the neural dynamics of gaze cuing and the brain areas that might contribute to this process.

**Conclusion**

Understanding dynamic information is a crucial tool in social cognition. In this study, the influence of expressive faces, emotionally salient targets, and underlying attitudes on gaze-triggered attentional orienting were investigated. Gaze cuing effects were prominent for validly cued items, regardless of facial expression or target type. Response accuracy was influenced by happy expressive cues, when modulated by validly cued control images, suggesting that gaze-triggered attentional orienting can be sensitive to affective context. Likewise, findings demonstrated an unexpected relationship between disgust cuing effects and positive attitudes. No ready explanation can be offered for these findings, collectively, but it further contributes to the body of literature investigating this phenomenon. It also illustrates the demand for further research to better understanding of gaze-cuing determinants, such as task goals, facial expression, and emotionally valenced targets. Information provided in faces is rich and complex. Thus, translating joint attention in natural social settings to laboratory settings in an ecologically valid manner remains a challenge. Nonetheless, reflexive orienting triggered by eye-gaze appears to be influenced by emotionally salient contexts created by expressive faces and motivationally-relevant cues, but not in an obligatory fashion. The current study adds to a growing body of inconsistent findings regarding the sensitivity of gaze cuing to expressive faces and valenced targets, suggesting that the conditions under which these task dimensions interact is affected dramatically by subtle changes in task design and demands.

## APPENDIX SECTION

Attitudes Towards Marijuana Survey

To what extent do you agree or disagree with the following statements?

Strongly disagree   Somewhat disagree   Neither agree nor disagree   Somewhat agree

Strongly agree

Marijuana users have no common sense.

It's okay to use marijuana, as long as it's not everyday.

Smoking marijuana (pot) lets you have more fun.

Marijuana users are irresponsible.

Marijuana users cannot be trusted.

Marijuana users are immoral.

Using marijuana is acceptable in some situations.

People who use marijuana (pot) have more friends.

Smoking marijuana (pot) makes you look cool.

People become more creative or imaginative on marijuana.

Marijuana causes people to lose control and become careless.

Marijuana can make people angry and possibly violent.

Marijuana should be legalized for medicinal use.

Marijuana should be legalized for recreational use.

People risk harming themselves (physically or in other ways), if they smoke marijuana occasionally.

How wrong do you think it is for someone to use marijuana or pot?

In general, how common do you think it is for people to use marijuana?

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