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# Visual Attentional Orienting by Eye Gaze: A Meta-Analytic Review of the Gaze-Cueing Effect

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Given limitations in the amount of visual information that a person can simultaneously process through to conscious perception, selective visual attention is necessary. Visual signals in the environment aid this selection process by triggering reflexive shifts of covert attention to locations of potential importance. One such signal appears to be others' eye gaze. Indeed, a gaze-cueing effect, whereby healthy adults respond faster to targets that are presented at locations cued rather than miscued by eye gaze has been consistently observed in the empirical literature. Critically though, the influences of task and cue features on this effect are not well understood. To address this gap, we report a meta-analytic integration of 423 gaze-cueing effects using a multilevel approach. A gaze-cueing effect emerged across all levels of the assessed task and cue features, indicating that others' eye gaze reliably directs observers' attention. We found that the magnitude of the gaze-cueing effect was moderated by whether direct gaze cues preceded directional gaze cues or not; the cue-target stimulus onset asynchrony (SOA), whether participants had to detect, localize, or categorize targets; and the cue's facial expression. Whether or not the gaze cue remained on screen after the target appeared, and whether schematic faces, computer-generated faces, or images of real faces were used as cues, did not appear to reliably function as moderators. The theoretical implications of these findings are discussed, particularly in relation to the social attention system.

***Public Significance Statement***
The findings from this meta-analysis provide the strongest evidence to date that others' eye gaze is a powerful social cue that reliably directs observers to reflexively shift their own visual attention such that they engage in joint attention with the gazing person. The findings also provide insights into the specific circumstances in which this reflexive gaze-cued attention is enhanced.

*Keywords:* social attention, social perception, gaze-cueing, emotional expression, visual attention

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Due to limitations in the amount of visual information that can simultaneously and adequately be processed through to conscious perception, selective visual attention is a necessary mechanism of human visual cognition (see Desimone & Duncan, 1995). Ideally, an adaptive selective attention mechanism would use informative cues in the environment to guide attention to locations of potential importance. Attentional cueing paradigms have demonstrated that people tend to respond faster to peripheral targets that are cued rather than miscued by specific visual stimuli (Posner, 1980; Posner et al., 1980; Posner & Petersen, 1990). These findings are taken as evidence that visual cues do indeed trigger shifts in the allocation of our covert visual attention.

One cue of particular interest has been others' directional eye gaze. During social interaction, where others look is often highly

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informative (see Emery, 2000; Kleinke, 1986). So much so that extracting and using others' directional eye gaze cues to direct our own attention has been proposed to contribute to, and perhaps even subserve, a great number of higher order human behaviors including social cognition, coordinated action, and language acquisition (see Argyle & Cook, 1976; Baron-Cohen & Belmonte, 2005; Conty et al., 2016; Emery, 2000; Frith, 2008; Kobayashi & Kohshima, 2001; Tomasello, 1992). It is a reasonable proposition then that others' directional eye gaze might function as an adaptive cue to guide selective visual attention.

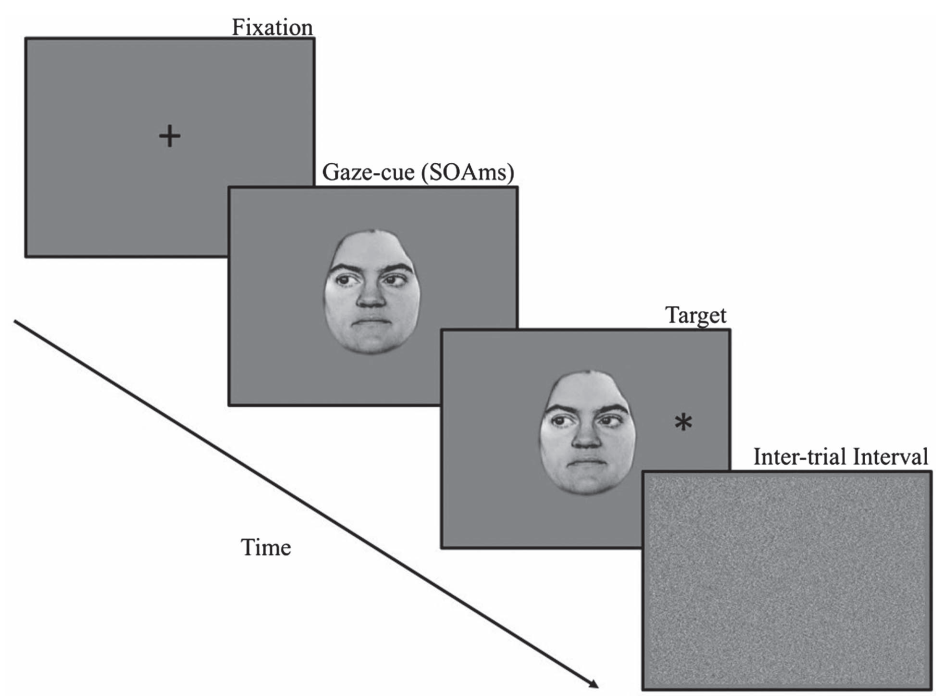
At present, a great deal of empirical support for this idea comes from the social attention literature. Healthy adults consistently exhibit what is termed a gaze-cueing effect, whereby they respond faster to targets that appear at locations that are cued rather than miscued by directional eye gaze (as in Driver et al.'s 1999 and Friesen & Kingstone's 1998 seminal gaze-cueing studies; see Frischen, Bayliss, et al., 2007 for an in-depth review). That is, observers typically respond faster to targets that are preceded by eye gaze stimuli that look directly toward the target (i.e., gaze-cued trials) than they do to targets that are preceded by eyes gaze stimuli that look directly away from the target (i.e., gaze-miscued trials; see Figure 1 for an illustration). Although this gaze-cueing effect appears to be robust, the effects of several task and cue feature variables are not well understood due to either a lack of investigation, or where there has been investigation, mixed findings.

This incomplete understanding of how the gaze-cueing effect might be influenced by specific task and cue features that has hindered theoretical progress in this literature, as it limits our capacity to make sense of seemingly disparate findings across individual studies. For example, Dalmaso, Castelli, et al. (2020) provides a detailed review of how the influence of emotional expression on gaze-cueing is difficult to interpret across the varying gaze-cueing paradigms that have been used. This is in addition to the obvious issue that our lack of understanding of how these features influence gaze-cueing prevents informed methodological decision-making.

This paper therefore reports the first meta-analytic integration of the gaze-cueing research literature. It was designed not only to provide a valuable point estimate of the average (aggregate) size of the gaze-cueing effect, but also to test whether specific task and cue features influence its magnitude. Because the gaze-cueing effect is a complex phenomenon, influenced by many different variables which themselves may potentially interact, we direct readers to excellent narrative summaries of this literature for a clearer understanding of these nuances (e.g., Dalmaso, Castelli, et al., 2020; Frischen, Bayliss, et al., 2007). The aim of this meta-analysis was to provide answers to base questions, collapsed across and controlling for those nuances. For example, there are mixed findings regarding the influence of specific facial expressions (Dalmaso, Castelli, et al., 2020). A question that can be addressed by pooling across individual study-level effects, as we do here, is whether moderating effects of specific emotional expression are robust when considered at an aggregate level. Given the complexity of gaze-cueing however, we encourage future meta-analyses to further build upon this work by providing more nuanced subanalyses once the literature has

**Figure 1**

*Example of a Trial Series in a Gaze-Cueing Task*




*Note*. The target, a black asterisk, appears at the location the directional gaze cue is looking away from, making this a gaze-miscued trial. The cue face is from the Facial Expressions of Emotions: Stimuli and Test (FEEST; Young et al., 2002) and has previously been used in gaze-cueing tasks (e.g., Slessor et al., 2008).

expanded to allow sufficient power to do so (and we have made the dataset for this meta-analysis publicly available to facilitate exactly this). Here, we detail the rationale behind each analysis we conducted in this initial, foundational meta-analysis.

## Variation Across Gaze-Cueing Paradigms: The Role of Prior Direct Gaze, Gaze-Cue Offset Timing, Cue-Target Stimulus Onset Asynchrony, and Task Type

As illustrated in Figure 1, at a minimum, a standard gaze-cueing task presents at least a central directional gaze cue (i.e., any cue stimulus that shows averted gaze including schematic, computer-generated, and real-face images, animations, or films) followed by a peripheral target. Four key task parameters vary substantially across gaze-cueing tasks: whether prior direct gaze is presented, gaze-cue offset timing, the length of time between the presentation of the cue stimulus and the target stimulus (i.e., the cue-target stimulus onset asynchrony, referred to as the SOA), and task type.

### *Prior Direct Gaze*

In some gaze-cueing tasks a direct-gaze pre-cue—the same face with eyes facing forward—is presented immediately before every directional gaze cue (e.g., as in Bayliss & Tipper, 2006; Cui et al., 2014; Dawel et al., 2015). In others, there is no such prior direct gaze cue (e.g., as in Bailey et al., 2014; Friesen & Kingstone, 1998; Hietanen & Leppänen, 2003). Although direct gaze has been shown to be a powerful moderator of many aspects of perceivers' social perception, visual attention, and behavior (e.g., Doi & Shinohara, 2013; Hietanen et al., 2018; Kaisler & Leder, 2016; Macrae et al., 2002; Mason et al., 2004, 2005; Wang & Apperly, 2017; Zhou et al., 2018; see Conty et al., 2016; Kleinke, 1986; Senju & Johnson, 2009, for reviews), the role of direct gaze in potentially modulating the gaze-cueing effect has been overlooked.

This is a surprising omission given (a) the inherent relationship between direct and averted gaze, two social visual cues that typically co-occur within everyday interpersonal interaction, and (b) the previously highlighted importance of direct gaze within the broader social attention literature. Senju and Johnson's (2009) fast-track modulator model proposes that direct gaze is a powerful social cue that enhances social perceptual and cognitive processes. According to this theoretical model then, a complete understanding of the influence of others' averted gaze on attention would need to account for the possible influence of direct gaze on gaze-cued attention.

Manipulation of prior direct gaze within existing studies is scarce or absent. Heimler et al. (2015) varied their pre-cues within participants. In their study, on half of the trials, the cue that preceded the gaze cue was the same face with direct gaze. On the other half of the trials, the cues that preceded the gaze cue was the same face with eyes closed. These researchers used this manipulation to assess whether the presence of visual motion in the gaze cue modulates the gaze-cueing effect for deaf adults. They reported that this pre-cue condition factor did not moderate gaze-cueing for either deaf or nondeaf adults. Hietanen and Leppänen (2003, Study 6) also manipulated this direct gaze pre-cue factor. In one gaze-cueing task, a face with direct gaze preceded the same face with averted gaze. In a second gaze-cueing task, completed by the same participants, only the face with averted gaze was presented. Similarly to Heimler et al. (2015), they reported finding no difference in the size of the gaze-cueing effect between these tasks. One study (Xu et al., 2018) manipulated prior direct gaze in a gaze-cueing task with the aim of assessing its influence in healthy adults. They found that prior direct gaze enhanced gaze-cued attention but only when the prior direct gaze was presented supraliminally. We did not identify any other studies that manipulated prior direct gaze. Given the strong theoretical grounds to expect gaze-cueing effects to differ when direct-gaze pre-cues are present versus absent however (i.e., in line with Senju & Johnson's fast-track modulator model), further systematic investigation of this question is needed.

### *Gaze Cue Offset Timing*

In some gaze-cueing tasks, the directional gaze cue remains on screen after the target has been presented (e.g., as in Gregory & Jackson, 2021; Law et al., 2010; Tipples, 2005). In other gaze-cueing tasks, the directional gaze cue offsets either at the same time as or before the target onsets (e.g., as in Deaner et al., 2007; McCrackin & Itier, 2020; Yoshizaki & Kato, 2011). We refer to this variable as the gaze cue offset timing. Within the broader attention literature, it is well established that attention can be captured by and consequently focused toward abruptly onsetting as well as offsetting visual stimuli (Chastain & Cheal, 1999; Theeuwes, 1991). When the gaze cue stimulus offsets before the target onsets this may therefore function as a cue that reallocates attention shifted to the gazed-at-location (i.e., via the gaze cue stimulus) back to the central fixation; thereby, disrupting gaze-cued attention. In other words, the sudden offset of the gaze cue stimulus might disturb the attentional process that results in the gaze-cueing effect. As such, it is important to assess whether the magnitude of gaze-cueing effects is affected by gaze cue offset timing.

### *Cue-Target Stimulus Onset Asynchrony*

The SOAs used varies considerably across gaze-cueing tasks with studies ranging in SOA from 14 ms to 2,500 ms (see Supplemental Appendix A). Variation in the gaze-cueing effect's magnitude across SOA, referred to as its timecourse, has been thought to speak to whether the gaze-cueing effect occurs automatically (i.e., that it is mandatory and not consciously produced) or volitionally (i.e., that it is consciously produced and context-dependent; in line with broad ideas of what constitutes an automatic effect; see Bargh et al., 2012; Jonides et al., 1985). To this end, the timecourse of the gaze-cueing effect can be compared to the timecourse of the peripheral-cueing effect (the tendency for people to respond faster to targets that are presented at locations where a visually salient cue such as a flash of light has just occurred, as in Posner, 1980). Because the peripheral-cueing effect is generally considered to be automatic, it has been suggested that if the gaze-cueing effect is likewise automatic, its behavioral and neural timecourse should be the same as that of the peripheral-cueing effect's (see Chanon & Hopfinger, 2011; Hietanen et al., 2006, 2008; and see Frischen, Bayliss, et al., 2007; Greene, 2010; Nagata et al., 2012 for more detailed overviews).

The peripheral-cueing effect is thought to emerge and then attenuate early (i.e., by 200 ms and 600 ms SOAs, respectively) and then reverse (i.e., by about 800 ms). This reversal is thought to reflect an inhibition of return (IOR) effect where, because reflexive attention has already been deployed to and then shifted away from the gazed-at location by the time the target onsets, the initial orienting effect to the peripheral cue does not emerge in the reaction times (see Klein, 2000; Posner et al., 1985). At present, although several studies show that the gaze-cueing effect appears to emerge very early (i.e., preconsciously; Bailey et al., 2014; Hietanen & Leppänen, 2003; Sato et al., 2007; Uono et al., 2018), and attenuate later than the peripheral-cueing effect (see Frischen, Smilek, et al., 2007); the timecourse of the gaze-cueing effect is unclear due to the complexity and amount of data across the literature. A quantitative synthesis is therefore needed.

### Task Type

The specific response task that participants are asked to perform also varies across gaze-cueing tasks: some require participants to complete a detection task in which they have to determine as quickly as possible that the target has appeared (e.g., as in Akiyama et al., 2007; Dalmaso et al., 2013; Graham et al., 2010); while, in others, participants complete a localization task in which they have to determine the location of the target as quickly and as accurately as possible (e.g., as in Carlson, 2016; Chanon & Hopfinger, 2011; Friesen & Kingstone, 2003). In other experiments still, participants complete a categorization task in which they have to determine the category membership of the target as quickly and as accurately as possible (e.g., as in Alwall et al., 2010; Fichtenholtz et al., 2009; Marotta et al., 2012). It has previously been suggested within the broader attention literature that such task type variations should influence the magnitude of attentional cueing effects. Of note, Posner (1980) argued that increases in task difficulty should result in reduced automatic attentional cueing effects via a zero-sum phenomenon, whereby the resources required for attentional orienting are hijacked and redirected toward task implementation.

Here, a particularly critical aspect of these reaction time tasks that has previously been overlooked is the number of stimulus-response associations that need to be held in working memory to successfully complete each task. This number differs systematically as a function of task type, with working memory demands increasing from detection tasks (wherein one target and one response key are to be remembered) through to localization tasks (wherein one target, two response keys, and the correct response-key-to-target-location mapping are to be remembered) through to categorization tasks (wherein two targets, two response keys, and the correct response-key-to-target mapping are to be remembered). A reasonable suggestion then is that *task difficulty* also increases from detection to localization to categorization tasks. In line with this suggestion, a main effect of task type, such that overall response times were fastest for detection followed by localization followed by categorization tasks, emerged in the only gaze-cueing study to date to have one set of participants complete all three reaction time tasks (Friesen & Kingstone, 1998). Given then that there is both theoretical and empirical support for the possibility that task type may modulate gaze-cueing effects, the influence of task type on the gaze-cueing effect should be further investigated.

## Variation Across Gaze-Cues: The Role of Face Type, Emotional Versus Neutral Expression and Specific Emotional Expression

Gaze-cueing tasks also vary substantially as a function of three key gaze cue features: face type, whether the expression is emotional or neutral, and if the expression is emotional, the *specific* emotional expression.

### Face Type

Gaze cues vary according to whether they are schematic line drawings of faces (e.g., as in Dodd et al., 2011; Friesen & Kingstone, 1998; Gayzur et al., 2014), computer-generated faces (e.g., as in Kuhn et al., 2016; Tipples, 2005; Weisbuch et al., 2017), or images of real faces (e.g., as in Holmes et al., 2010; Slessor et al., 2010; Yan et al., 2016). This face type variable is another aspect of gaze-cueing tasks that has been surprisingly overlooked in prior gaze-cueing literature. As illustrated in Figure 2, across this variable, gaze cue stimuli clearly vary in their degree of similarity to an actual human face, and thus their ecological validity, from schematic faces (least ecologically valid), through to computer-generated faces (intermediate ecological validity), through to images or videos of real human faces (most ecologically valid).

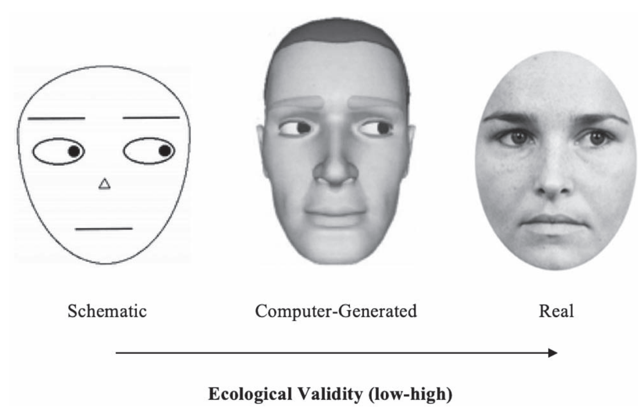
Within the broader social cognition literature, manipulation of ecological validity is considered critical to establishing whether an effect is restricted to highly controlled laboratory tasks and stimuli, or whether it is likely to generalize to real-life settings (Risko et al., 2012; Skarratt et al., 2012). At present, owing to a lack of research, it is not clear whether gaze-cueing effects do differ as a function of cue ecological validity, although in one notable early study, a larger gaze-cueing effect emerged when images of schematic rather than real faces were used as cues (see Hietanen & Leppänen, 2003). Yet while this study has subsequently been cited as evidence that gaze-cueing effects may not generalize to real-life (Risko et al., 2012), this finding has not yet been replicated conceptually or otherwise and therefore warrants further investigation.

### Facial Expression

When a real face image is used as the gaze cue stimulus, it can hold either a neutral or an emotional expression (i.e., any non-neutral facial expression). Given the strong motivation we hold as a

**Figure 2**

*Examples of Face Types Used in Gaze-Cueing Tasks Illustrating Their Variation in Ecological Validity*




*Note*. Faces were reproduced from Hietanen and Leppänen (2003), Tipples (2005), and Dawel et al. (2015), respectively. The real face image was originally from the Radboud Faces Database (Langer et al., 2010).

species to connect socially with others, we are highly motivated to understand their mental states (Emery, 2000). Clearly, relative to neutral expressions, emotional expressions present more detailed and therefore more useful cues to others' mental states. This predicts that humans should pay more attention to locations gazed-at with an emotional expression relative to those gazed-at with a neutral expression.

The specific type of facial expression is also likely to be an important determinant of attentional focus (e.g., whether the gaze cue stimulus holds an angry expression, a sad expression, or a happy expression). Social perception during real interpersonal interaction requires recognizing and appropriately responding to multiple co-occurring social cues including gaze direction and facial expressions. Within the broader social perception literature, these two cue types have previously been observed to mutually influence one another (Adams & Kleck, 2003; Adams & Kleck, 2005; Bindemann et al., 2008; Doi & Shinohara, 2013; Ganel et al., 2005; Lobmaier et al., 2008), suggesting then that emotional expression is a likely moderator of the gaze-cueing effect.

Indeed, from a theoretical perspective, there are compelling grounds for predicting that expression type may modulate gaze-cueing effects because the potential rewards associated with following gaze differs meaningfully as a function of emotion type. For instance, those who follow fearful gaze may be alerted to physical threat, those who follow happy gaze to food, those who follow disgusted gaze to something to be avoided for the sake of maintaining good health, those who follow sad gaze to a conspecific in need, and so forth. Following others' gaze clearly serves different purposes as a direct function of the gazer's emotional expression. Additionally, it is reasonable to suggest that, from an evolutionary perspective, the speed at which a person would need to orient their attention to the gazed at location to serve each purpose should also vary (i.e., with a potential threat warranting the fastest response; see Hadjikhani et al., 2008; Öhman & Mineka, 2001).

Individual studies that have attempted to assess whether emotional expressions affect the gaze-cueing effect have however identified mixed results (see Dalmaso, Castelli, et al., 2020 for a recent and detailed review). Thus, although several studies have uncovered modulation of gaze-cueing by emotional expression, the specific patterns of gaze-cueing effects across emotional expression have been mixed. To date, the greatest focus has been on the potential influence of fearful and happy emotional expressions. A stronger gaze-cueing effect has been identified for fearful faces in some studies (e.g., compared to happy faces in Putman et al., 2006; and neutral faces in Becker, 2010; Tipples, 2006; Uono, Sato, & Toichi, 2009). While some studies reported no gaze-cueing effect for happy expressions (Putman et al., 2006), others suggest that happy expressions produce weaker gaze-cueing than neutral expressions (Becker, 2010), and others still that happy gazing faces produce gaze-cueing effects equivalent to those produced by fearful gazing faces (Hietanen & Leppänen, 2003; Tipples, 2006).

In addition, other studies that manipulated emotional expression have not uncovered any modulation of gaze-cueing by emotional expression at all. Hietanen and Leppänen (2003) failed to identify any interaction of gaze cue validity and emotional expression among faces with happy, neutral, and angry expressions nor gaze cue validity and emotional expression among faces with happy, neutral, and fearful expressions, despite overall gaze-cueing effects emerging. Galfano et al. (2011) and Holmes et al. (2010) also did not find modulation of gaze-cueing effects by facial expression across real faces with a variety of emotional expressions (see Dalmaso, Castelli, et al., 2020 for more examples of studies finding null effects of facial expression). Taken together, despite the theoretical importance of this question, the pattern of gaze-cueing effects across specific emotional expressions remains unclear.

## The Present Study

The present study aimed to address the key gaps described above using meta-analytic methodology. To this end, we performed a meta-analysis of gaze-cueing effects and assessed for moderation of the magnitude of the gaze-cueing effect by (a) prior direct gaze; (b) gaze cue offset timing; (c) SOA; (d) task type; (e) face type; (f) whether emotional expression was used; and (g) when emotional expression was used, the specific emotional expression that was used.

## Hypotheses

All reported moderator analyses were planned and preregistered prior to being conducted (see https://bit.ly/32AJvox). Some analyses were associated with specified hypotheses and additional theoretical motivations, which are also detailed here. Given the strong theoretical basis for the existence of a gaze-cueing effect (i.e., the importance of eye gaze cues), we predicted that, overall a significant gaze-cueing effect would emerge. That is, collapsing across all samples, it was anticipated that responses to peripheral targets would be faster when eye gaze had cued rather than miscued the subsequent target location.

There were no a priori predictions regarding the potential influence of direct-gaze pre-cues, gaze cue offset timing, or task type. We did, however, have a priori suggestions regarding the pattern of the gaze-cueing effect across SOA. SOA was assessed as a continuous variable but also, to facilitate comparisons, as a categorical variable. The partitioning or categorizing of SOAs is a way to deal with the issue that skewness raises in the continuous moderator analysis (i.e., because more studies use shorter SOAs). That is, the categorization of SOAs allows a comparison of summary gaze-cueing effects across each category of SOA, such that potential differences that might be masked by skew observed in the continuous variable can be detected. It is therefore the case that while the continuous variable approach allows us to best determine *that* SOA is influencing the magnitude of the gaze cueing effect, it is the categorization approach that allows us to best interpret *where* the effect of SOA on gaze-cueing is emerging. For this reason, the categorical comparisons offer strong supporting insight into the pattern of the data through the data analysis techniques available within meta-analysis. We categorized SOAs up to and including 200 ms as early, SOAs from 201 to 400 ms as short, SOAs from 401 to 600 ms as medium, SOAs from 601 to 80 ms as long, and SOAs exceeding 800 ms as extended. These are not categories of SOA that explicitly exist in the literature, but rather categories we considered reasonable based on the general distribution of SOAs across published studies.

It was anticipated that the gaze-cueing effect would emerge for early, short, medium, and long SOAs but would be largest for short SOAs. This suggestion was based on event-related potential studies that show heightened neural processing at approximately 200 ms after observation of gaze-cue stimuli via face-selective components (see Itier & Batty, 2009 for a review). These components refer to specific time-constrained patterns of enhanced neural activity associated with the observation of faces or with the observation of eye gaze stimuli but not with the observation of other stimuli, such as the N170/M170 component which occurs 170 ms post stimulus onset. Soon after this (e.g., at 200 ms cue-target SOAs, allowing for orienting to occur), we therefore expected to observe the largest positive gaze-cueing effect. We suggested that for extended SOAs, there was the possibility that no gaze-cueing effect would emerge, or even that participants might be slower to respond to gaze-cued targets (i.e., based on the possibility of a classic IOR effect).

An anonymous reviewer suggested that findings from experimental studies that manipulated SOA have identified larger effects at 200–300 ms SOAs and that these therefore likewise support our hypothesis. Although this was suggested in an earlier review (Frischen et al., 2007), and is a commonly accepted view in this literature, we identified few findings supporting this suggestion. In one study (Bonato et al., 2009) SOAs of 200, 350, 550, and 800 ms were used. No overall gaze-cueing effect was found but an SOA by gaze-cue validity interaction was uncovered such that a gaze-cueing effect only emerged when 200 ms SOAs were used. In another study (Gregory & Jackson, 2021) SOAs of 150, 300, 500, 750, and 1,000 ms were used. They found that SOA influenced the magnitude of the gaze-cueing effect such that it did indeed peak at 300 ms SOA and gradually weakened thereafter.

We identified many more studies that did not find effects of SOA on gaze-cueing. In one of the earliest, Friesen and Kingstone (1998) found no effect of SOA on gaze-cueing using SOAs of 105, 300, 600, and 1,005 ms. Hietanen and Leppänen (2003) then reported no effect of SOA on gaze-cueing using SOAs of 200 and 600 ms. Although Tipples (2005) reported an SOA by gaze-cue validity interaction using SOAs of 300 and 700 ms, the pattern of gaze-cueing effect magnitudes over SOA was not reported (probably because the focus of the study was not to investigate the influence of SOA) and in a subsequent study (Tipples, 2006), that also used SOAs of 300 and 700 ms, they reported a failure to identify any gaze-cue validity by SOA interaction. Akiyama et al. (2006) also identified no effect of SOA on gaze-cueing effects in their healthy adult sample when using SOAs of 100, 300, and 700 ms. More recently, both Dalmaso et al. (2013) and Dalmaso, Castelli, Franchetti, et al. (2015) found no effect of SOA on gaze-cueing for healthy controls using SOAs of 200 and 700 ms and Langton et al. (2018) found no effect of SOA on gaze-cueing using SOAs of 125, 333, and 667 ms.

As noted earlier, we assessed moderation of the gaze-cueing effect with SOA entered as a continuous variable; however, because we did not initially anticipate using the multilevel approach that allowed this, we have no preregistered specific hypotheses regarding SOA as a continuous variable. This consideration noted, the results from the continuous SOA analysis provide a valuable supplement to the categorical SOA analysis and hopefully provide more nuanced answers. Together, our SOA analyses aim to provide a comprehensive picture of whether extant literature is supportive or nonsupportive of a moderating effect of SOA on gaze-cueing and insight into the timecourse of gaze-cueing across all available primary study data.

With respect to a potential moderating influence of face type, we noted that there are competing plausible, theoretically derived predictions regarding possible directional influence. On the one hand, due to the greater social relevance of gaze-cues embedded in images of real faces (i.e., their higher ecological validity and thus closer approximation to real-life social cues; see Itier et al., 2007; Itier & Batty, 2009; Risko et al., 2012; Skarratt et al., 2012 for overviews of ecological validity in social perception paradigms), real face images might be expected to produce larger cueing effects relative to more artificial schematic or computer-generated stimuli. However, given computer-generated and schematic stimuli are visually much simpler stimuli than real faces, we noted that the reverse effect might also be anticipated given simpler cues are extracted more efficiently (see Biederman, 1987). We further noted that, because schematic and real-face images are likely processed according to different timecourses (i.e., due to their differing visual complexity; see Biederman, 1987), a moderating effect of face type may depend on SOA. We therefore planned to conduct an exploratory moderator analysis of schematic versus real face images at each level of SOA.

Finally, specific directional predictions were made regarding the influences of cue facial expression on the gaze-cueing effect. We hypothesized that, as discussed earlier, given humans are highly motivated to understand the mental states of others (Emery, 2000) and facial emotional expressions communicate more information about others' mental states than neutral expressions, locations gazed at with an emotional expression would produce larger cueing effects relative to those gazed at with a neutral expression. We also hypothesized that, as discussed earlier, there would be variation in gaze-cueing effect sizes across specific emotional expressions. We considered that locations gazed at with threat-related facial emotional expressions (i.e., fear or anger) would produce larger cueing effects relative to those gazed at with any other facial emotional expression given they signal the location of potentially threatening stimuli in the environment and thus have a higher survival relevance (similar predictions have been made in the broader visual attention literature; see Hadjikhani et al., 2008; Öhman & Mineka, 2001).

# Method

## Exclusion and Inclusion Criteria

For transparency, the specific reason associated with the exclusion of each study that was full text reviewed but not included in the meta-analysis is detailed in Supplemental 1. Papers that were not available in English, did not report unique data from an experiment, or did not test a sample of healthy adult (17 years and older) human participants were excluded. If the same dataset was reported in multiple experiments, the experiment with the highest number of participants was used. If the number of participants was equal in experiments reported more than once, the first published experiment was used. If a sample was selected to have specific subclinical traits as a proxy for assessing a clinical group, this sample was not considered representative of healthy adults and was, therefore, excluded. We chose to exclude children because our aim was to assess the task and cue feature moderators of the gaze-cueing effect rather than the developmental trajectory of the effect or the influence of individual differences.

To be eligible for inclusion in the meta-analysis the gaze-cueing task had to be administered via a computer either directly or via a mirror, each participant had to have been presented with an equal number of gaze-cued and gaze-miscued trials, and participants could not have been completing any other concurrent task during the gaze-cueing task (for instance, a visual or verbal memory task). Only one gaze cue stimulus could be presented at any time, and it must have been an image, a series of images, or a video of a face or pair of eyes, such that, both eyes had gazed left or both eyes had gazed right, embedded in an upright and forward-facing schematic human, computer-generated human, humanoid robot, or real human face. Gaze cues had to have been centrally presented and must not have been manipulated in such a way as to interfere with their recognition as human eyes (for instance, by manipulating the proportion of white sclera to dark pupil and iris).

Targets had to have been presented in the center periphery and could only appear at cued and miscued locations. Responses must have been made manually via a keypress. This is because the gaze-cueing task is not supposed to measure overt gaze movement but rather where attention is prioritized within the visual field. Studies were excluded if there was a manipulated or meaningful preexisting relationship between participants and either the cue or target stimuli. If there was either some task parameter that systematically varied with gaze-cue validity or all authors on this paper agreed that the methodology of the primary study in some way seriously undermined the validity of the gaze-cueing paradigm the study was excluded. Finally, the minimum required data for effect size calculation—the condition means and standard deviations for gaze-cued and gaze-miscued trials—had to be reported or made available upon request. If the required data were not available and the experiment was published in 2005 or later, we contacted the corresponding author with a request for the required data. We set this cutoff a priori, under the assumption that data would not be available for studies published more than 15 years ago.

## Search Strategy

A multistep search strategy was used with the aim of identifying all studies that included gaze-cueing tasks. In April 2020, we conducted title and abstract searches of Web of Science, PsycINFO, PUBMED, Scopus, and ProQuest Dissertations and Theses Global electronic databases to retrieve all citations with *social* and *gaz** and *cue** or *cuing* or *follow** or *direction** or *perce** or *orient** in their title or abstract. We excluded any citations with *ophthalmol** in their title or abstract because gaze orienting and following is commonly referred to in the entirely distinct ophthalmology literature. We limited searches to citations published in English in 1990 or later. Given the first gaze-cueing studies were published in the late 1990s (i.e., Driver et al., 1999; Friesen & Kingstone, 1998), this ensured a more than adequate coverage of the time span of the relevant literature. To supplement these database searches, we conducted systematic backward (searches of the works cited by the paper) and forward (searches of the works citing the paper) citation searches on relevant reviews. Specifically, Dalmaso, Castelli, et al. (2020) and Frischen, Bayliss, et al. (2007) were used. These were particularly useful for our purpose given Dalmaso et al.'s review was recently published and Frischen et al.'s review is very highly cited in the field. Using these strategies, we uncovered 10,549 citations. An additional five were later identified during the process of emailing requests for data. Duplicates were automatically removed upon the citations being uploaded to Covidence (https://support.covidence.org/help/how-can-i-cite-covidence), leaving 5,627 citations to be screened along with the five additional citations.

## Study Selection

The study selection procedure is illustrated in a flow diagram (see Figure 3). In line with Cochrane recommendations (Higgins et al., 2019), to reduce the chance of eligible studies being excluded by mistake, we duplicated the abstract screening procedure. The first author and second author each read each abstract in full and made an exclusion/inclusion decision. If both screeners recommended exclusion, the citation was excluded as irrelevant. If both screeners recommended inclusion, the citation was sent to full text review. If at least one screener did not recommend exclusion, the abstract was discussed until a mutual decision regarding whether the citation should be sent to full text review was made. If a decision could not be made, the last author was consulted, and their decision was used. We always erred on the side of cautious inclusiveness. Of the 5,632 citations screened, 5,315 were excluded at the abstract screening stage. This left 317 full texts to be screened for eligibility.

Full text review could not proceed for 12 citations that were not available as full texts or were not available in English. A further 15 were manually detected duplicate citations (i.e., not detected by the software because of a spelling error or some other discrepancy) and therefore removed. The first author downloaded and read the remaining 290 full texts and applied the exclusion/inclusion criteria to each. The first author sent any full texts requiring a second opinion to the second author who made an independent decision. If their decisions did not match, they had a discussion until consensus was reached. Consensus was reached for all full texts.

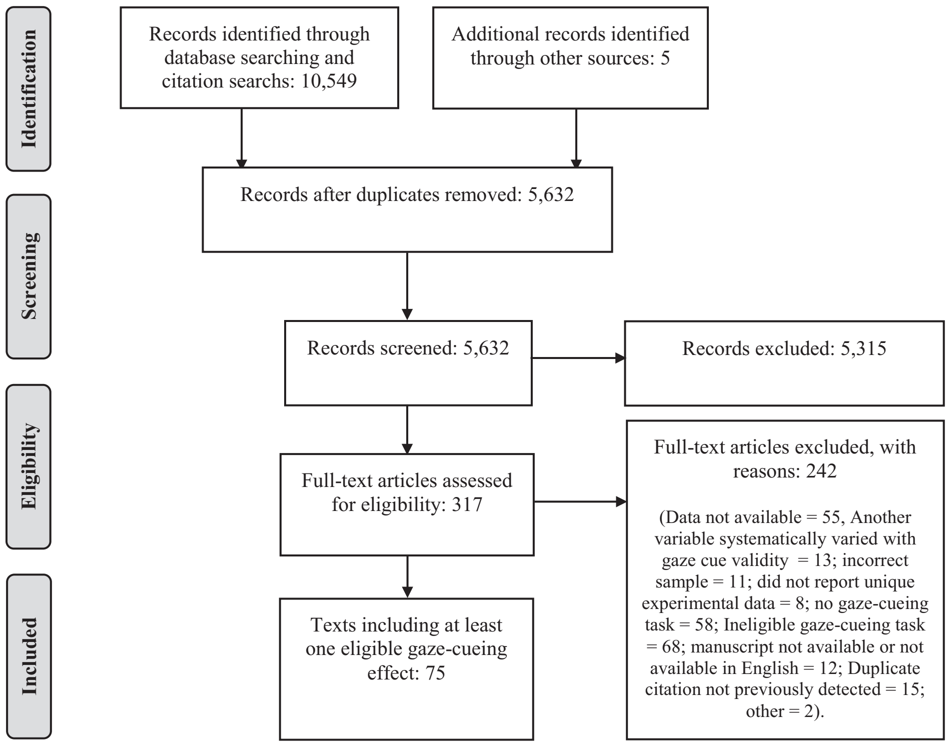
We determined that 58 of the full text articles or theses did not include any gaze-cueing task; eight did not report unique data from an experimental study; 11 did not include a sample of healthy adult participants; 68 did not include an eligible gaze-cueing task; 13 had another variable systematically vary with gaze cue validity; and two were excluded because we determined there was a reason the validity of the gaze-cueing effects associated with those studies may have been undermined (see Supplemental 1). Remaining full-text articles and theses proceeded to the data extraction stage. There, an additional 55 articles or theses were excluded because the minimum required data were not provided in text and either not available upon request or the study was published prior to 2005. In the end, 75 articles or theses were identified that reported at least one eligible gaze-cueing effect. A list of the citations associated with all included studies is provided within the reference list.

## Study Quality

The validity of a meta-analytic effect size depends on the validity of the contributing effect sizes. As it is difficult to objectively determine what constitutes a high-quality gaze-cueing study, recommended practice is to not complete a study quality assessment and to instead assess the influence of several potential moderator variables, as we report later (Valentine, 2009). However, to safeguard against the risk posed by study parameters to the validity of the meta-analytic effect sizes, we developed strict inclusion criteria to only include studies that unambiguously measured the gaze-cueing effect. As discussed later, we also conducted assessments for selective reporting and small study effects and found no evidence of these issues among the contributing effects.

**Figure 3**

*Flowchart Illustrating the Study Screening and Selection Process*




## Data Extraction

For each effect size emerging from an eligible gaze-cueing task, the first author extracted each of the task and cue characteristics to be assessed (namely, whether direct-gaze pre-cues were included or not; whether the gaze cue remained on screen with the target or not; the SOA used in milliseconds; the task type; the face type, and, for real faces, the cue expression) along with other variables including sample mean age and the number of female participants. For effect size calculation, the reported mean and standard deviation reaction times for gaze-cued and gaze-miscued trials were extracted along with the post-data-reduction sample size. Additionally, where available, the Pearson's bivariate correlation between gaze-cued and gaze-miscued trial reaction times was also extracted.

## Interrater Reliability

We initially planned to deal with the issue of statistical dependency between effect sizes by only extracting one aggregate gaze-cueing effect per sample but later decided to conduct a multi-level meta-analysis instead. Prior to that change, the third author independently coded and extracted data from a randomly selected subset of the samples included in the meta-analysis. Thirty percent of the then 112 total samples were duplicate coded (a comparable subset to that used in other meta-analyses with a similar total number of included experiments, e.g., Dargue et al., 2019; Kurdi et al., 2019). Because, at that time, we were planning to assess the influence of SOA and specific emotional expression in sub-analyses (i.e., to deal with the statistical dependency between effects produced by most gaze-cueing tasks using multiple SOAs and expressions), SOA and specific emotional expression were not coded as moderator variables and hence not double coded.

For each of the double-coded moderator variables, we calculated the percentage agreement, because this is a highly intuitive statistic, as well as the Cohen's kappa (κ) coefficient of agreement, which accounts for agreement by chance (Cohen, 1960) using the R package "irr" (Garner et al., 2019). We used the suggested interpretations of κ reported by McHugh (2012), that κs of 0.60–0.79 are moderate, 0.80–0.90 are strong, and 0.91–1.00 are almost perfect. We interpreted the percentage agreements subjectively because specific benchmarks for their interpretation have not been established (Orwin & Vevea, 2009). The first author assessed any disagreements and their final coding decisions were used for analyses. Table 1 provides the percentage agreement and Cohen's kappa coefficient for each variable. Percentage agreements ranged from 94.1% to 100% and the mean percentage agreement was 98.5%. We interpreted this as a very high level of agreement. Cohen's kappa coefficients ranged from .90 to 1 with a mean of .97, suggesting strong to almost perfect agreement. These results suggest we had a highly reliable coding system. As such, although we decided to conduct a multilevel meta-analysis and therefore had to recode at the effect size level rather than the sample level and code for two additional variables not coded at the sample level (SOA and specific expression), we feel justified in having only the first author complete the recoding.

## Statistical Approaches

All included gaze-cueing effect sizes are Cohen's $d$ standardized repeated-measures mean differences with Hedges's $g$ corrections for repeated-measures applied, hereafter referred to as $g_{\mathrm{rm}}$. We chose this

**Table 1**
*Interrater Agreement of Study Coding*

| Variable | Interrater agreement | |
|---|---|---|
| | % | κ |
| Prior direct gaze | 97.1 | .94*** |
| Gaze cue offset timing | 100 | 1*** |
| Task type | 94.1 | .90*** |
| Face type | 100 | 1*** |
| Neutral vs. emotional expression | 100 | 1*** |
| Publication status | 100 | 1*** |
| Overall mean | 98.5 | .97 |

*Note*. Interrater agreement was calculated using the data from the 30% of the initial 112 samples which were double coded. κ is Cohen's kappa, a measure of interrater reliability that accounts for agreement by chance.
*** $p < .001$.

effect size because it is recommended for repeated-measures mean difference effect size estimation (Lakens, 2013). We calculated the effect sizes and sampling variances using custom code in base R. We ensured the accuracy of the calculations by checking that the effect sizes and sampling variances produced by our R code were the same as the effect sizes and sampling variances produced using the software Comprehensive Meta-Analysis (Borenstein et al., 2013).

We calculated effect sizes such that a positive effect would indicate faster responses on gaze-cued compared to gaze-miscued trials (see Equation 1). Note that $i$ and $j$ were used to represent gaze-cued and gaze-miscued, respectively, as $c$ and $m$ have other common meanings in equations and that $d_{\mathrm{rm}}$ in Equation 2 is $g_{\mathrm{rm}}$ without the Hedges's $g$ correction (more information is provided in the annotated R-script). The corresponding estimated sampling variance associated with $g_{\mathrm{rm}}$ was calculated by squaring the standard error of $g_{\mathrm{rm}}$ (see Equation 2; as in Borenstein et al., 2009). For all analyses, primary study effect sizes were combined using a three-level multilevel meta-analysis using the rma.mv function within the R package "metafor" (Viechtbauer, 2010). This is the best approach available for use with statistically dependent effect sizes as it minimizes data loss and enhances the validity of statistical comparisons relative to the alternative aggregation methods previously used. Throughout the paper, we will be reporting the number of participants ($N$), the number of effect sizes ($ES$), and the number of independent samples ($k$) contributing to each analysis.

$$\text{Hedges's } g_{\mathrm{rm}} = \left(1 - \frac{3}{4df - 1}\right) \frac{M_i - M_j}{\sqrt{SD_i^2 + SD_j^2 - 2 \times r \times SD_i \times SD_j}} \sqrt{2(1-r)}, \tag{1}$$

$$\text{Sampling Variance } g_{rm} = \left(\left(1 - \frac{3}{4df - 1}\right) \sqrt{\left(\frac{1}{n} + \frac{d_{\mathrm{rm}}^2}{2n}\right)(2(1-r))}\right)^2. \tag{2}$$

The dataset had a multilevel structure such that effects comprising participant data were nested within samples (i.e., each sample contained one or more effect sizes and each effect size belonged to one and only one sample). To these data, we therefore applied a three-level random-effects meta-analytic model, modeling sampling variation (Level 1; i.e., variation attributable to participants), within-samples variation (Level 2; i.e., variation attributable to sets of effects sharing a common sample), and between-samples variation (Level 3; i.e., variation attributable to pooled sample effects). In other words, the three-level model—as opposed to the traditional two-level univariate model—further divided variance into that which could be attributed to between-sample variance and that which could be attributed to within-sample variance. For detailed information about the three-level multilevel meta-analysis model, including model equations, interested readers should consult relevant methodology papers (e.g., see Van den Noortgate et al., 2013). To address potential correlated sampling variance, robust variance estimation was performed on all three-level multilevel meta-analytic models produced in metafor using the R package "clubSandwich" (Pustejovsky, 2022).

Moderator analyses were conducted using the "metafor" package. Given it has previously been demonstrated that the Knapp–Hartung method (see Hartung & Knapp, 2001) produces lower Type I error rates than other meta-regression techniques (Viechtbauer et al., 2015), we initially aimed to apply a Knapp–Hartung correction to our analyses. This is however not yet available for a multilevel model. As an alternative, we used a $t$-distribution (using the tdist = TRUE command; see Assink & Wibbelink, 2016) rather than the default $z$-distribution given this provides similar results to the Knapp–Hartung method (see Harrer et al., 2021). Pairwise follow-up comparisons were conducted using the "clubSandwich" package. This uses robust variance estimates in its computations and provides an adjustment for small sample sizes. The small sample correction we used was "Naive-Fp" which returns an $F$ test with degrees of freedom equal to the number of unique samples minus the number of regression coefficients.

Because the correlations between gaze-cued and gaze-miscued trials, $r$ in (1) and (2), were only available for 62 effect sizes, we computed an estimate of the cued-miscued correlation using the available data and imputed this value where the cued-miscued correlation was missing. As in Rusz et al.'s (2020) meta-analysis that likewise investigated the mean difference in reaction times at two levels of a within-participants variable, we used a mean imputation method to resolve the problem of missing correlations. However, given the multilevel nature of our data, we conducted a three-level multilevel meta-analysis—as we did for the main analyses—on the 62 available Pearson's bivariate correlations and used this meta-analytic correlation estimate for imputation. These came from 23 samples comprising 840 participants. The meta-analysis revealed a point estimate for the correlation coefficient of $r$ = .92, 95% CI [.90, .94]. In the interest of precision, we rounded to six decimal places and used $r$ = .920169 for the imputation. This is a typical magnitude for a pre–post correlation (Estrada et al., 2019).

We assessed the moderating effect of each of the potential moderator variables in turn. Where omnibus moderation effects were significant or specific comparisons were planned, we conducted follow-up pairwise comparisons. For these, the pooled magnitudes of relevant subgroups of effect sizes were directly compared in additional meta-regression analyses. Although no correction for family-wise error was applied, we kept comparisons to the absolute minimum by only assessing pre-specified variables, and as mentioned above, we used the more conservative approach of using a $t$-distribution in our tests where possible.

To determine whether significant moderating effects remained after accounting for the variance attributable to the other coded-for task and cue features, multiple moderator analyses were conducted on the set of effect sizes for which all other moderator variables could be coded. Note that, for these multiple moderator analyses, SOA was entered as a continuous variable and expression was not included in the model because, given it could only be coded for a subset of effects (i.e., those associated with real face cues), its inclusion would result in a substantial loss of power. For all analyses where SOA was entered as a continuous variable it was mean-centered.

Studies that used a range of SOAs but only provided effect size data collapsed across SOAs were not excluded. Although they could not contribute to analyses where SOA was a moderator variable (i.e., because they could not be coded as a specific SOA), they were allowed to contribute to both the overall gaze-cueing effect and the analyses of other moderator variables. For the cue expression analyses, studies had to use real faces as cues and the expressions had to either be neutral or one of the six basic emotional expressions at full intensity (i.e., happy, sad, angry, surprised, fearful, disgusted; Ekman & Friesen, 1971). In other words, moderation by emotional expression was assessed using only the subgroup of effect sizes associated with gaze-cueing tasks that used real faces as cues. Given we found few eligible studies that used expressions other than happy and fearful, including more variation in expression type or intensity would have introduced variance we would not be able to explore.

## Transparency and Openness

We took several measures to ensure that our meta-analysis would be reproducible and that its quality would be easily assessable. We used the non-interventional, reproducible, and open (NIRO) preregistration guidelines for systematic reviews (Topor et al., 2020) and the PRISMA guidelines for conducting and reporting systematic reviews and meta-analyses (Moher et al., 2009) to inform our reporting. Additionally, we preregistered the study protocol including the aims, predictions, and methodological and analytic plans on the Open Science Framework (OSF; https://bit.ly/32AJvox). We also made all data and the full annotated analysis scripts available online via the OSF (https://bit.ly/3fpGCcK). All relevant information associated with each effect size is available within these files (i.e., all data included in the meta-analysis).

# Results

## Sample Description

Overall, 423 gaze-cueing effect sizes were extracted from 137 samples comprising 4,239 participants. Supplemental Appendix A provides a table that shows each effect size along with the sample and task characteristics associated with each. The post data reduction mean age was reported for 88 samples. The mean of these samples mean ages was 28.24 years; the median was 22.00 years. The post data reduction sex of participants was reported for 107 samples. Within these samples, there were 3,429 participants in total and all participants were reported as being either male or female. Of these participants, 2,163 (63.08%) were female. Thirty-nine effect sizes were from unpublished studies. The publication year of the papers and theses from which the remaining effect sizes were extracted ranged from 1998 to 2020 ($M$ = 2011, *Median* = 2013). With respect to where studies were conducted, samples were collected across the following continents: Asia ($k$ = 15); Australia ($k$ = 8); Europe ($k$ = 67); and North America ($k$ = 46). None were collected in Africa or South America. It was not possible to determine the country in which one study was conducted. Ethnicity/Race was seldom reported (see Supplemental Appendix A). A summary of the sample composition's sex and age at each level of each assessed moderator variable is provided within Table 2.

## Overall Effect

To establish the direction, significance, and magnitude of the overall gaze-cueing effect, we combined the 423 effect sizes in a three-level multilevel meta-analysis. This revealed a small but significant positive overall gaze-cueing effect $g_{\mathrm{rm}} = 0.26$, $SE = 0.02$, $t(134) = 14.40$, $p < .001$, 95% CI [0.22, 0.29]. Significant heterogeneity was detected among the included effect sizes, $Q(422) = 3316.71$, $p < .001$.

$I^2$ values provide the proportion of variance explained by each level of the model (i.e., the variance in gaze-cueing effects attributable to within- and between-samples heterogeneity). To calculate these values, we applied the variance functions within the "dmetar" package in R (Harrer et al., 2019) to the fitted rma.mv multilevel model. This revealed that the total variance attributable to heterogeneity was 90.25% comprising 18.82% that was attributable to within-sample and 71.43% that was attributable to variance between samples. This large amount of heterogeneity between samples provides a good foundation for assuming the gaze-cueing effect differs as a function of parameters that vary across tasks such as the cue-and task-features we planned to assess.

We assessed for potential outlying effect sizes by calculating standardized residuals, with scores exceeding ±2.24 regarded as extreme (Aguinis et al., 2013; Martin & Roberts, 2010). Because no statistical outliers were identified, all subsequent analyses were conducted on the full available data set.

## Moderator Analyses

Table 2 shows the meta-analytic $g_{\mathrm{rm}}$s calculated separately for each level of each of the categorical moderator variables along with relevant descriptive statistics including the number of participants, effects, and samples contributing to each variable's aggregate effect.

### *Prior Direct Gaze*

Whether direct-gaze pre-cues were present or not was coded for 421 effect sizes ($k$ = 136, $N$ = 4,218). The gaze-cueing effect was significant and positive both when direct-gaze pre-cues had been used and when they had not been used. However, prior direct gaze was found to be a significant moderator of the gaze-cueing effect, $F(1, 419) = 9.88$, $p = .002$, revealing that a larger gaze-cueing effect emerged when direct-gaze pre-cues had been used compared to when they had not been used. Significant heterogeneity remained after accounting for prior direct gaze, $QE(419) = 3071.36$, $p < .001$. The moderating effect of prior direct gaze remained significant in the multiple moderator model after controlling for the effects of gaze

**Table 2**
*Effect Sizes for Each Level of Each Categorical Moderator Variable*

| Variable | $N$ | Proportion of female participants | Mean sample age | $ES$ | $k$ | $g_{rm}$ | $SE$ | $t$ | $p$ | 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|
| Prior direct gaze | | | | | | | | | | |
| Yes | 2,729 | 62.84% | 24.77 | 238 | 85 | 0.31 | 0.03 | 11.60 | <.001 | [0.26, 0.36] |
| No | 1,560 | 63.51% | 35.29 | 183 | 53 | 0.17 | 0.01 | 13.80 | <.001 | [0.15, 0.20] |
| Gaze cue remains after target onset | | | | | | | | | | |
| Yes | 2,739 | 65.63% | 27.90 | 253 | 90 | 0.24 | 0.02 | 13.70 | <.001 | [0.20, 0.27] |
| No | 1,265 | 58.63% | 28.99 | 147 | 42 | 0.31 | 0.04 | 7.11 | <.001 | [0.22, 0.40] |
| SOA | | | | | | | | | | |
| Early | 2,430 | 62.34% | 29.44 | 148 | 76 | 0.27 | 0.03 | 9.61 | <.001 | [0.22, 0.33] |
| Short | 1,466 | 76.11% | 27.37 | 73 | 43 | 0.25 | 0.03 | 8.61 | <.001 | [0.19, 0.30] |
| Medium | 1,552 | 55.72% | 30.72 | 83 | 47 | 0.27 | 0.03 | 9.45 | <.001 | [0.21, 0.32] |
| Long | 779 | 78.46% | 21.00 | 39 | 26 | 0.21 | 0.03 | 6.67 | <.001 | [0.14, 0.27] |
| Extended | 766 | NA[a] | NA[b] | 35 | 26 | 0.07 | 0.01 | 5.05 | <.001 | [0.04, 0.10] |
| Task | | | | | | | | | | |
| Detection | 856 | 57.22% | 29.65 | 124 | 32 | 0.20 | 0.02 | 11.30 | <.001 | [0.16, 0.24] |
| Localization | 2,138 | 60.65% | 30.12 | 194 | 65 | 0.34 | 0.03 | 10.60 | <.001 | [0.28, 0.40] |
| Categorization | 1,293 | 72.38% | 23.69 | 105 | 42 | 0.17 | 0.02 | 9.12 | <.001 | [0.13, 0.20] |
| Face type | | | | | | | | | | |
| Schematic | 1,095 | 65.12% | 36.24 | 118 | 36 | 0.17 | 0.01 | 12.20 | <.001 | [0.14, 0.20] |
| Computer-generated | 713 | 59.56% | 24.02 | 53 | 25 | 0.27 | 0.04 | 7.34 | <.001 | [0.19, 0.35] |
| Real face image | 2,331 | 63.18% | 25.60 | 246 | 74 | 0.29 | 0.03 | 9.66 | <.001 | [0.23, 0.35] |
| Expression | | | | | | | | | | |
| Neutral | 1,759 | 63.65% | 29.22 | 108 | 56 | 0.25 | 0.03 | 8.11 | <.001 | [0.19, 0.31] |
| Any Emotion | 1,220 | 62.70% | 22.64 | 121 | 34 | 0.38 | 0.05 | 8.33 | <.001 | [0.28, 0.47] |
| Happy | 891 | 67.81% | 24.71 | 50 | 25 | 0.30 | 0.04 | 6.81 | <.001 | [0.21, 0.39] |
| Angry | 195 | 100.00% | 21.60 | 9 | 4 | 0.17 | 0.02 | 11.40 | .007 | [0.11, 0.23] |
| Disgusted | 50 | NA[a] | NA[b] | 3 | 2 | 0.49 | 0.21 | 2.35 | .256 | [−2.15, 3.13] |
| Fearful | 1,153 | 54.39% | 21.80 | 59 | 31 | 0.43 | 0.05 | 7.89 | <.001 | [0.32, 0.54] |

*Note*. SOA = stimulus onset asynchrony. A positive effect size indicates faster responding on gaze-cued compared to gaze-miscued trials. Participant Mean Sample Age is given in years. The mean sample age refers to the mean of the mean sample ages that were extracted. *ES* is the number of effect sizes. *k* is the number of samples. The proportion of female participants and participant age were calculated with missing data removed. None of the coded effect sizes used sad or surprised faces as cues.
[a] No samples reported postdata reduction sex. [b] No samples reported postdata reduction age.

cue offset timing, SOA, task type, and face type, $t(346) = 3.43$, $p < .001$—again revealing larger gaze-cueing effects when direct-gaze pre-cues had been used compared to when they had not been used.

## Gaze Cue Offset Timing

Whether gaze cues had remained on screen after the target onset or not was coded for 400 effect sizes ($k = 130$, $N = 3{,}978$). This gaze cue offset timing variable was not found to be a significant moderator of the gaze-cueing effect, $F(1, 398) = 2.44$, $p = .119$. The gaze-cueing effect was significant and positive both when the gaze cues had remained on the screen after the target onset and when they had not. Significant heterogeneity remained after accounting for gaze cue offset timing, $QE(398) = 3058.06$, $p < .001$.

## Stimulus Onset Asynchrony

We were able to include 378 effect sizes ($k = 120$ samples, $N = 3{,}792$), with associated SOAs ranging from 14 ms up to 2,500 ms. Figure 4 is given as a visualization aide. It shows the distribution of gaze-cueing effects at each SOA level.

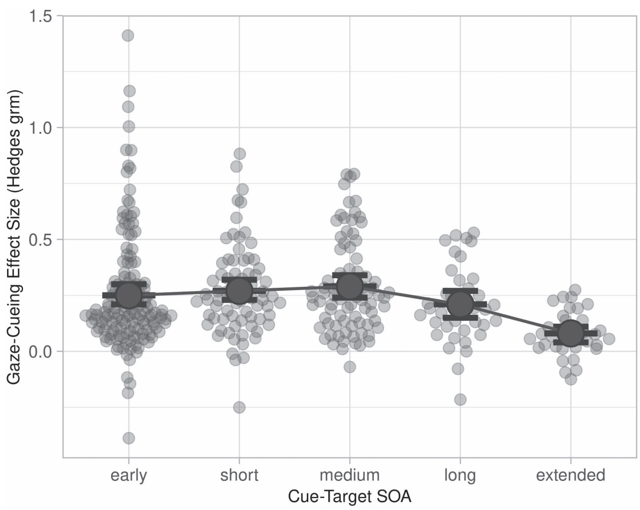
We first assessed the influence of SOA as a continuous variable. A significant moderating effect of SOA was detected, $F(1, 376) = 17.11$, $p < .001$ such that as SOA increased, the magnitude of the gaze-cueing effect decreased. Significant heterogeneity remained to be explained by other moderator variables, $QE(376) = 3089.49$, $p < .001$. We also found that the gaze-cueing effect decreased as SOA increased in the multiple moderator model, $t(346) = 4.44$, $p < .001$, where the effects of prior direct gaze, gaze cue offset timing, task type, and face type were controlled. It should be noted that the continuous SOA variable was right skewed (*skewness* = 1.75, *mean* = 412.59, *median* = 300.00) indicating that short SOAs were more commonly chosen within experiments. It is possible this may have influenced the results of the continuous variable analysis.

To gain a more nuanced picture of the magnitude of the gaze-cueing effect across SOA, we partitioned SOA into five levels and performed comparisons. Consistent with the a priori categories defined in the preregistration, we categorized SOAs up to and including 200 ms as early, SOAs from 201 to 400 ms as short, SOAs from 401 to 600 ms as medium, SOAs from 601 to 800 ms as long, and SOAs exceeding 800 ms as extended. A significant omnibus moderating effect of SOA on the gaze-cueing effect emerged, $F(4, 373) = 10.31$, $p < .001$.

The gaze-cueing effect was significantly smaller for extended SOAs compared to all other SOA groups: that is, the effect for extended SOAs was smaller compared to early, short, medium, and long SOAs, $Fs(1, 115) > 12.45$, $ps < .001$. Overall, these results suggest that after 800 ms SOA the gaze-cueing effect is reduced in magnitude. Supporting this, the initial overall moderation effect of the gaze-cueing effect by SOA as a continuous variable disappeared when effects with extended SOAs were removed, $F(1, 341) = 0.56$, $p = .456$. The pairwise comparisons also revealed that there

**Figure 4**

*Hedges's $g_{rm}$ Gaze-Cueing Effect Sizes Grouped by Categorical SOA, Showing the Arithmetic Mean Effect Size Within Each Group*




*Note.* A positive effect size indicates faster responding on gaze-cued compared to gaze-miscued trials. Error Bars are the 95% Confidence Interval around the mean of the group specific set of effect sizes. Graph created using SuperPlotsOfData (Goedhart, 2021).

were significant differences between early SOAs and all other SOA groups, $F$s(1, 115) > 31.43, $p$s < .001. According to the meta-analytic effect sizes (see Table 2) this was such that the gaze-cueing effect was larger for early compared to short, medium, and long SOAs; however, the effect sizes are notably similar in magnitude so this possible difference should be further explored in future research. No other comparisons were significant, $F$s(1, 115) < 2.95, $p$s > .088.

**Test of a Quadratic Trend for SOA.** As stated, we were interested in the relationship between the SOA chosen by experimenters and the magnitude of the ensuing gaze-cueing effect. Visual inspection of the SOA values against effect sizes (Figure 4) suggested that should a relationship between SOA and effect size exist, it may not be linear. We therefore re-ran the metaregression analysis including an additional quadratic SOA term (i.e., $SOA^2$). This revealed that there was a significant omnibus moderating effect of SOA on effect size magnitude when including all eligible effect sizes across the entire SOA range, $F(2, 375) = 10.19$, $p < .001$.

By inspecting the fit statistics for each model, we were able to determine statistically that the meta-analytic model with only the linear term (Akaike's information criterion; AIC = −246.67, Bayesian information criterion; BIC = −230.95) had a better fit to the data than the meta-analytic model with the added quadratic term (AIC = −246.00, BIC = −226.37) as indicated by its lower AIC and BIC fit statistics. Considering the quadratic model had an extra parameter and is also consequently less parsimonious than the linear model, we decided to retain the linear term for SOA in subsequent analyses.

## Task Type

Task type was coded for all 423 effect sizes and was found to be a significant moderator of the gaze-cueing effect, $F(2, 420) = 11.23$, $p < .001$. A significant positive gaze-cueing effect emerged when detection, localization, and categorization tasks were used. That being said, localization tasks produced a larger gaze-cueing effect than detection tasks, $F(1, 134) = 13.77$, $p < .001$, which in turn produced a larger gaze-cueing effect than categorization tasks, $F(1, 134) = 14.59$, $p < .001$. No significant difference between gaze-cueing effects emerging from localization and categorization tasks was detected, $F(1, 134) = 0.08$, $p = .777$. Significant heterogeneity remained after accounting for task type, $QE(420) = 3031.16$, $p < .001$.

In the multiple moderator model controlling for the effects of prior direct gaze, gaze cue offset timing, SOA, and face type, task type remained a significant moderator of the gaze-cueing effect, $F(2, 346) = 10.48$, $p < .001$. Specifically, the gaze-cueing effect remained significantly larger for localization compared to detection tasks, $t(346) = 2.33$, $p = .020$ and detection compared to categorization tasks, $t(346) = 2.04$, $p = .042$.

## Face Type

Face type was coded for 417 effect sizes ($k = 135$, $N = 4{,}139$). Significant positive gaze-cueing effects emerged when schematic, computer-generated, and real face images were used. A significant moderating effect of face type did not emerge, $F(2, 414)$ 2.81, $p = .062$. Significant heterogeneity remained after accounting for the omnibus effect of face type, $QE(414) = 3104.91$, $p < .001$. We then directly compared schematic and real faces, consistent with our preregistration. The results showed that a larger gaze-cueing emerged when an image of a real face had been used as the cue stimuli compared to when a schematic face had been used, $F(1, 362) = 5.16$, $p = .024$. This effect was not retained in the multiple moderator model, where the effects of prior direct gaze, gaze cue offset timing, SOA, and task type were controlled, $t(346) = 0.37$, $p = .708$, suggesting it is not reliable.

As planned, we then compared the effects of schematic versus real face images at each of the five levels of SOA. A significant effect emerged for medium SOAs, $F(1, 78) = 4.36$, $p = .040$, but not for any other SOAs, $F$s < 2.32, $p$s > .133, and as before, given the close proximity of the $p$ value to .05 and the number of comparisons being made in this meta-analysis, the significant effect at medium SOAs is not interpreted as meaningful. Indeed, accounting for direct-gaze pre-cues, gaze-cue offset timing, and task type in a multiple moderator model, the effect of face type for medium SOAs was not retained, $t(74) = 0.56$, $p = .578$.

## Facial Expression

We identified 229 effect sizes ($k = 68$, $N = 2{,}178$) that used images of real faces displaying either a neutral expression or a basic emotional expression. The planned pairwise comparison of neutral versus emotional expressions revealed that, as expected, the gaze-cueing effect was significantly larger when emotional expressions were used compared to when neutral expressions were used, $F(1, 227) = 11.12$, $p < .001$. Significant heterogeneity remained after accounting for whether neutral or emotional expressions were used, $QE(227) = 2216.93$, $p < .001$. Accounting for the effects of prior direct gaze, gaze-cue offset timing, SOA, and task type, in a multiple moderator model, the gaze-cueing effect remained significantly larger when an emotional expression had been used compared to when a neutral expression had been used, $t(182) = 3.12$, $p = .002$.

Including only the effect sizes coded as having used a real face cue displaying an emotional expression, we found that specific emotional expression (i.e., happy, angry, disgusted, or fearful) was a significant moderator of gaze-cueing effect, $F(3, 117) = 5.02$, $p = .003$. Significant heterogeneity remained after accounting for the effect of specific emotional expression though, $QE(117) = 1354.61$, $p < .001$. A follow-up pairwise comparison revealed that the gaze-cueing effect was significantly larger for fearful faces compared to happy faces, $F(1, 30) = 9.67$, $p = .004$. The other possible pairwise comparisons were not conducted due to the possibility that the highly uneven number of contributing effect sizes or too few contributing effect sizes for anger and disgust (9 and 3 effect sizes, respectively, compared to 59 for fearful and 50 for happy) would produce unreliable results. Including only real faces that used happy or fearful emotional expressions in a multiple moderator analysis, we were able to determine that, controlling for the effects of prior direct gaze, gaze-cue offset timing, SOA, and task type, fearful expression cues still produced a larger gaze-cueing effect than happy expression cues, $t(86) = 2.85$, $p = .006$.

## Publication Bias Analyses

It is now well understood how publication biases can affect the distribution of available effect sizes and lead to inflated effect size estimates (see Ferguson & Brannick, 2012; Friese & Frankenbach, 2020). To mitigate the chances of publication bias affecting our effect size estimates, we aimed to include unpublished effects by not limiting our searches to published articles. We included unpublished datasets sent to us by primary study authors and searched the Proquest dissertations and theses database. We then conducted systematic assessments to assess for the potential impact of publication biases on our sample of effect sizes using techniques which allowed us to deal with our statistically dependent effect sizes. We used multilevel modeling and robust variance estimation approaches to retain all effect sizes.

Using the full multilevel data set, we conducted a moderation analysis to assess the effect of publication bias on the magnitude of the gaze-cueing effect. An effect of publication status on the gaze-cueing effect was not detected, $F(1, 421) = 1.03$, $p = .310$. Additionally, we examined whether publication status would affect the significance of the moderators. Multivariate modeling revealed that the unique effects of all significant moderators were retained. Publication status therefore does not appear to affect the status of the significant moderators.

Finally, Rodgers and Pustejovsky (2021) regression methods were used to conduct publication bias analyses. Two analyses were completed: the Egger sandwich test and the Egger MLMA test. Respectively, these two approaches combine the Egger's regression approach with robust variance estimation and multilevel meta-analysis to handle dependency in the assessment of selective reporting (see Rodgers & Pustejovsky, 2021 for detail). These analyses were completed using two R packages; namely, "robumeta" (Fisher et al., 2017) and "metafor". Nonsignificant results were returned using a robust variance estimation approach, $\beta = 1.25$, $SE = 1.04$, $p = .117$, as well as the multilevel meta-analytic approach, $\beta = 1.71$, $SE = 0.67$, $p = .118$, indicating no statistically significant asymmetry in the distribution of effect sizes (i.e., no detection of publication bias).

# Discussion

In daily life, others' eye gaze is a commonly encountered directional visual cue that influences many aspects of behavior. Gaze-cueing tasks consistently show that observers respond faster to targets that are cued rather than miscued by eye gaze (Frischen, Bayliss, et al., 2007). The present meta-analysis provides the first quantitative integration of this extensive gaze-cueing literature, aggregating 423 gaze-cueing effects from 137 independent samples comprising 4,239 healthy adult participants. Here, we discuss the practical and theoretical implications associated with each key finding.

As predicted, an overall gaze-cueing effect was identified. Additionally, except for the (likely) underpowered disgust facial expression analysis ($ES = 3$, $k = 2$), this gaze-cueing effect emerged at every level of every assessed task and cue feature variable (see Table 2). These findings therefore provide strong support for theoretical models that regard eye gaze cues as a powerful and influential visual social signal (e.g., as in Argyle & Cook, 1976; Emery, 2000; Frith, 2008; Kleinke, 1986) as well as for the more specific idea that directional eye gaze is a visual cue that elicits reflexive shifts in the spatial allocation of observers' covert visual attention (as in Driver et al., 1999; Friesen & Kingstone, 1998; Stephenson et al., 2021). Indeed, these findings provide the strongest evidence to date that eye gaze cues reliably produce an attentional cueing effect whereby observers are faster to respond to targets that are presented at locations cued rather than miscued by eye gaze.

## Prior Direct Gaze

Our findings show that presenting direct gaze cues prior to averted gaze cues results in a larger gaze-cueing effect. This finding is in line with research that suggests that direct eye gaze is a powerful modulator of human cognition and behavior (e.g., Doi & Shinohara, 2013; Hietanen et al., 2018; Kaisler & Leder, 2016; Macrae et al., 2002; Mason et al., 2004, 2005; Wang & Apperly, 2017; Zhou et al., 2018; see Conty et al., 2016; Kleinke, 1986 for reviews of direct-gaze effects). Individual studies within the broader gaze-mediated attention literature have recently observed similar eye-contact effects on related but nominally distinct gaze-mediated attention phenomena (Dalmaso, Alessi, et al., 2020; Kompatsiari et al., 2018). Kompatsiari et al. (2018) used a cueing paradigm where the gaze cue was a robot that shifted its head (and therefore also where it could be interpreted as *looking*) either after eye contact was established between the robot and the participant or after no such eye contact was established. Response times were faster to targets presented at the location cued by the robot's head/gaze direction than they were to targets presented at the location that had been miscued by the robot's head/gaze direction, but only in the eye contact condition. Thus, an eye contact effect on social attention was observed, which suggested that eye contact was required to elicit reflexive joint attention between the observer and the robot.

In the second study, Dalmaso, Alessi, et al. (2020) asked participants to perform an overt gaze movement or *saccade task* wherein the location the participant had to look toward by moving their eyes was either congruent or incongruent with the location gazed at by the cue stimulus. On individual gaze cue trials eye contact cues either were or were not presented before the averted gaze cues. In one experiment, the eye contact conditions were blocked and in a second experiment, the eye contact conditions were intermixed. Both when the eye contact conditions were blocked and when they were intermixed, saccadic latencies were faster for congruent relative to incongruent trials, thereby indicating a standard overt- gaze-mediated attention effect. Notably, when the eye contact conditions were intermixed but not when they were blocked, an eye contact effect was also observed, such that the effect of gaze direction on overt attention was larger when there had been prior direct gaze compared to when there had not been. Dalmaso, Alessi, et al. (2020) suggested that this pattern of results was indicative of direct gaze cues serving to enhance subsequent gaze following but only when they are contextually salient (i.e., the enhancement does not occur when every trial has a direct-gaze pre-cue because, in that case, its usefulness as a cue to *which* gaze to follow is eliminated).

Our results are somewhat in line with those just discussed. We also observed an eye contact effect on a social attention phenomenon, which in this case was the gaze-cueing effect. However, our study did not find this was necessitated on intermixed trials. Indeed, the studies we compared either *did* or *did not use* prior eye contact. As such, our findings suggest that covert gaze-cued attention is enhanced by prior eye contact without the need for the contextual salience of eye contact that Dalmaso, Castelli, et al. (2020) concluded was necessary for eye contact to exert an influence on overt gaze-cued attention.

Our findings support the fast-track modulator model of social cognition proposed by Senju and Johnson (2009). Our finding that prior eye contact results in a larger gaze-cueing effect is an example of a so-called “eye-contact effect”, in which the observation of eye contact enhances concurrent and/or subsequent cognitive processes. As noted earlier, in their fast-track modulator model, Senju and Johnson (2009) propose that eye-contact effects occur via expedited subcortical processing enacted via the observation of eye contact cues. The next critical step in this literature is now to directly test whether these effects of prior eye contact are expressed at the neural level in the manner that this model predicts. Notably, Xu et al. (2018) found that eye contact enhanced gaze-cued attention when the eye contact was presented supraliminally but not when it was presented subliminally. This suggests that visual awareness of the eye contact may be necessary for an eye contact effect on gaze-cued attention to emerge. Xu et al.’s finding is therefore not consistent with the fast-track modulator model, which highlights a need for future research that aims to test whether the fast-track modulator model is a suitable explanation for the eye contact effect on gaze-cueing.

That aside, the finding that gaze-cueing effects are larger when direct-gaze pre-cues are used indicates that any complete model of social attention requires that the currently quite disparate eye-contact effect and gaze-cueing effect literatures now be integrated. Jording et al.’s (2019) work highlights one possible way by which this might be achieved, noting that in the context of gaze following, prior eye contact may serve as a clear visual signal that communicates the intention behind the gaze shift. Specifically, direct gaze prior to a gaze shift is proposed to communicate to the observer that the subsequent gaze shift has a social intention and should be followed. By contrast, a gaze shift alone with no eye contact would be indicative of a private act of looking that is not to be followed (i.e., in line with Gobel et al.’s, 2015 suggestion that our eye gaze functions to both cue others’ attention and to look at specific objects ourselves). This view would suggest that we may be programmed to reflexively detect eye contact as a cue to whether upcoming directional gaze cues are inviting engagement in shared attention with the gazing person or not (see Stephenson et al., 2021 for a review of shared attention), and consequently that it is because of their role in social connection that direct-gaze pre-cues elicit stronger gaze-cueing effects. However, another alternative suggested by others (e.g., Fichtenholtz et al., 2009; Heimler et al., 2015; Hietanen & Leppänen, 2003; Lassalle & Itier, 2013; Newport & Howarth, 2009), is that it may be the closer approximation of an actual gaze shift via the illusion of biological motion created when direct-gaze pre-cues are used that confers this enhanced gaze-cueing effect. Having now established that a robust moderating effect exists, future studies are now needed to determine the role of, and mechanisms subserving, prior eye contact on subsequent visual orienting by eye gaze.

## Gaze Cue Offset Timing

With respect to gaze cue offset timing, although a significant moderating effect was initially identified, this effect was not retained once the other moderator variables were accounted for. This means that whether the gaze cue offsets at, or before, the target onset, or remains on screen after the target onsets, does not have any reliable moderating effect on the magnitude of the gaze-cueing effect across studies. This finding could reasonably be interpreted as indicating that observers do not necessarily require others’ eye gaze to be held at the gazed-at location for their own attention to remain focused at that specific location, and that once a gaze-cueing effect is established other typically oriented to cues are less effective in capturing attention. This has implications for the use of gaze cues in interpersonal interactions where directing others’ attention resources is a means of achieving a specific goal (as is often the case in teaching and in psychological interventions).

## Cue-Target Stimulus Onset Asynchrony

Also supporting a conceptualization of gaze-cueing in which gaze-cued attention has a delayed offset, we found that the gaze-cueing effect emerges at the same magnitude up to 800 ms SOA before reducing (but still emerging) thereafter (although note that reverse gaze-cueing effects have previously been observed at very long SOAs in studies that were not able to contribute to this meta-analysis: namely, Frischen & Tipper, 2004; Frischen, Smilek, et al., 2007 where IOR was observed using a 2,400 ms SOA). Interestingly, the timecourse of gaze-cueing effects identified here appears to differ from that of classic peripheral-cueing effects which, as discussed earlier, seemingly disappear and even show an IOR effect by a comparatively early 800 ms SOA (see Klein, 2000; Posner et al., 1985). Given we also found that the gaze-cueing effect reliably emerges with SOAs < 200 ms, this late emergence of the gaze-cueing effect must be driven by an *extended* rather than a *shifted* timecourse relative to other cueing effects. In saying that, our findings also suggest that the magnitude of the gaze-cueing effect may be larger for early SOAs than it is for later SOAs, suggesting the possibility that its full strength occurs early. However, the absolute differences in magnitude between gaze-cueing effects produced by early and nonearly SOAs were notably small.

Although further systematic comparative work is needed to delineate the uniqueness of the attentional effects that directional eye gaze cues produce relative to those elicited by other visual cues, this extended timecourse is consistent with the proposal that attentional cueing by gaze cues is a special class of attention effect that may have emerged later in evolutionary time and for some distinct *social* purpose (see e.g., Emery, 2000). Further comparative work using high-level statistical modeling of inflection points will be required to draw definitive conclusions regarding the differences and similarities of attentional cueing via central eye gaze cues and peripheral cues. Nonetheless, the present results provide support for the view that gaze-cued attention has a different timecourse to peripherally-cued attention.

## Task Type

Although task type was found to reliably moderate the magnitude of the gaze-cueing effect, in contrast to our suggestion that its magnitude may be attenuated with increasing task demands, the gaze-cueing effect was largest for localization tasks relative to less demanding detection tasks. Differences in task demands therefore do not easily explain the pattern of gaze-cueing effects across task type that was identified here. In saying that, categorization tasks (the most difficult task) were found to have a smaller magnitude than detection tasks (the easiest task). This difference may be driven by differences in task demands. If this is the case, this is not consistent with Law et al., 2010 findings that concurrent *cognitive load* is not disruptive to gaze-cueing. This should be investigated in future research.

One possibility that accommodates the finding that localization tasks produced the largest effect is the task relevancy of directional gaze cues when the task is to localize a target (i.e., a cue-relevance account). By this view, it may simply be more difficult to suppress attentional orienting by gaze cues when they would ordinarily be useful. Indeed, when determining the location of an object under time pressure, looking first where others are looking would be a useful search strategy. By this account we would expect that, given localization tasks are the only type of gaze-cueing task that involve a direction-based decision, localization tasks would produce the largest gaze-cueing effects.

However, it is also possible that the effect of task type we identified was driven by a cue-direction to response key spatial Simon effect (i.e., a spatial congruency account). A spatial congruency account predicts that on leftward gaze trials, responding with the left-hand-side response key is enhanced and responding with the right-hand-side response key is disrupted and, on rightward gaze trials, responding with the right-hand-side response key is enhanced and responding with the left-hand-side response key is disrupted.

The critical difference between the cue-relevance account and the spatial congruency account is in their more nuanced predictions. The cue-relevance account predicts enhanced gaze-cueing for all localization tasks, irrespective of what the response keys are. This is because the relevance of the cue is dictated by the global task of localizing targets. In contrast, the spatial congruency account requires that the response keys be horizontally in-line, such that left targets are responded to with the left-hand-side response key and right targets are responded to with the right-hand-side response key.

Nearly all localization tasks to date have used a horizontal response key mapping (e.g., Bailey et al., 2014; Carlson, 2016; Chanon & Hopfinger, 2011; Deaner et al., 2007; Friesen & Kingstone, 1998; Friesen & Kingstone, 2003; Galfano et al., 2011; Gayzur et al., 2014; Greene et al., 2009; Gregory & Jackson, 2021; Lasalle & Itier, 2013, 2015a, 2015b; Law et al., 2010; Lo Gerfo et al., 2018; McCrackin & Itier, 2020; Nagata et al., 2012; Neath et al., 2013; Putman et al., 2006; Takao et al., 2018; Yoshizaki & Kato, 2011). Further experiments that directly manipulate the response key mapping within localization tasks are therefore now needed to disentangle the effect of spatial congruency and attention effects in localization tasks and thereby speak to whether the cue-relevance account or the spatial-congruency account offer a better explanation for the findings identified here.

It should also be noted that the possibility suggested by the current meta-analysis that spatial compatibility could enhance gaze-cueing raises an important question for future research. Specifically, because the gaze-cueing effect has long been characterized as solely due to an attentional shift and spatial compatibility effects do not require an attentional shift, it raises the intriguing possibility that covert attentional shifts may not be necessary for gaze-cueing effects to occur. If spatial compatibility effects can, to any extent, elicit the reaction time mean differences that are observed between gaze-cued and gaze-miscued trials, perhaps it is possible that other cognitive mechanisms besides attention might be able to produce gaze-cueing effects.

## Face Type

With respect to the type of face stimuli presented—schematic, computer-generated or, real—we found no strong evidence of moderation. Indeed, no moderation effects emerged despite testing for the omnibus effect of schematic, computer-generated and real face images overall, as well as the effect of schematic versus real face images both overall and at each level of SOA separately. These findings are particularly noteworthy given that they are inconsistent with Hietanen and Leppänen's (2003) finding that a larger gaze-cueing effect emerged when schematic rather than real faces were used as cues. Our findings instead provide strong evidence that gaze-cueing effects emerge equivalently regardless of whether the stimuli used are highly artificial (i.e., schematic faces) or more complex and true-to-life (i.e., images of real faces). However, whether the gaze-cueing effect is unaffected by further increases in the cue stimuli's ecological validity (e.g., outside-of-the-lab where the gazing stimulus is a real person with whom the participant is interacting) remains an important avenue for future empirical investigation.

## Facial Expression

Consistent with broader research literature showing that facial expressions of emotion and gaze cues have a combinatory effect on social cue processing and subsequent behavior (e.g., Adams & Kleck, 2003, 2005; Bindemann et al., 2008; Doi & Shinohara, 2013; Ganel et al., 2005; Lobmaier et al., 2008), we found that cue expression affects the magnitude of the gaze-cueing effect. As predicted, a larger gaze-cueing effect emerged when real face images with emotional expressions were used as cues compared to when real face images with neutral expressions were used as cues. This finding is consistent with our argument that people are more likely to follow eye gaze cues associated with emotional expressions because they are motivated to understand the cognitive and affective states of others. In addition, and also as predicted, we found that the specific emotional expression on the cue face affects the magnitude of the gaze-cueing effect. Specifically, a larger gaze-cueing effect emerged when real face images with fearful rather than happy expressions were used as cues. This finding is consistent with broader literature showing that threat-relevant stimuli produce larger attentional effects, potentially because of the importance for survival that attending to threatening stimuli confers (Hadjikhani et al., 2008; Öhman & Mineka, 2001). Although a significant gaze-cueing effect emerged for angry but not disgusted expressions, the estimates for the size of these specific gaze-cueing effects was likely underpowered and therefore imprecise. What these findings do clearly speak to is the need for future studies to assess a broader range of basic emotional expressions beyond happiness and fear, as well as the more complex self-conscious emotions, such as embarrassment and shame. Also, critically needed are theoretical models of the interactions of gaze and facial expression that account for the full range of expressions and consider other characteristics such as emotional authenticity (i.e., the degree of genuineness of facial expression; see Dawel et al., 2017; Gunnery & Ruben, 2016). We consider these more detailed and nuanced analyses as a particularly exciting future step in this literature.

## Methodological Recommendations

From a practical perspective, one of the key contributions of the present study is aiding methodological decision-making in future gaze-cueing research. First, given that gaze cue offset timing and face type were not found to have any reliable influence on the magnitude of the gaze-cueing effect, researchers are relatively free to vary these features according to study-specific theoretical considerations without concerns of this meaningfully influencing their findings. For example, if a researcher's goal is to use a gaze-cueing task as a measure of social perceptual functioning, they may choose to maximize ecological validity by having the cue stay on screen with the target —a choice that our results suggest would not impact on the gaze-cueing effect.

Second, and similarly, as the magnitude of the gaze-cueing effect did not differ between 200 ms and 800 ms SOA, researchers may be able to vary SOA with little impact within this range, again allowing for such methodological decisions to be driven by other considerations related to the specific question being explored. It would thus be appropriate for experimenters examining the modulating effects of other variables on gaze-cueing to choose SOAs based entirely on their expectations for the effects of different SOAs on those other variables. In this way, researchers will be able to make informed methodological decisions, without the need for undue compromises. For instance, researchers investigating modulation of gaze-cueing by a variable not expected to have an early influence on gaze-cueing might choose a longer SOA and still expect gaze-cueing effects to emerge within their study.

Third, considering the gaze-cueing effect was enhanced by using (a) prior direct gaze cues, (b) localization relative to detection and detection relative to categorization tasks, (c) emotional rather than neutral expressions, and (d) fearful rather than happy expressions, researchers should be careful when making methodological decisions related to these variables. For example, a detection or categorization task would be a more appropriate choice for experimenters wishing to assess gaze-orienting when they have tasked participants with ignoring gaze cues, as localization tasks appear to make eye gaze cues harder to ignore. Alternatively, given the gaze-cueing effect is largest for localization tasks, a localization task may act as a better litmus test when attempting to establish whether, in specific clinical groups or in specific circumstances, the gaze-cueing effect is eliminated.

Following on from this, given gaze-cueing tasks are often used as a way to compare gaze following behavior between clinical or subclinical goups and healthy controls (e.g., see Dalmaso et al., 2013, 2015; Dawel et al., 2015; Langdon et al., 2017; Magnée et al., 2011; Marotta et al., 2018; Narison et al., 2020; Talipski et al., 2021; Uono, Sato, & Toichi, 2009; Wei et al., 2019), an important avenue for future research is to determine whether performance on gaze-cueing tasks is related to performance on well-established measures of social perception and real-life social functioning. Such an assessment would be particularly valuable given that social cognitive function is now firmly established as a critical predictor of mental health and well-being, and there is a need for objective, bias free measures to be developed (Henry et al., 2016). Given our findings that both task and cue features significantly influence the magnitude of gaze-cueing effects, an important next step is to also establish which specific task and cue parameters produce the most sensitive indicators of real social gaze behavior in actual, daily life.

## Limitations

Firstly, across the quite extensive gaze-cueing literature, participant and sample diversity factors were only rarely reported within individual primary studies. We therefore cannot be sure whether the moderating effects identified here would generalize universally across all healthy adults. Future primary studies should make their full data sets open and available online with detailed individual participant demographics provided so that future meta-analyses are able to give an even more comprehensive understanding of the gaze-cueing effect. The open availability of such data could, for example, allow for investigations of whether specific individual difference variables moderate the magnitude of the gaze-cueing effect as well as whether the task and cue feature moderation effects identified here are robust across specific demographics.

Secondly, there are many parameters that differ across gaze-cueing tasks that were not accounted for here. These are factors that vary less substantially than the ones we coded but could nonetheless influence the magnitude of gaze-cueing effects and should be investigated further in future studies. For example, future work may consider the inclusion of distracters appearing on the side opposite to target stimuli within categorization and localization tasks (as in Gregory & Jackson, 2021), the use of no-target attention check trials, the use of more complex target stimuli, the intertrial interval length, and so on. Finally, the moderation findings here need to be replicated in adequately powered primary studies, given the primary studies from which our data were drawn were not themselves aiming to assess the effects assessed in this meta-analysis.

Thirdly, although we identified several substantive moderators in this meta-analysis, the assessment was at the general population level. It is possible that the moderating effect of these variables on the gaze-cueing effect might itself be moderated by specific individual difference variables, such as sex, age, and race/ethnicity. The body of studies presented in this meta-analysis did not vary sufficiently with regard to these particular individual difference variables so as to allow assessments of moderation by them to be meaningful. A limitation of the present study is therefore that the generalizability of the present findings across a variety of populations cannot be determined, and it is important that future primary studies investigate the roles of these variables on the findings presented here.

## Conclusion

The data presented in this meta-analysis provide novel insights into our understanding of an effect that has been studied extensively and has also been the focus of considerable theorizing—the gaze-cueing effect. Faster responses to targets cued rather than miscued by eye gaze emerged as a remarkably robust effect suggesting that spatial visual attention is reliably cued by eye gaze. We also found that some task features—specifically, prior direct gaze, SOA, task type, and cue facial expression, meaningfully strengthened or reduced the absolute magnitude of the gaze-cueing effect, a finding which will be particularly relevant for methodological decisions in future research as well as to inform comparisons between effects in existing studies. Taken together, the results of the current review provide evidence that others' directional eye gaze acts as a major cue in shifting our visual attention, and that this effect is influenced, but never eliminated by, a range of cue and task features.

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