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Doctoral Thesis :

Sex differences in the dissociation between social and non-social attention

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CHAPTER I

Introduction

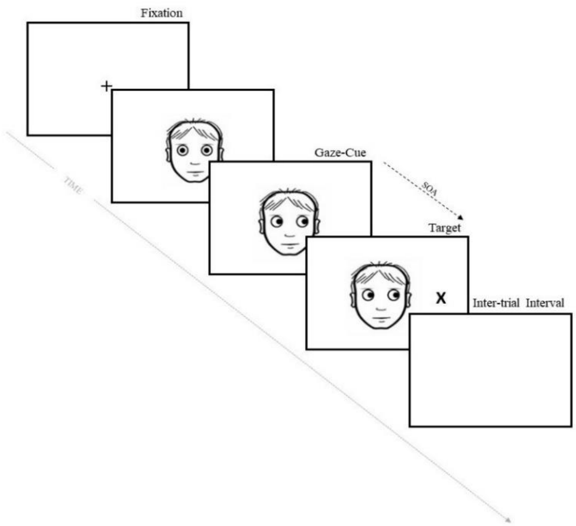
Attending another person's focus of attention has been proven to be crucial for the development of social communication. This behaviour appears since a very early age and represents an important milestone for the development of fundamental processes in social cognition such as language acquisition, cultural learning, or theory of mind abilities (Baron-Cohen, 1995; Bruner, 1983; Tomasello, 1995; Tomasello, Kruger, & Ratner, 1993).

A number of studies have found that from a few hours of birth, infants already manifest preferential interest for other individual's eyes (see Maurer, 1985; Batch et al., 2000; Farroni et al., 2002), and after a few weeks children already attend towards other individuals focus of attention (i.e., Hains & Muir, 1996; Hood et al., 1998; D'Entremont et al., 1997; Gredebäck et al., 2010). From an evolutionary point of view, this phenomenon may provide adaptive advantages regarding predator awareness and food detection, while from a social perspective it may provide advantages regarding social interaction, communication and the building of more intimal connections with other individuals (Baron-Cohen, 1995; Langton et al., 2000).

According to the relevance of this phenomenon in social cognition, for decades, several researchers have shown special interest in understanding the attentional mechanisms that hide behind it, particularly the mechanisms of social attention (see Frischen et al., 2007 for a review). Social attention can be understood as the people's interest in the focus of attention of other individuals (Birmingham & Kingstone, 2009). Therefore, the mechanisms underlying the tendency to orient attention to the direction of another's eye gaze have been widely studied using a variant of spatial cueing paradigm (Posner, 1980). In this variant, known as the gaze cue paradigm, a typical trial sequence consists in the presentation of a central fixation point, followed by a real or schematic neutral face looking straight ahead or with closed eyes. Then the eyes change to gaze either to the left or to the right from the fixation point. Subsequently, a target appears either accordingly to the location towards which the eyes are gazing at (congruent trials) or at the opposite position (incongruent trials; see Figure 1 for an illustration). Participants are asked to detect, discriminate, or localize the target as quickly and as accurately as possible. Results of this paradigm show that individuals respond significantly faster on congruent than on incongruent trials, even when they have previously been informed that the direction of the cue does not predict the location where the target will appear (i.e., Friesen & Kingstone, 1998). These findings have been replicated by a number of authors (for a review, see McKay et al., 2021) showing a robust phenomenon that reasonably can lead to believe that another people's eye gaze works to trigger individuals' "social attention".

Figure 1

Example of the procedure of the gaze-cueing paradigm.



Note. The illustration represents a schematic face in a congruent trial.

However, it is unclear whether the attentional mechanisms induced by eye-gaze direction represent a unique hallmark of social attention or a more general phenomenon also found in response to biologically and socially irrelevant directional stimuli such as arrows. To address this issue, several authors (i.e., Ristic et al., 2002; Tipples et al., 2002) have tried to quantitatively dissociate the attentional orienting produced by gaze cues from the attentional orienting engaged by arrows. However, no general agreement has yet been achieved, and since very similar effects have been observed for these two types of stimuli, some researchers have suggested that gaze attentional effects are at least partially due to a domain-general attentional processing (Brignani et al., 2009). Given this discrepancy between the so distinct in nature arrow and gaze stimuli and their similarities when orienting attention, Birmingham and Kingstone (2009) proposed that the supposed uniqueness of eye gaze as an attentional stimulus must be correct, but the gaze-cueing task may not be highlighting properly the characteristics of gaze that differentiate it from other non-biological and social stimuli such as arrows.

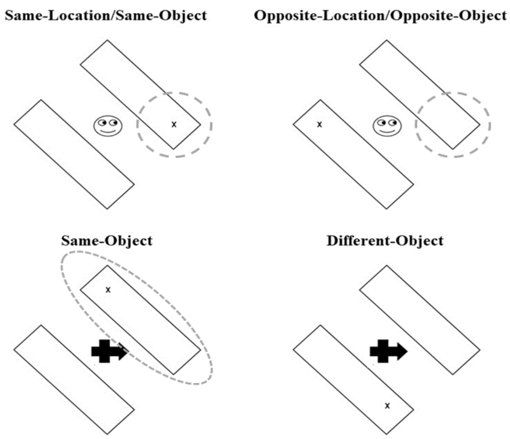
Therefore, following the idea that the quantitative approach of the classical gaze-cueing paradigm may not be enough to highlight social attention, several researchers have proposed that a qualitative methodology may provide a broader insight into this matter. The logic here is that the attentional differences between gaze and arrow cues might be regarding the nature rather than the size of the attentional modulation induced by each cue type.

For instance, Marotta and colleagues (2012) showed that cueing a portion of an object spread attention across the entire object when arrows are used as cues, while it restrict attention at the specific portion of the cued object when eye-gaze cues are used. They used a variant of the double-rectangle task (Egly et al., 1994), in which two rectangle objects were displayed on the scene, one of which was cued at one end or another by central non-predictive arrow or eye-gaze cues. Targets followed in one of four critical conditions (see Figure 2 for an illustration): at the cued direction (and object) indicated by the cue (same-location/same-object trials), in the opposite object and direction to which the cue was directed (opposite-location/opposite-object trials); at the uncued location of the same object (same-object trials) or at the uncued location in the other object (different-object trials).. Interestingly, results showed that when arrows cues were used, attention spread across the entire object (i.e., a same-object advantage compared to different-object trials), while when using eye-gaze cues attention is restricted to the specific signalled portion of the cued object (i.e., a same-location/same-object advantage compared to same-object trials).

These findings seem to indicate a qualitative differentiation between the attentional selection triggered by arrows and gaze. In particular, this dissociation leads the authors to suggest that whereas arrow-cueing is truly stimulus-driven, gaze-cueing might be mediated by theory of mind processes, as a consequence of a specific intention automatically attributed to gaze but not to arrows (i.e., when we see somebody clearly looking to one end of a surface, we only pay attention to this end).

Figure 2

Illustration of the four possible target positions in the study of Marotta and cols. (2012).



Note. The image represents the gaze-cue and the rectangles orientation of -45º from vertical.

In the same vein, Gregory and cols. (2018), combining a traditional gaze cueing paradigm with a visual memory task, have shown that, despite similar cueing attentional effects, only gaze cues but not arrow cues improved memory accuracy for cued information.In this study, the procedure was similar to the classic arrow/cueing paradigm, with the difference that the participant's task was to try to remember a set of coloured squares (4, 6 or 8) that appeared either congruently with the direction signalled by the cue (congruent trials), or at the opposite position (incongruent trials). After a blank 1000ms, a single coloured square appeared at the centre of the screen, and participants had to indicate whether or not this square have been displayed in the previous array. Interestingly, results show that when eye-gaze was cueing, working memory accuracy was significantly better in congruent than in incongruent trials. In contrast, when arrows were the cues, no modulation of working memory was observed, showing once again that those social and non-social stimuli could be a part of two separate underlying mechanisms.

As a result of the these and other previous findings (for a more detailed description of the qualitatively dissociation observed between gaze and arrows stimuli, see Chapter 3) some authors suggest that whereas both arrow and gaze cues possess similar automatic orienting properties, the attentional orienting triggered by eye-gaze could be mediated by "social-specific" processes probably related to its ability to convey intention and mentalizing phenomena such as empathy and theory of mind (ToM), that help us to identify, understand, and interpret another individual's thoughts and mental states (i.e., Bayliss et al., 2005; Marotta et al., 2012).

Therefore, if individual differences in social skills could be an important gravestone for the dissociation between social and non-social orienting of attention, we then can speculate that across different groups of people that "are known” or “can be” classified as having higher or lower social skills, we may be able to find an accurate classification just by employing this aforementioned task.

For instance, many studies have widely utilized the classical gaze-cueing paradigm to study social cognition in populations known to have an atypical social development and of functioning, such as individuals with autism or high functioning autism (Chawarska et al., 2003; Marotta et al., 2013; Ristic et al., 2005; Swettenham et al.,2003), women with Turner syndrome (Lawrence et al., 2003), children diagnosed with attention deficit hyperactivity disorder (ADHD; Marotta et al., 2014) or individuals with schizophrenia (Akiyama et al., 2008; Catalano et al., 2020; Dalmaso et al., 2013; Langdon et al., 2006, 2017).

Furthermore, several authors were also interested in investigating these same differences in social attention among normotypical population groups who are thought to have different social skills. For example, some studies inquired whether or not the sex of participants could be one of the factors that modulate the processing of social cues (Bayliss et al., 2005; Merritt et al., 2007; Alwall et al., 2010). Researchers found that female participants tend to show a stronger gaze-cueing effect than males. Interestingly, in some cases (Bayliss et al., 2005; Alwall et al., 2010), the differences were associated with self-reported measurements of social skills; thus leading to the speculation that people who are more socially skilful may tend to have a stronger attentional orienting effect when exposed to social stimuli.

However, it must be highlighted that the reported sex differences in attentional orienting when using the classical gaze/arrow cueing task were also observed when non-social cues were presented to participants (Bayliss et al., 2005; Merritt et al., 2007). Therefore, it is not clear if sex attentional differences are due to more general differences in the orienting of attention or whether they are rather due to a distinct way of processing social stimuli.

CHAPTER II

Aims and organization of the experimental section

In spite of generating a large amount of data and a notable increase in interest in multiple fields of research (i.e. social cognition, spatial attention, developmental psychology) the experimental comparison between the attentional mechanisms triggered by eye-gaze and arrow cues has produced few univocal conclusions. On the one hand, observing subtle differences between the two types of cues, some authors argued that the gaze might represent a unique attentional cue. On the other hand, underlining the numerous similarities, other authors have postulated that the gaze might rather trigger a general domain attentional orienting mechanism. To explain these contrasting results, Birmingham and Kingstone (2009) have underlined the limits of the spatial cueing paradigm as a tool for the evaluation of social attention. In particular, they suggested that the supposed exceptionality of eye-gaze as an attentional stimulus is correct, but the cueing paradigm may not be able to highlight the characteristics of the eyes that differentiate them from other non-social cues like arrows. Indeed, with the cueing paradigm, eyes and arrows have generally been compared with respect to a dimension in which they are very similar, namely their ability to communicate directional information (Gibson & Kingstone, 2006). One of the main goals of the present work is based on a relative sharing of this possibility. In particular, to discern the potential usefulness and/or limitations of the gaze cueing task in detecting cue-specific social attentional, in Chapter 3 we performed a meta-analysis of the behavioral studies examining the quantitative differences in attentional orienting triggered by directional eye-gaze vs. arrow stimuli. At same time, the effect of possible moderator variables was also investigated to get a deeper understanding of the cueing phenomenon. Results of this meta-analysis clearly showed that the classic spatial cueing paradigm produces the same attentional effects for social directional cues, such as eye-gaze, and non-social directional cues, such as arrows. These findings question the potential utility of the classic cueing task in revealing social-specific attentional effects.

Therefore, the second goal of this manuscript was to develop a behavioural task to effectively dissociate between social and non-social attention exploring their qualitatively different effects on information selection. Based on previous evidence, we run an experimental series of two experiments to assess whether the attentional shifts triggered by eye-gaze and arrow cues differ in the way people select objects in response to them. In particular, we explore whether the orienting of attention triggered by social and non-social stimuli can be modulated by the presence and distribution of placeholders on the scene.

Based on previous evidence from our and other laboratories, we speculated that gaze cues may encourage more specific attentional orienting, compared to arrow cues, since a specific intention may be automatically attributed to gaze and not to arrows. In particular, we expected that when using eye-gaze cues, attention would focus only on the specific location or placeholder pointed by the cue and that when arrows were used, the attention would spread to the entire hemifield or group of signaled placeholders.

The final aim of this work was to explore whether sex could be a moderator of differences in social attention among participants; or whether other factors such as autistic traits, social skills, sex roles, or individuals' academic choices, could better explain any variations.

To this end, we conducted two separate studies. In the first one, we collected evenly matched groups of males and females, and by using the same double-rectangle task as Marotta and colleagues' (2012), we aimed, first, to replicate the important dissociation between eye-gaze and arrow attentional orienting found by them, and second, to investigate if this dissociation can be observed regardless of the sex of individuals. Additionally, in this study, participants completed two social cognition measures used to assess autistic traits (as measured by the AQ; Baron-Cohen, 2003) and theory of mind skills (as measured by the Yoni test; Shamay-Tsoory & Aharon-Peretz, 2007). In this study, we hypothesize that females would show stronger dissociation between social and non-social stimuli and that this dissociation would be inversely associated with higher scores in autistic traits and lower punctuation in the theory of mind assessments.

Following this line of research, the second study consisted of collecting again a different sample of well-matched male and female participants. However, in this study, besides sex, we focused on their academic background. On the one hand, we collected a sample of undergraduates or graduates in technology, engineering, and mathematics-related careers. On the other hand, we collected an evenly matched group of undergraduates or graduates of careers more related to humanities and social sciences.

To assess the dissociation between social and non-social attention, participants performed in this occasion the paradigm designed in the third chapter of the present manuscript. In addition, all participants completed four self-report questionnaires that assessed different personal aspects ranging from individual traits to social roles. The self-reported measures used in this study were the short versions of the Autism Spectrum Quotient (AQ-10; Allison et al., 2012; see Baron-Cohen et al., 2001 for the original version), The Empathy Quotient (EQ-10; Greenberg et al., 2018; see Baron-Cohen & Wheelwright, 2004 for the original version) and the Systemizing Quotient-Revised (SQ-R-10; Greenberg et al., 2018; see Baron-Cohen et al., 2003 for the original version). As well as an adaptation of the Bem Sex-Role Inventory (Páez et al., 2003; see Bem, 1974 for the original version). This time, we hypothesized that, regardless of sex, the different academic backgrounds, and the personal aspects of participants, as assessed by the aforementioned self-reported measures, would be the breaking point to find a dissociation between social and non-social attention in the general population.

CHAPTER III

Are there quantitative differences between eye-gaze and arrow cues? A meta-analytic answer to the debate and a call for qualitative differences[1]

Abstract

Gaze appears to be special to humans, acting from an early age as a cue to orient attention and, thereafter, to infer our social partners' interests, intentions, thoughts, and emotions. Variants of the spatial cueing paradigm have been used to study the attentional orienting triggered by eye-gaze. However, it is still unclear whether this methodology truly assesses "social-specific" processes exclusively involved in attention to eye-gaze or the operation of domain-general attentional processes. The present study provides a comprehensive meta-analysis of the evidence collected with these procedures indicating that eye-gaze and non-social directional stimuli, such as arrows, produce equivalent attentional effects. This results casts doubt on the potential utility of the classic cueing task in revealing social-specific processes. On the other hand, we review behavioural evidence suggesting that eye-gaze stimuli may induce higher-order social processes when more specific experimental procedures that analyse qualitative rather than quantitative differences are used. These findings point to an integrated view in which domain-general and social specific processes both contribute to the attentional mechanisms induced by eye-gaze direction. Finally, some proposals about the specific social attentional components involved in eye-gaze perception will be discussed.

Keywords : social attention; gaze cueing; arrow cueing; social cognition

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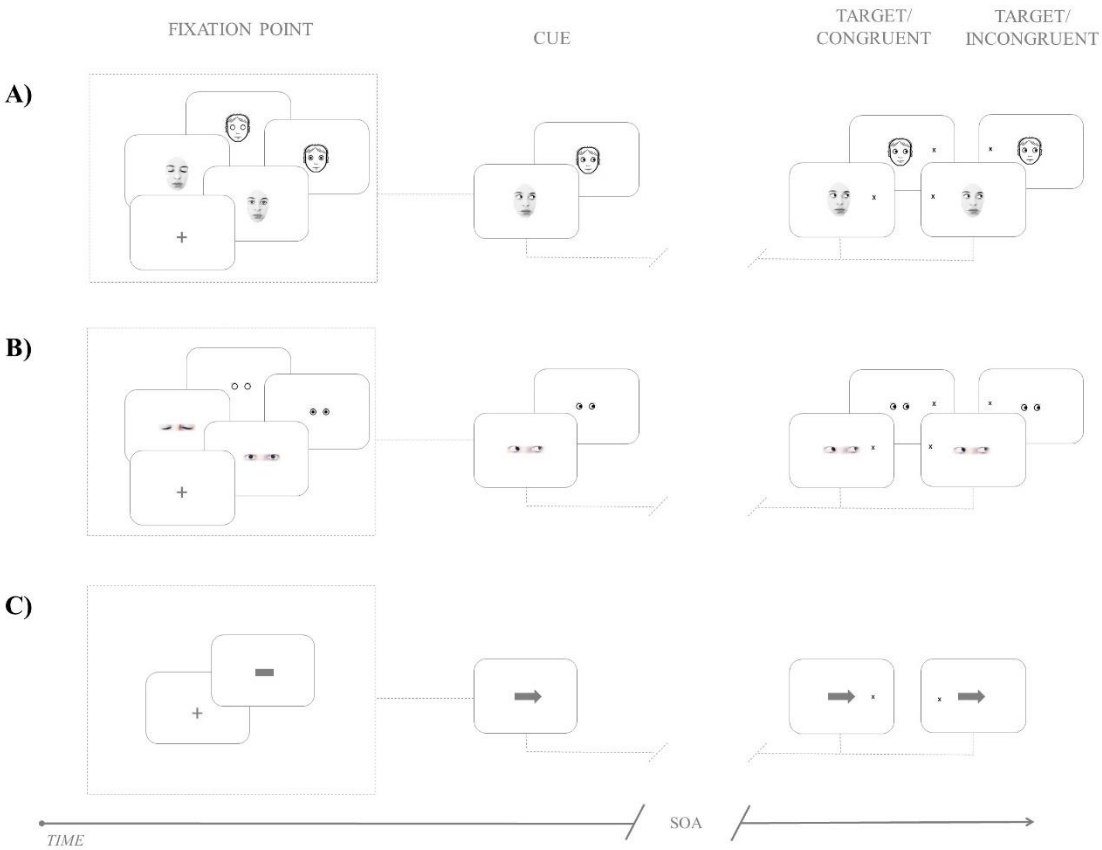
[1] Jeanette Alicia Chacón Candia, Rafael Román-Caballero, Belén Aranda-Martín, Maria Casagrande, Juan Lupiáñez, and Andrea Marotta (2022). Are there quantitative differences between eye-gaze and arrow cues? A meta-analytic answer to the debate and a call for qualitative differences. [Under review].

Introduction

Attending towards another individual's focus of attention has shown to be of great importance for the development of social communication. From a very early age, infants manifest a special sensitivity to other people face, first by showing preferential interest for the eyes (see Maurer, 1985; Batki et al., 2000; Farroni et al., 2002), and soon later by actually following their interlocutor's gaze (i.e., Hains & Muir, 1996; Hood et al., 1998; D'Entremont et al., 1997; Gredebäck et al., 2010). From an evolutionary point of view, the importance of eye-gaze detection has led (across evolutionary pressure) humans to sacrifice camouflage for communication, developing a higher eye contrast morphology with respect to non-human primate eyes (Kobayashi & Kohshima, 1997). Recently, besides investigating this component of social interaction as a tool to understand social cognition and human development, researchers started to be interested in the underlying attentional mechanisms, more specifically, the mechanisms of social attention (for a review, see Frischen et al., 2007). To address this line of research, an adaptation of the classical Posner's (1980) spatial cueing paradigm has been used, the so-called gaze-cueing paradigm. In a typical example of this task, a fixation point is presented at the centre of the screen, followed by a schematic or real face looking straight ahead or with closed eyes (see Figure 1). Afterwards, participants see the same face with the gaze averted either to the left or right from the fixation point. Then, following a variable temporal interval (stimulus-onset asynchronies [SOA]), a target appears randomly either at the cued position (congruent-trials) or at the opposite position indicated by the cue (incongruent-trials). After each trial, participants have to detect, localize or discriminate the target, usually with a keypress. Participants typically answer faster on congruent than on incongruent trials, even when they have been previously informed that the central eye-gaze does not predict where the target will appear (i.e., Friesen & Kingstone, 1998).

Figure 1

Example of a trial sequence of the classic gaze and arrow cueing paradigms.



Note. A) Representation of the gaze-cueing task using real or schematic full faces. B) Representation of the gaze-cueing task using real or schematic eyes. C) Representation of the arrow-cueing task.

In contrast to peripheral cueing, which is known to be triggered automatically by non-predictive abrupt onsets, it was assumed that central symbolic information, like arrows or gaze, should be predictive of the target location to trigger attentional orienting. Indeed, Jonides (1981) found a significant cueing effect in response to a central arrow only when it was predictive of the target location. This effect disappeared when arrow predictability was reduced, suggesting that central symbolic cues will not automatically drive attention if they are not predictive of the target location.

Consequently, the finding of attentional orienting triggered by non-predictive central gaze led to the consideration of eye-gaze cues as uniquely able to elicit endogenous but automatic orienting of attention. It has been proposed that this effect was due to the biologically relevant and innate functions of eye gaze (Baron-Cohen, 1995), which would explain why even 10-to-28 weeks old infants automatically attend locations looked at by unpredictive human faces (Hood et al., 1998).

Nonetheless, shortly after, Hommel et al. (2001) critically showed that also arrows, which are not biologically relevant but support overlearned communicative cues, do trigger automatic orienting of attention, even if they are non-predictive. Importantly, many authors (e.g., Eimer, 1997; Ristic et al., 2002; Tipples et al., 2002) replicate this robust orienting effect thereafter.

Other researchers used a paradigm in which a person looking at one of the walls of a room was shown to observers, who were asked to discriminate the number of dots shown in the whole room. However, this number could be congruent or incongruent with the number of dots displayed exclusively at the looked at wall of the room. Results showed worse performance in the incongruent condition, an effect by then thought to be elicited exclusively by social agents (Samson et al., 2010). The explanation of the effect observed in this perspective-taking task assumed implicit mentalizing, i.e., that the presence of the person in the display would activate his/her mental state, which would be different to that from the observer in the incongruent condition, consequently leading to a worse performance in the task. Again, this effect, supposedly elicited exclusively by people-cues, was later similarly observed with arrows (Santiesteban et al., 2014).

Whether or not these results are comparable with the gaze-cueing effect is the major concern of the present study. Assuming the overview that both biologically relevant and non-biologically relevant stimuli serve as facilitators of attentional orienting, the important question is whether or not these two types of stimuli, supposedly so different in nature, produce exactly the same or somehow different effects of cueing. In recent years, many studies have extensively tried to answer this question but leading to mixed results, with some studies finding a significant difference between the two stimuli and others suggesting that the effect provoked by them is indistinguishable behaviourally and even at the neural level (e.g., Blair et al., 2017; Brignani et al., 2009; Callejas et al., 2014; Hietanen et al., 2006; Joseph et al., 2014; Marotta et al., 2012; Stevens et al., 2008; Ristic et al., 2007).

However, to our knowledge, no meta-analysis has been conducted to synthesize the literature and examine the differences in the attentional orienting triggered by those two types of cues. Therefore, the main goal of our work is to review and meta-analyse this literature systematically. Given the increasing amount of research and the ongoing questions regarding this topic, there is an evident need for a combined analysis of the different effects and for examining the moderator variables across studies to better understand this phenomenon.

Birmingham and Kingstone (2009a) propose that even when evidence does not clearly capture the distinction between gaze and arrows, the intuition that gaze is special must be correct, but using the classical gaze-cueing paradigm (or the perspective-taking task) as a measure may not allow capturing the real aspects that reflect the uniqueness of the gaze. According to them, these tasks measures both types of stimuli in a dimension with an evident similarity: the property of indicating directional information (Gibson & Kingstone 2006). Furthermore, social cues might trigger both shared-with-arrows and unique attentional orienting mechanisms (Hemmerich et al., 2022; Marotta et al., 2019). Marotta et al. (2012) argued that instead of looking for quantitative differences between non-social and social cues, it might be more productive to analyse qualitative differences distinguishing between non-social and social attentional mechanisms to investigate the unique components of the latter.

In the present research, we first performed a meta-analysis of all the behavioural evidence (from spatial cueing and perspective-taking paradigm) about quantitative differences between the attentional orienting triggered by eye-gaze and arrow stimuli. There are at least two important reasons why it is relevant to discern the potential usefulness and / or limitations of the cueing task in detecting cue-specific attentional effects. First, the cueing paradigm is a classic procedure for decades used as an experimental cornerstone for triggering, measuring and characterizing shifts of social attention. Second, the data produced by this task (and others like the "perspective taking" procedure) has been instrumental in establishing the theoretical division between social and non-social attention.

After the meta-analysis on quantitative differences, we review the literature with other tasks aiming at demonstrating qualitative differences between gaze and arrow stimuli. In these studies, gaze and arrows are used either as cues but looking at qualitatively different modulations on target processing (perceptual or post-perceptual effects), or as targets, looking at qualitatively different processes incidentally triggered by these two types of cues. The review of the whole literature reinforces the view that although attentional mechanisms elicited by gaze and arrows might trigger similar orienting effects like in the spatial cueing paradigm, they might also involve qualitatively different processes, which can only be revealed through precisely targeted experimental designs.

In the last sections, we discuss a theoretical framework suggesting the existence of both shared and dissociable attentional effects between these two types of stimuli. In particular, shared processes would be linked to their similar ability to communicate directional information, whereas "social-specific" processes would be exclusively involved in attention to eye-gaze and probably related to its ability to convey intention and mentalizing phenomena.

Meta-analyses of quantitative differences between gaze and arrows in cueing effects

Method

Search Strategy

A systematic review was conducted following the recommendations of Preferred Reporting Items in Systematic Reviews and Meta-Analyses (PRISMA; Moher et al., 2009). We consulted PubMed, ProQuest, Scopus, and Web of Science using the following search syntax: ("cueing" OR "attentional” OR “orienting" OR "implicit mentalizing" OR "perspective taking t*") AND (("social" OR "eye*" OR "gaze*" OR "avatar") AND ("symbolic" OR "arrow" OR "nonsocial" OR "non social" OR "nonsocial")). The latest search was carried out in November 2021 and included all articles written in English that were published before that date with no time restrictions.

Inclusion Criteria

The studies selected in the review had to meet the following criteria:

1. Empirical articles written in English that contained a sample of adult participants with no cognitive impairment or brain damage;

2. The studies used both social and nonsocial stimuli as a central cue in experimental tasks, regardless of whether they were tasks traditionally used in cueing paradigms (i.e., detection, localization, and discrimination tasks) or other types of tasks (e.g., go/no-go);

3. The studies included the results for both types of cues (i.e., arrow and eye gaze) in the same publication, either manipulated within or between participants (i.e., both cues were presented to the same group of participants or different groups), either within or between blocks (i.e., both cues intermixed in each block or separate into different blocks);

4. Arrows or eye gaze were not the target in the task;

5. The studies included reaction times (RT) as a behavioral measure and contained sufficient information to calculate at least one effect size;

6. The participants of the study did not suffer from neurological or psychiatric conditions.

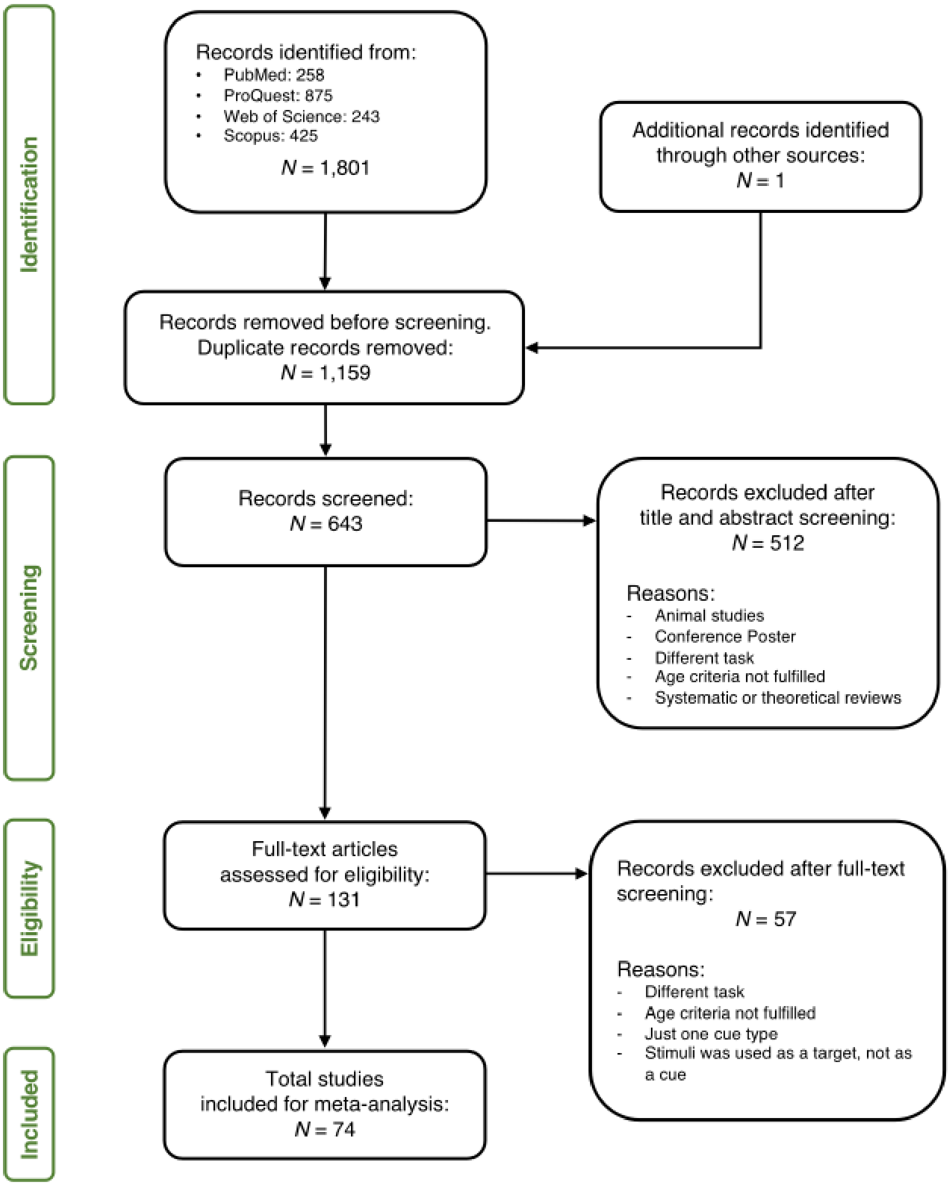
When using the implicit metalizing paradigm, we only considered the implicit version, in which participants responded from their perspective, thus ignoring the perspective of the irrelevant avatar.

Study Selection

In total, 1,802 potential articles were identified (see **Figure 2**). After removing duplicates, 643 articles were partially screened by JACC in order to exclude the articles that were not related to the topic or did not meet the inclusion criteria, remaining 131 studies to assess for eligibility. Two authors (JACC and AM) independently appraised the selected studies' suitability by reading the whole article. Any discrepancies were resolved by consulting a third author (JL), and subsequently having a consensus. Finally, 74 articles met the required criteria and were included in the meta-analysis, 67 for arrow/gaze cueing and 7 with visual perspective tasks.

Figure 2

PRISMA flowchart of the selection of articles included in the systematic review and meta-analysis.



Statistical Analysis

Effect Size

Mean RTs and standard deviations were recorded for valid and invalid trials for each type of cue and each stimulus onset asynchrony (SOA). We used the unbiased one-sample Cohen's *d* (g_z; Lakens, 2013) as the main estimator of the effect size,

$$g_z = \frac{M_{\text{invalid}} - M_{\text{valid}}}{\sqrt{SD^2_{\text{invalid}} + SD^2_{\text{valid}} - 2 \times r \times SD_{\text{invalid}} \times SD_{\text{valid}}}} \times \left(1 - \frac{3}{4n-5}\right),^2$$

(1)

where M_{invalid} and M_{valid}, and SD_{invalid} and SD_{valid} represent the mean RTs and the standard deviations in invalid and valid trials, respectively, *r* the correlation between the scores in both types of trials, and *n* the number of participants. The variance of g_z was calculated following the formula:

$$V_{g_z} = \frac{1}{n} + \frac{g_z^2}{2n}.$$

(2)

Positive values of g_z represent faster responses for valid than invalid trials (i.e., classic cueing effect), negative values represent slower responses for valid than invalid, and values close to zero represent no cueing effect. As *r* is rarely reported, we assumed a correlation of .70 based on previous studies with arrow and gaze cueing tasks in our laboratory (Chacón-Candia et al., 2019). However, we conducted a sensitivity analysis using alternative values of *r* to test the robustness of the findings ($r = .60$ and $r = .80$). In the studies in which the *SD*s for the individual SOAs were not available, we imputed the overall *SD* (97 of the total of 327 outcomes). We conducted the main analyses with and without the outcomes we estimated using this imputation process to prove the robustness of

[2] When means and standard deviations where not available and F value or t value were reported, we respectively estimated g_z as $g_z = \sqrt{\frac{F}{n}} \times \left(1 - \frac{3}{4n-5}\right)$ and $g_z = \frac{t}{\sqrt{n}} \times \left(1 - \frac{3}{4n-5}\right)$.

the findings. Moreover, moderator analysis was conducted only with the outcomes in which all the necessary information was available in the study.

Although g_z offers a standardized estimate of the difference between invalid and valid trials, which allows the comparison across experimental paradigms, we also conducted the analyses with the raw mean difference ($D = M_{invalid} - M_{valid}$) for informative purposes. The variance of D was calculated following the formula:

$$V_D = \frac{SD^2_{invalid} + SD^2_{valid} - 2 \times r \times SD_{invalid} \times SD_{valid}}{n}. \quad (3)$$

Meta-Analysis, Heterogeneity and Moderator Analysis: Cueing Tasks

Due to the inclusion of within-participant designs and the estimation of the effect in each SOA separately, most of the studies contributed with more than one effect size from the same sample. Thus, we used robust variance estimation (RVE; Hedges et al., 2010) that deals with correlated structures of outcomes estimating the correlation matrix and setting the weights according to, in our case, a correlated structure. RVE has shown to be accurate even with a small number of studies (m = 10) and when they include a large number of dependent estimates each (k = 10; Hedges et al., 2010). We used the *robumeta* package for R (Fisher et al.,2017) to implement RVE with small-sample corrections (Tipton, 2015). In addition, we computed the usual heterogeneity indexes, τ^2 and I^2.

First, we studied the difference in the cueing effect size triggered by eye gaze and arrows, fitting an overall meta-analytic model with tasks that had a similar design to the seminal paper by Friesen and Kingstone (1998): *classic-design* and *similar-to-classic-design tasks*. The characteristics of the classic-design tasks were:

a. Arrows or eye gaze were used as a central non-predictive cue (i.e., the target appeared on 50% of trials at the cued location);

b. Cue was displayed together with the target until the participant's response;

c. The target was a simple stimulus (e.g., a letter or geometric shape);

d. The task was a detection, localization, or discrimination task;

e. There was no other distracting stimulus in the task.

In addition, similar-to-classic-design tasks added some variation in:

a. The inclusion of distractor stimuli, as some of them included distractors simultaneous with the target onset;

b. The predictiveness of the cue, making the gaze/arrow cue predictive (> 50% of chance to predict the target location);

c. Cue duration, using brief cues (≤ 300 ms) instead of displaying it until the participant's response;

d. Type of target, using a complex or realistic stimulus instead of a letter or geometric figure as usual.

Outlier studies were identified fitting a multilevel model with the *rma.mv()* function of *metafor* (Viechtbauer, 2010) and estimated the studentized residuals (> 2) and Cook's distance (> $4/(n - 1)$). Apart from the difference between the arrow and gaze cueing, we assessed then the influence of the following moderating variables on effect sizes:

1. Between- or within-block manipulation of cue type;

2. Between- or within-group manipulation of cue type;

3. SOA, as a linear predictor with only one slope, or alternatively, with two different slopes (i.e., piecewise linear predictor), one for SOAs up to 200 ms (considered an early stage of attentional shifting in which cueing effect reaches its peak value; Friesen & Kingstone, 1998) and a second

slope for all SOAs longer than 200 ms [β_1SOA +$\beta_2\lambda$(SOA − 200); where β_1 and β_2 are the two slopes, and λ is a dummy variable with a value of 0 for SOAs ≤ 200 ms, and 1 for greater values];

4. Percentage of catch trials;
5. The average age of the sample;
6. Task type (detection, localization, or discrimination task);
7. Complexity of eye gaze stimulus (simple/schematic vs. realistic/photograph);
8. Year of publication of the study. A visual inspection suggested the presence of two different slopes for this moderator, a negative one for the studies published before 2011 and a second slope for the publications after that year [β_1Year +$\beta_2\lambda$(Year − 2011)];
9. The inclusion of distractor stimuli;
10. The predictiveness of the cue;
11. Cue duration (short: ≤ 300 ms vs. long: > 300 ms). Additionally, we assessed the hypothesis that cueing effect results from a spatial conflict between the spatial dimensions conveyed by the cue and the target (cue direction and target location; Green et al., 2013). For that purpose, we added the interaction between cue period of presentation and SOA to the model, for what the spatial-conflict hypothesis predicts no cueing effect with short cues in any SOAs (i.e., zero slope), whereas long cue displays would trigger larger cueing effects in shorter SOAs.
12. Type of target (simple vs. complex or realistic stimulus).

We examined the influence of all these moderators, fitting a backward stepwise selection ($\alpha_{exclusion}$ = .05) with them.

Finally, we assessed the differences between arrow and eye gaze cues when they were counterpredictive (*counterpredictive tasks*) and presented immediately before the target onset in tasks different to detection, localization, and discrimination (such as working memory or go/no-go tasks; *other tasks*).

Meta-Analysis, Heterogeneity and Moderator Analysis: Visual Perspective Tasks

As in cueing paradigms, we used RVE meta-analysis to assess the between-cue differences in the consistency effect. The visual perspective paradigms have used two types of nonsocial cues (Santiesteban et al., 2014; Wilson et al., 2017): (a) stimuli inherently directional such as arrows, with which participants have previous long-term learning of the contingency between the cue direction and target position (Ristic & Kingstone, 2012) and produce spatial orienting in non-predictive designs; and (b) symbolic cues, which require that the directional meaning is learned and, in general, only produce a shift of attention in predictive designs. Therefore, we analyzed the cue interference considering three categories: "social", "nonsocial directional", and "nonsocial symbolic". We conducted the analyses only with self-perspective trials, as the interference during other-perspective conditions has always a social nature (i.e., the perspective of the participant). We followed the same procedure as in cueing paradigms to identify outlying studies. Finally, the influence of the following variables was assessed:

1. Between- or within-block manipulation of cue type;
2. Between- or within-group manipulation of cue type;
3. Between- or within-block manipulation of the perspective (self- vs. other-perspective);
4. Percentage of filler trials;

5. The average age of the sample;
6. Year of publication of the study.

In contrast with cueing paradigms, the used perspective tasks had similar design characteristics, such as the type of target stimuli that were colored geometric figures in all the analyzed studies. This fact substantially reduces the number of moderating variables that we could assess (for more information about the characteristics of the studies using visual perspective tasks, see **Table S3**).

Publication Bias

Multiple factors of the publication procedure can affect the results of a meta-analysis. Studies reporting significant and large effect sizes are more likely to be published (Carter et al., 2019). One popular approach is plotting the individual effect sizes (*x* axis) against their standard error and visually inspecting the symmetry of the funnel-shaped distribution (i.e., funnel plot). Otherwise, an asymmetric distribution can be a sign of publication bias, with missing studies in non-significant regions of the plot. In addition, we added to the model the standard error of the effect size as a moderator (Egger et al., 1997; Stanley & Doucouliagos, 2014) to assess the statistical significance of the asymmetry and to adjust the final effect size for small-study effects. We fitted a multilevel meta-regressive model using RVE to consider the dependence among effect sizes coming from the same sample of participants (Fernández-Castilla et al., 2019; Friese et al., 2017; Rodgers & Pustejovsky, 2020). In addition, we used a modified formula of the sampling variance ($W_{g_z} = \frac{1}{n}$) to prevent the artefactual dependence between the effect size and its precision estimate (Pustejovsky & Rodgers, 2019), as the traditional estimation of V_g (Equation 2) includes effect size as a term in the formula.

Results

Meta-Analysis of Cueing Paradigms

Study Description

A total of 67 studies were included in the meta-analysis of arrow/gaze cueing, with 118 independent samples, 424 effects sizes, and 3374 participants in total. Among all the studies, 23 (1094 participants) were analyzed as using classic tasks, 24 (1160 participants) as similar-to-classic tasks (**Supplementary Material, Table S1**), 2 (107 participants) as counterpredictive tasks, 12 (622 participants) as other tasks (**Supplementary Material, Table S2**). Six studies (with 391 participants) used more than one type of task in the same sample or in separate experiments (Green et al., 2013; Gregory & Jackson, 2021; Gregory et al., 2017; Guzzon et al., 2010; Kuratomi et al., 2016; Pruett et al., 2011).

The participants included in the meta-analysis came from 12 different countries in Europe, Asia, North America, and Oceania, and their mean age was 26 years (SD = 9.9; range: 19.1–73.11 years). Regarding design characteristics, the studies used tasks with a mean of 109 trials per cue (SD = 75; range: 14–360 trials), and a mean cue-target asynchrony of 481 ms (SD = 417.6; range: 0–2000 ms). Most of the studies (79%) used simple targets, whereas 45% included schematic faces or eyes as an eye-gaze cue (vs. 55% of real or realistic faces/eyes). Most of the tasks were detection (29%), localization (38%), or discrimination paradigms (24%), with few studies using other types of tasks (go/no-go, 5%; working memory, 1.5%; categorization, 2.5%).

No difference Between the Magnitude of Arrow and Eye-Gaze Effects

The overall meta-analysis of the studies using classic tasks (for details of this categorization, see section above **«Meta-Analysis, Heterogeneity and Moderator Analysis »**) showed the traditional cueing effect, g_z = 0.42, 95% CI [0.33, 0.50], p < .0001; 11.2 ms, 95% CI [9.87, 12.50], which represents faster responses of the participants to valid targets than to invalid ones. This effect was not modulated by the type of cue, ⍰ = −0.001 p = .986, as both eye gaze, g_z = 0.37, 95% CI [0.27, 0.47], p < .0001, and arrows, g_z = 0.41, 95% CI [0.33, 0.49], p < .0001, produced cueing effects of similar magnitude. The same results appeared when we included the studies with similar-to-classic tasks in the analysis (gaze cueing, g_z = 0.44, p < .0001; arrow cueing: g_z = 0.48, p < .0001; between-cue difference, ⍰ = −0.06, p = .300).

However, the between-studies heterogeneity was high, τ^2 = 0.12; I^2 = 76.23%, probably because of the presence of studies with outlying outcomes and the influence of moderating variables. By examining the outcomes with classic and similar-to-classic tasks, we identified two studies contributing with implausibly large effect sizes (gs > 2.5 or < −1; Guzzon et al., 2010; Pino et al., 2015). After removing those studies and all the outcomes in which we used any imputation process to estimate them, we detected two additional outlier studies (Bonato et al., 2008, Slessor et al., 2014) based on their studentized residuals and Cook's distance. The meta-analysis of the remaining outcomes showed identical positive gaze and arrow cueing effects (g_z = 0.44 and g_z = 0.48, respectively), but reduced heterogeneity, τ^2 = 0.09; I^2 = 70.55%.

Moderator and Publication Bias Analyses

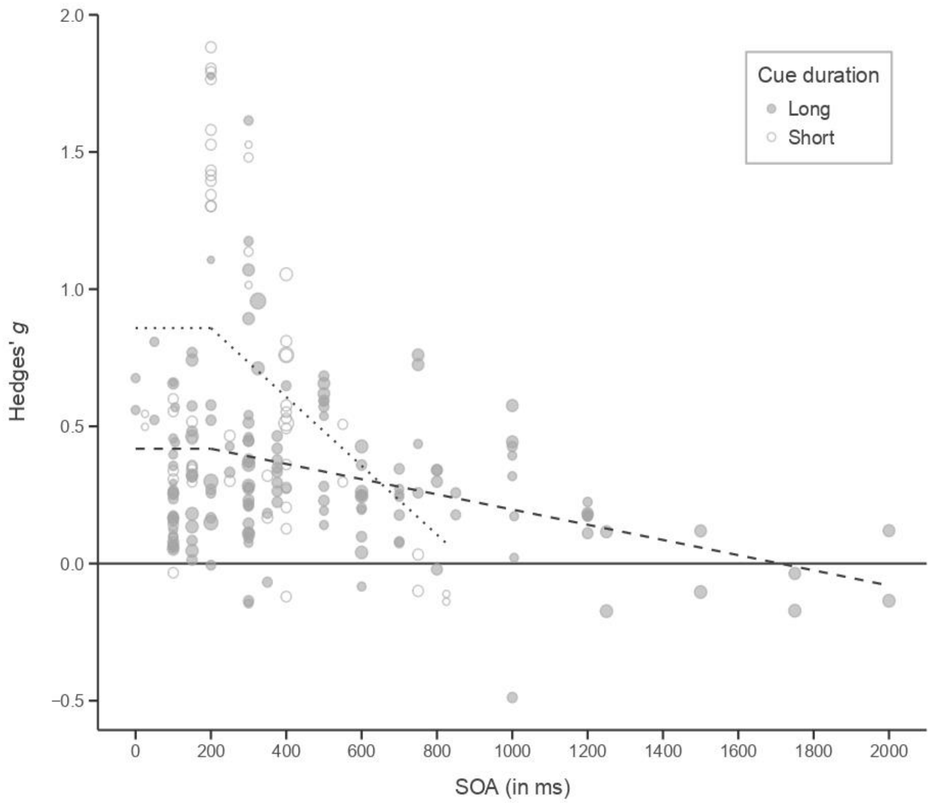
We carried out a backward stepwise selection ($\alpha_{exclusion}$ = .05) with all the moderators to determine which combination of variables provided the best fit for the data. The best meta-regressive model retained $SOA_{>200\ ms}$, type of task, year of publication (with two slopes), cue duration, and cue duration × $SOA_{>200\ ms}$ (residual heterogeneity: τ^2 = 0.04; I^2 = 49.90%; **Table 1**). The model suggests that, from an SOA of 200 ms, the cueing effect with both gaze and arrow decreased progressively as the cue-target interval increased. This reduction in the magnitude of the effect was more pronounced with short cues (≤ 300 ms of duration) compared to long cues (**Figure 3**). In addition, the use of short cues, and discrimination and localization tasks (in comparison to detection tasks) triggered larger overall cueing effects.

Table 3. Results of the best meta-regressive model in cueing paradigms with (bottom) and without (top) a specific term for publication bias ($\sqrt{W_g}$ × *Before/After 2011*).

Moderator(s)	*F*	*df*	*p*	
Best meta-regressive model (~ SOA$_{> 200\ ms}$ + Type of task + Year of publication + Year of publication$_{after\ 2011}$ + Cue duration + Cue duration × SOA$_{> 200\ ms}$				
SOA$_{> 200\ ms}$	6.16	1, 9.67	.033	β = −0.0002
Type of task	9.06	2, 29.70	< .001	Discrimination (vs. detection): β = 0.11 Localization (vs. detection): β = 0.36
Year of publication + Year of publication$_{after\ 2011}$	5.60	2, 22.60	.011	β_1 = −0.04; β_2 = 0.03
Cue duration	8.26	1, 23.50	.008	Short cue (vs. long): β = 0.42
Cue duration × SOA$_{> 200\ ms}$	6.89	1, 6.88	.035	β = −0.001
Best meta-regressive model using $\sqrt{W_g}$ × Before/After 2011 (~ SOA$_{> 200\ ms}$ + Type of task + $\sqrt{W_g}$ × Before/After 2011 + Cue duration + Cue duration × SOA$_{> 200\ ms}$)				
SOA$_{> 200\ ms}$	8.26	1, 8.94	.019	β = −0.0002
Type of task	6.19	2, 33.10	.005	Discrimination (vs. detection): β = 0.06 Localization (vs. detection): β = 0.29
$\sqrt{W_g}$ × *Before/After 2011*	3.28	1, 23.10	.083	β = 0.73
Cue duration	6.28	1, 22.10	.020	Short cue (vs. long): β = 0.38
Cue duration × SOA$_{> 200\ ms}$	5.71	1, 7.17	.047	β = −0.001

Figure 3

Decrease of the standardized cueing effect with SOA.

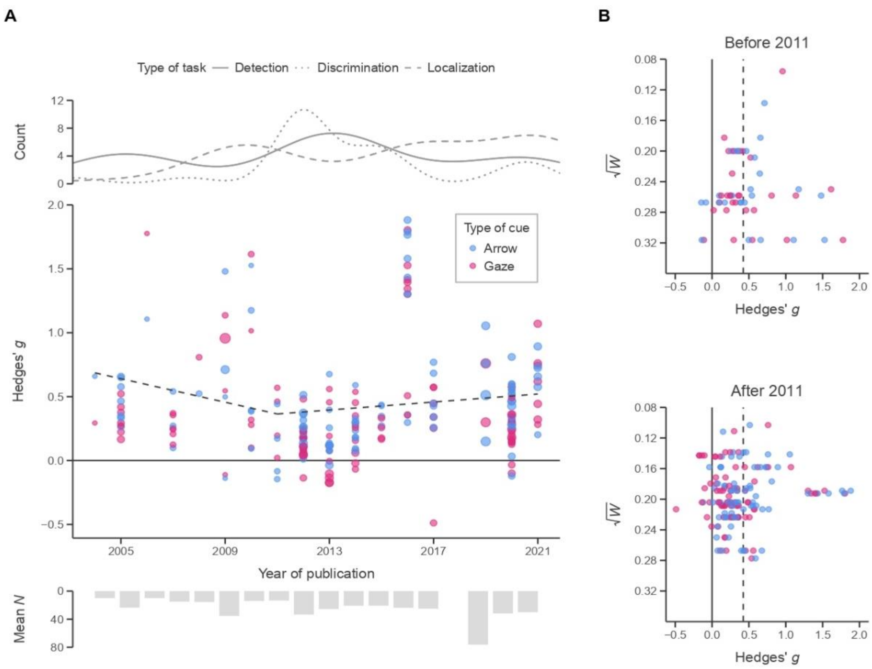


Note. Filled circles represent studies using cues with long duration, whereas empty circles represent short cues (≤300 ms of duration). The size of the circles was proportional to the number of participants contributing to the effect. Dashed and dotted lines show the decrease in the cueing effects with long and short cue displays, respectively.

A surprising result was that the year publication also explained part of the between-studies variance. Specifically, the cueing effect size was larger in the initial period of investigation of this literature (i.e., the 2000s) and, after that, the effect became smaller to stabilize at $g_z \approx 0.4$ since 2011 (**Figure 4A**). An explanation for this result is that there was a higher degree of publication bias during the first decade of research than in the second. In fact, the average sample size of the studies has linearly increased over the years, r = .57, p = .018. The standard error of the effect size ($\sqrt{W_g}$; see **2.5. Publication Bias**) can be used to model if the reporting process favored the publication of small studies (i.e., with higher standard error), finding large positive outcomes over small studies with null or negative results. Therefore, when we included in the model the interaction of standard error of the effect sizes with a dichotomous variable before/after 2011 ($\sqrt{W_g}$ × Before/After 2011), the year of publication was no longer a significant moderator. When we substituted the year of publication by this interaction in the best meta-regressive model, the higher the standard error in studies reported before 2011, the larger the cueing effect [F(1, 23.10) = 3.28, p = .083; **Table 1** and **Figure 4B**]. However, it was not the case for the studies published after 2011.

Figure 4

(A) Distribution of standardized cueing effects along years. (B) Funnel plots of the studies before and after 2011.

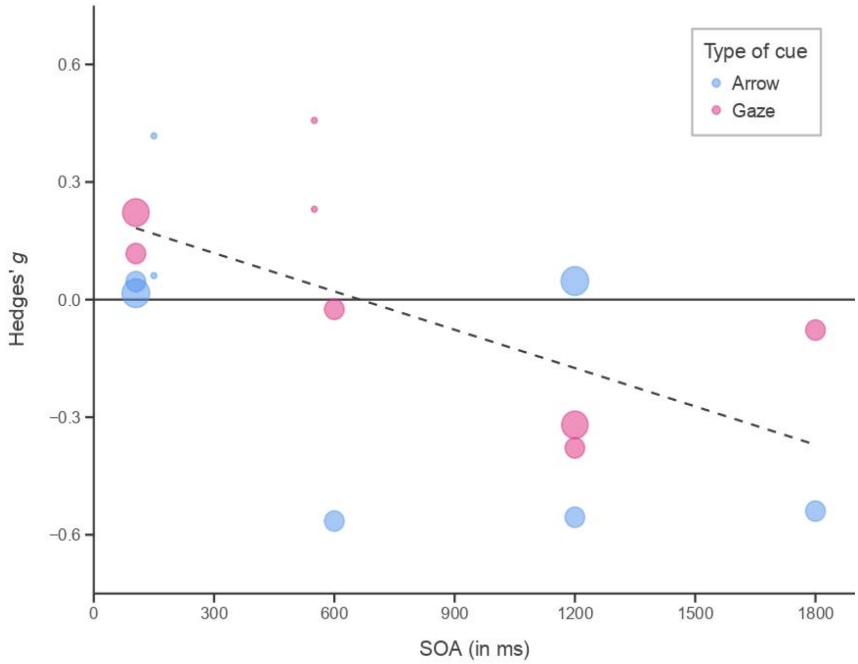


Note. A) Before 2011, cueing effect, regardless with an arrow or eye gaze, was progressively reduced, probably because of a higher degree of publication bias (i.e., small-study effects) in the initial period of investigation of this literature. The size of the circles was proportional to the number of participants contributing to the effect. B) Before 2011, asymmetric distribution of effect sizes is apparent, with more effects in the positive region.

Finally, the lack of difference between gaze and arrow cues in the cueing effect also appeared in the counterpredictive and in other tasks (respectively $\beta = 0.10$, $p = .667$; and $\beta = 0.05$, $p = .625$). In the case of counterpredictive tasks, the cueing effect was positive immediately after the cue onset (i.e., faster responses for valid than invalid targets), $g_z = 0.12$, 95% CI [−0.01, 0.25], $p = .059$; 6 ms, 95% CI [1, 12]; representing a reflexive attentional shift to the cued location regardless of the predictiveness of the cue. After that early stage (here, less than 200 ms of SOA), the cueing effect became negative as the SOA increased (but similarly for both cue types, $\beta = 0.10$, $p = .667$; **Figure 5**), indicating that participants voluntarily used the cue to predict the target in the opposite side to the cued location. On the other hand, the studies that used other types of tasks showed a positive effect similar to the present with classic or similar-to-classic tasks, $g_z = 0.44$, 95% CI [0.32, 0.56], $p < .0001$; 22 ms, 95% CI [16, 28].

Figure 5

Distribution of standardized cueing effects along SOA with counterpredictive tasks.



Note. Whereas the cueing effect was positive immediately after the cue onset, the outcome became negative as the SOA increased with both gaze and arrow. The size of the circles was proportional to the number of participants contributing to the effect.

Meta-Analysis of Visual Perspective Paradigms

Study Description

We identified a total of 7 studies that examined between-cue differences with the visual perspective task and met our inclusion criteria (**Supplementary Material, Table S3**). They included 21 independent samples, with 30 effects sizes and 730 participants in total. In contrast to cueing studies, the studies with visual perspective tasks were carried out in only three countries (UK, USA, and Austria), and the participants in all of them were university students. Regarding design characteristics, the studies used tasks very homogeneous in design, following the characteristics of two of the first studies in the literature (Samson et al., 2010; Santiesteban et al., 2014). Human avatars were used as social cues, arrows or arrowheads as directional nonsocial cues, and colored rectangles or sticks as symbolic nonsocial cues. Half of the included effect sizes came from social cues (53.3%), whereas 33.3% and 13.3% of the effects were respectively obtained with directional and symbolic nonsocial cues. In all the studies, the targets were colored geometric figures (0 to 3; mainly, red dots), and the task of the participants was to answer "yes" or "no" the number of target stimuli was the same as a digit previously displayed (except Kronbichler et al., 2019, in which the participants had to count the number of boxes displayed). Whereas some tasks asked the participants only from their self-perspective (19%), most of the tasks included trials where the participants had to respond from their self-perspective and the perspective of the cue (other-perspective trials). The experimental paradigms had a mean of 83 trials per cue (SD = 22; range: 48–102 trials).

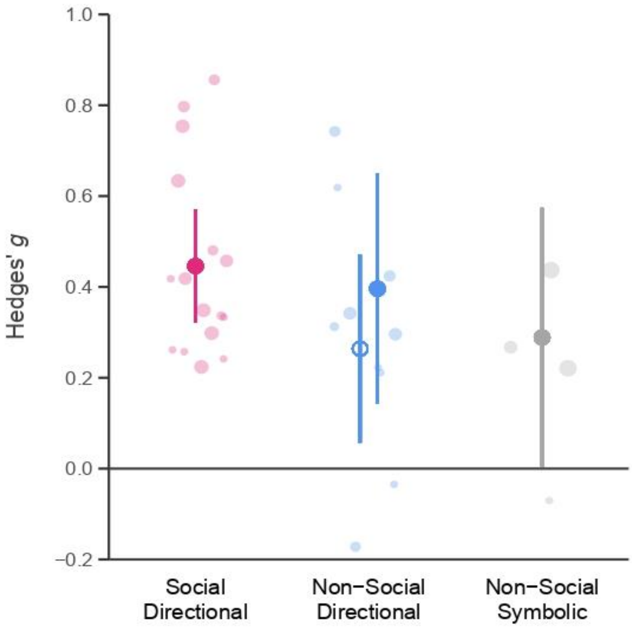
No Difference Between the Magnitude of Arrow and Avatar Consistency Effects

The pooled effect of the studies using visual perspective task showed the expected consistency effect, g_z = 0.39, 95% CI [0.28, 0.49], $p < .0001$; 64 ms, 95% CI [43, 86], indicating faster responses of the participants to consistent trials than to inconsistent ones. In contrast to cueing tasks, heterogeneity was low, τ^2 = 0.02; I^2 = 38.77%.

The type of cue did not significantly interact with the consistency effect, $F(2, 7.55) = 2.49$, $p = .148$, although its magnitude for social cues was numerically larger, g_z = 0.49, 95% CI [0.35, 0.63], $p < .0001$, than for nonsocial directional, g_z = 0.29, 95% CI [0.07, 0.52], $p = .015$, and nonsocial symbolic cues, g_z = 0.27, 95% CI [−0.02, 0.56], $p = .056$ (**Figure 6**). When we constrained the analysis to the comparison between human avatar and arrow cues, we found no between-cue difference, $F(1, 7.18) = 0.83$, $p = .393$, as the magnitude of the consistency effects with both stimuli were very similar (avatar: $g_z = 0.49$, 95% CI [0.35, 0.63]; arrow: $g_z = 0.40$, 95% CI [0.14, 0.65]).

Figure 6

Standardized consistency effects of perspective tasks regarding the type of cue.



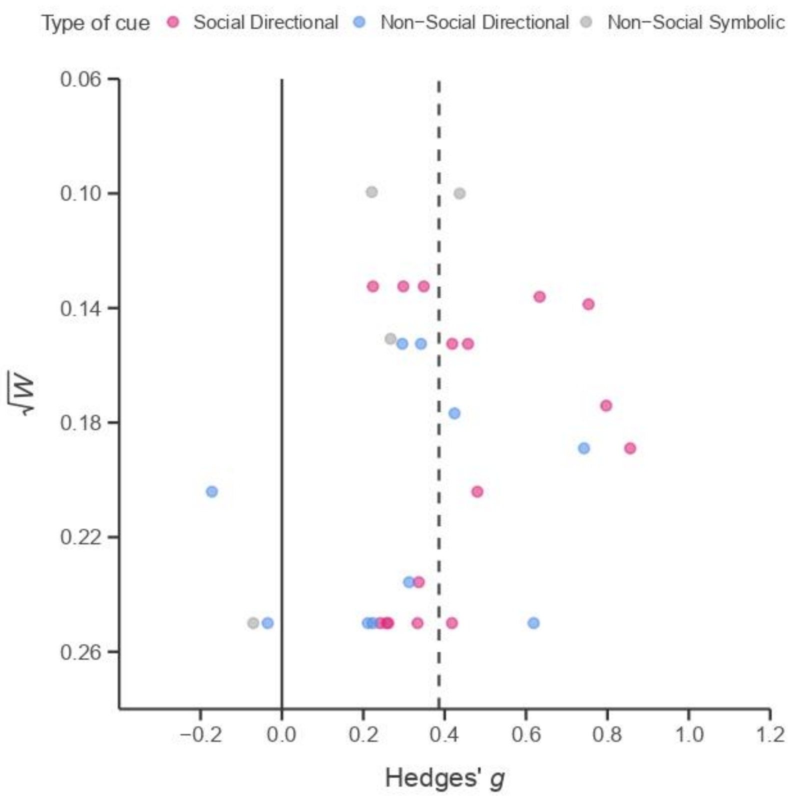
Note. Individual effect sizes are depicted in a lighter color. The size of the circles was proportional to the number of participants contributing to the effect. The filled circle in non-social directional cues represents the pooled effect size just with arrow cue, whereas the empty circle is the overall effect, including other stimuli than arrow. The error bars represent the 95% confidence interval.

Moderator and Publication Bias Analyses

Following a similar procedure to cueing tasks, the backward-stepwise model ($\alpha_{exclusion} = .05$) did not retain any moderator. When assessed individually (i.e., fitting a model with just one moderator), no moderator reached statistical significance explaining the between-studies variance. We also found no evidence of publication bias including $\sqrt{W_g}$ in the model: β = −1.03, p = .246 (**Figure 7**).

Figure 7

Funnel plot of the studies using visual perspective tasks.



Note. The dashed line represents the overall effect size.

Discussion

The present meta-analysis showed that cueing and visual perspective effects were robust and similar for gaze and arrows (g_z around 0.4). This lack of differences remained regardless of multiple variations in the task design, such as classic and similar-to-classic cueing designs as well as counterpredictive cueing paradigms or other versions of the task (e.g., working memory or go/no-go). Moreover, the meta-analysis revealed some key factors that moderate the observed effect, especially in cueing paradigms, with more available evidence. One of them is the interval between the cue and target onset. Individual studies about the effect of cue duration on eye-gaze cueing effects have previously yielded inconclusive results. While one study reported a rapid gaze cueing effect only when the cue overlapped in time with the target (Green et al. 2013), another study showed significant cueing effects for both gaze cues that overlapped in time with the target and for gaze cues that were removed before target presentation (Gayzur et al. 2014). Our results showed that cueing effects triggered by both gaze and arrows cues are smaller with a greater temporal distance. Short and sudden cues (i.e., ≤ 300 ms) also trigger a larger cueing effect but tend to decrease more markedly with longer cue-target intervals. It seems, therefore, that the facilitatory effect of gaze and arrow cues is long-lasting when they are presented until response as usual in classic designs (Friesen & Kingstone, 1998). Finally, the cueing effect in discrimination and localization tasks was greater than in detection tasks.

Importantly, similar results have also been observed in a recent comprehensive meta-analysis on gaze cueing (McKay et al., 2022a), where larger gaze-cueing effects emerged with localization tasks and shorter SOAs, and numerically for short gaze cues (0.31 vs. long gaze cues: 0.24; p = .119). Interestingly, however, the critical results of the present study showed that the moderating variables observed in McKay et al.'s meta-analysis are not limited to the gaze-cueing paradigms but fully shared with arrow-cueing paradigms. Crucially, then, these moderating variables are not representative of a specific modulation of "social attention" since a similar modulating effect has been observed in the present study when nonsocial arrow cues were considered.

The finding that cueing effects are present with both short and long cues speaks against the hypothesis according to which they are the consequence of a spatial conflict between cue direction and target location (Green et al., 2013; see also Crump et al., 2008). This hypothesis predicts that as long as the cue direction is not present with short cue displays, there is no spatial dimension conflicting with the target location and the cueing effect would not emerge. In contrast, we found even a larger effect with short cues with SOAs below 600 ms.

Another finding of relevance to understanding the mechanism underlying cueing effect is that both arrows and gaze produced a facilitatory effect for short SOAs (around 100–200 ms) in counterpredictive paradigms (e.g., the target is more likely to appear in the location opposite to the one indicated by the cue). Previous studies about the effects of counterpredictive design on gaze and arrow cueing have produced inconsistent findings. Friesen et al. (2004) showed that, with this type of design, attention shifts to the unpredicted, but signalled cued locations were only observed when eye gaze was used as a cue, but not when the indicated location was cued by an arrow. However, using the same counterpredictive paradigm, Tipples (2008) found that both eye and arrow cues produce similar reflexive shifts of attention, while Guzzon and colleges (2010; Experiment 1) observed an early (i.e., from 100 ms) advantage for the predicted, although spatially not signaled, positions for both eye gaze and arrow cues. Results of the present meta-analysis are consistent with the idea that eye gaze and arrow cues produce similar reflexive shifts of attention since a significant and early cueing effect (around 100–200 ms) was observed with both types of cues in counterproductive paradigms.

Therefore, taken together these findings seem to suggest that the cueing paradigm produces quantitatively similar attentional effects for social and nonsocial directional cues (however, for a study showing a significant difference see Ristic et al., 2007 [3]). As both types of stimuli convey similar spatial information about the direction in which they are looking at or pointing to, it is not surprising that the observed effect was quantitatively the same. Despite the attempts to measure differences in social cognition with the quantitative outcome of cueing effect, it seems that cueing effect fundamentally acts as a more general measure of spatial attention.

Hence, the quantitative approach may be not sufficient to understand if there are any differences between arrow and gaze cues that could be related to social cognition. The use of a qualitative-differences methodology seems more suited to provide a broader insight onto social attention.

Qualitative difference approaches to investigate orienting effects by social and non-social cues

Attentional target selection after gaze vs. arrow cueing

In order to explore qualitative differences in the attentional mechanisms triggered by eye gaze and arrows, variations of the classic gaze cueing paradigm have been used. For example, using a variant of the double-rectangle task (Egly, Driver, & Rafal, 1994), Marotta and cols. (2012) used a paradigm in which, besides a central non-predictive arrow or gaze cue, two rectangles were presented on the scene. At difference with Egly et al's procedure, however, the rectangles were tilted +45º or −45º from the vertical meridian so that one edge of each rectangle was positioned either to the left or to the right of the fixation point, i.e., at the typical locations in the standard cueing paradigm, whereas the other ends were below or above fixation (see **Figure 8A**). After the presentation

[3] Supporting the view that gaze cueing can be considered more reflexive than arrow cueing, Ristic, Wright, and Kingstone (2007) showed that only attentional orienting triggered by arrow cues is sensitive to arbitrary cue-target color contingencies (i.e., it occurs when the cue and target share the same color), while gaze cueing is not. However, this study is the first and only one that ever assessed the effect of cue-target color contingencies on both gaze and arrow cueing effects, and it is essential to replicate and extend this result to other procedures.

of the cue (see **Figure 8A** for details of the procedure), a target letter appeared ("X" or "O") inside of one of the ends of the presented object-rectangles, i.e., either to the left, right, above or below the fixation point. In order to analyse the classical attentional effect produced by eye gaze and arrows (general cueing effect), the authors compared the trials in which the target appeared at the position congruently indicated by the cue or in the opposite direction. Results indeed showed, congruently with the above meta-analysis, similar general cueing effects for arrow and gaze cues.

Moreover, and importantly, to explore the attentional effect produced by those orienting stimuli in the entire object (object-based cueing effect), responses to targets appearing at the same signaled object but in the location opposite to the cued end were compared to those appearing at the non-cued object, either above or below fixation. The results showed qualitatively different results for arrows and gaze. Thus, by cueing a portion of an object, attention seemed to spread across the entire object when arrows were used as cues (i.e., faster responses were observed at the cued than at the uncued object), while attention seemed to be restricted to the specific portion of the cued object when using eye-gaze cues, as no difference was observed between cued and uncued object locations (see Chacón-Candia et al., 2020, for a replication). Interestingly, gaze cues did elicit object-based attentional orienting in a different procedure in which a gazed object moved to a different location before the target was presented (Marotta et al., 2013). Therefore, these findings suggest that although the effects of both arrows and eye-gaze cues seem to be mediated by object-based processes, only gaze seems to produce an extra effect that restricts attention specifically to the part of the object that is looked at, thus avoiding spreading of attention to the whole object. This notion seems to be supported by observations by Vuilleumier (2002) and Wiese et al. (2013), who showed that when reference placeholders are presented on the scene, gaze cues seem to orient attention only to the exact gazed-at placeholder, whereas arrow cues seem to orient attention to the whole group of placeholders (Chacon-Candia et al., under review). These findings seem to indicate a “special” aspect of gaze attentional orienting, perhaps mediated by theory-of-mind processes, which might automatically activate the intention to attend to one specific side of one object, thus automatically keeping attention at this gazed-at location and avoiding its spreading over the whole object.

Further dissociations have been observed between arrows and gaze when looking at the consequences of cueing the placeholder object. Here it is important to note that when one of the placeholders is cued by a peripheral exogenous cue (e.g., the presentation of an asterisk in the placeholder, or the brightening of its outline) a facilitation effect is observed at the cued location at short cue-to-target SOAs, similar to that observed with arrow and gaze cues, whereas at longer SOAs responses are slower at the cued than the uncued location, leading to the well-known inhibition of return (IOR) effect (Posner & Cohen, 1984). This effect is considered a consequence of the automatic target selection triggered by the peripheral cue, and the subsequent cost of selecting again the same object when the target later appears at the cued location (Lupiáñez et al., 2013).

Interestingly, whereas IOR has not been observed with central arrows as cues, Frischen and Tipper (2004) reported that when using long enough gaze-target intervals, responses were slower at the gazed-at than at the opposite location, leading to an IOR effect with gaze. This effect was later replicated (Frischen et al., 2007), at the same time that the general procedure for observing an IOR effect with gaze cues was established: apart from a very long SOA (longer than 2000 ms), it seems necessary that another stimulus be presented at fixation between the gaze cue and the target. The special nature of this IOR effect triggered by central gaze is revealed by the fact that it does not emerges until 9 years of age (Jingling et al., 2015), whereas 6-month-old infants already show IOR with peripheral cues (Clohessy et al., 1991). Interestingly, Marotta et al., (2013) later showed that whereas typically developing adolescents showed an

IOR effect for both peripheral and central gaze cues, the group of participants with Asperger's disorder only showed the effect with peripheral cues. At clear difference from their age-matched controls, they showed no IOR effect for gaze cues.

In summary, both arrows and gaze seem to similarly orient attention in the indicated/gazed at direction. However, whereas attentional orienting following arrows involuntarily spread over the indicated surface, when attention is oriented following gaze, it seems to be restricted to the gazed location. Furthermore, gazing seems to induce the automatic selection of the object or part of the object, thus later leading to IOR. However, such a sophisticated way of processing faces that leads to IOR effects seems to only emerge later in adolescence, likely through the maturation of the social attention system.

Processes beyond target selection after gaze vs. arrow cueing

In addition to just orienting attention, maybe also as a consequence of object selection, eye-gaze cues, in comparison to arrows, seem to produce extra effects beyond attentional selection. Thus, experimental procedures that have measured consequences of attentional orienting beyond the basic facilitation in responses to targets and their attentional selection have also found qualitative differences between attentional orienting triggered by arrows and gaze.

Indeed, research in joint attention has shown that gaze influences language development and object learning (Morales et al., 1998; Mundy & Newell, 2007), extending its effects beyond perception to learning and memory. These effects have been tested in the social attention literature by combining the standard cueing paradigm with other tasks measuring post-perceptual processes. For instance, Gregory and Jackson (2017) have compared the effects of arrow and gaze cues on visual working memory. As represented in **Figure 8B**, participants performed a standard cueing task with arrows or gaze cues (in different experiments) indicating either the same or opposite location where a group of colored squares (4, 6, or 8) was presented for 100 ms. Then the squares and the cue disappeared and, after a period of 1000 ms, a single square was presented at fixation. Participants had to answer whether the square had been shown before or not. Once again, previous pilot studies showed that both arrows and gaze produced a similar cueing facilitation effect on the cued targets when participants had to quickly respond to them, as shown in the above meta-analysis. Importantly, however, gaze, but not arrows, additionally showed better posterior working memory performance for the cued squares, so that gazed squares seemed to be more easily retained in working memory than those appearing at the non-cued position. No effect of arrow cueing was observed on working memory performance.

In a subsequent study by the same authors (Gregory & Jackson, 2018) the same working memory task was used to investigate the effects of barriers between the gazing face and the memory display (i.e., the set of squares to be kept in working memory). When the barriers were open, the previous pattern of results was replicated with better working memory for the gazed than the non-gazed squares, but not when the barriers were closed. Interestingly, however, no effect of barriers was observed when a typical gaze cueing paradigm was used, participants having to respond to the gazed or non-gaze target: responses were faster to gazed targets, no matter whether the barriers were open or closed.

The effect of gaze on working memory seems to be quite robust, as it has been recently replicated once more in young and older adults by Gregory and Kessler (2021). Furthermore, similar results have been found when testing long-term memory using words as targets (Dodd et al., 2012). The authors used a standard cueing paradigm in which either an arrow or gaze (in different experiments) was presented at fixation indicating either the left or right location where a word could be presented (for a total of 32 words presented, one on each trial). In several experiments, the authors observed that more words were recalled from the gazed than the non-gazed location, provided that an SOA shorter than 1000 ms was used, and no matter whether participants had the intention to memorize the words, or they were incidentally encoded (i.e., when long term memory was evaluated in a surprise test). No such effect was observed when gaze was substituted by arrows. Thus, although both arrows and gaze speed responses to indicated targets, as repeatedly seen with cueing tasks, eye gaze seems to further influence the subsequent target processing up to encoding into short and long-term memory.

As an additional post-perceptual effect of gaze, some authors have found that gaze but not arrows influence how objects are later valued (Bayliss et al., 2006). In their study, Bayliss et al. asked participants to perform a standard arrow or gaze cueing task (in different experiments) in which one object was presented on each trial, either at the gazed/indicated or the opposite location, and participants had to categorize objects as fast as possible. After 5 blocks of gaze cueing trials, in the sixth final block, after categorizing each object, participants were asked to rate how much they liked it. Despite the similar cueing effects for arrow and gaze cues, objects that had been cued by gaze, but not by arrows, were judged as more likable than the non-gazed ones. This "gaze-liking effect" should nevertheless be taken with caution, as later attempts to replicate the effect have been inconsistent, and a recent preregistered replication report by Tipples and Pecchinenda (2019) showed a close to zero, much smaller than the original, effect.

In conclusion, even if gaze and arrows produce quantitatively analogous attentional orienting effects on target perception in standard cueing tasks, there seem to be several qualitative differences between gaze and arrows linked to effects on subsequent post-perceptual processing of the target specifically triggered by eye gaze.

Arrows vs. Gaze as targets instead of cues

All the above paradigms have shown qualitative differences between gaze and arrows cues by using variations of the cueing paradigm where the social or nonsocial stimuli acted as a cue to orient attention towards a target that had to be detected, discriminated, or located, but added additional manipulations that allowed measuring extra processes beyond target perception on which qualitative differences between social and nonsocial cues could be observed. But perhaps the clearest evidence for qualitatively dissociating attentional mechanisms between eye gaze and arrows is observed by using a spatial interference task, in which the critical social or nonsocial stimuli are used as targets instead of as cues.

In the typical spatial interference (or Spatial Stroop; Logan, 1980) task, participants must identify the direction, right or left, of a lateralized directional stimulus (e.g., an arrow or a word), while ignoring its location. The stimulus is also presented either to the right or the left of a fixation point leading, as shown in **Figure 8C**, to congruent trials when direction matches the stimulus location (e.g., right-pointing arrows displayed on the right) and incongruent ones when direction and location do not match (e.g., right-pointing arrows displayed on the left). Contrary to cueing paradigms, stimuli's direction, instead of signaling a location of a potential incoming target, becomes the target itself. With this paradigm, responses are typically slower on incongruent than congruent trials, leading to the so-called spatial interference or Spatial Stroop effect. This spatial congruency effect produced by arrows or words is explained by the interference generated between the relevant spatial dimension of the target (i.e., the directionality of the arrow) and its irrelevant spatial dimension (i.e., the location in which it is presented) (Kornblum et al, 1990).

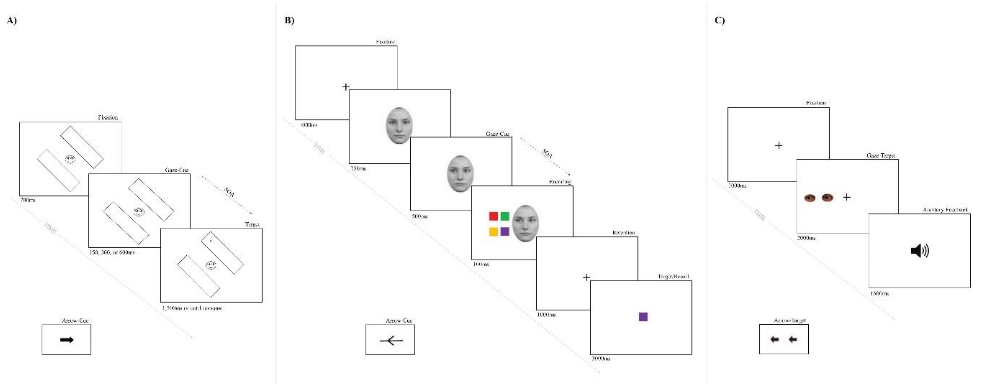
Cañadas and Lupiáñez (2012) used this paradigm but with social stimuli (full faces or cropped eyes) instead of nonsocial arrows or words, and showed reversed congruency effect, i.e., slower responses and more errors for congruent than incongruent trials. Later, Marotta et al., (2018) compared social (i.e., eye gaze) and nonsocial (i.e., arrows) within the same experiment (in different blocks of trials) and observed opposite congruency effects for social and nonsocial targets: whereas a standard spatial congruency effect (i.e., faster responses for congruent than incongruent targets) was observed for arrows, a reversed congruency effect (i.e., slower responses for congruent than incongruent targets) was observed for eye gaze. This opposite effect has been extensively replicated (Ishikawa et al., 2021; Jones, 2015; Marotta et al., 2019; Román-Caballero et al., 2021a, b; Torres-Marín et al., 2017) even when presenting either social or nonsocial targets randomly within the same block of trials (Aranda-Martín et al., 2022; Hemmerich et al., 2022).

The reverse congruency effect observed for social targets is not related to the lateralization of the response, as it can be also observed with verbal responses; however, it is required that participants explicitly pay attention to gaze direction for the effect to be observed (Narganes-Pineda et al., 2022). Indeed, no reverse congruency effect is observed if participants respond to another irrelevant aspect of the eyes like their color. Furthermore, the effect seems to be modulated by the emotional expression of the target face (Jones, 2015; Marotta et al., 2022; Torres-Marín et al., 2017), thus emphasizing its social nature. Interestingly, the effect seems to require a mature social attention system, as it does not appear until early adolescence (Aranda-Martín et al., 2022), as in the case of IOR for gaze cues above described.

In a recent study, apart from the usual behavioral measures, event-related brain potentials were analyzed to disentangle intermediated processes involved in the effects observed in this paradigm with arrows and gaze. Interestingly, whereas early potentials (P1, N1, and N170) showed similar congruency modulations by both gaze and arrow stimuli, opposite modulations were observed for gaze and arrows in later components (N2 and P3) (Marotta et al., 2019). This finding seems to suggest the existence of both shared and dissociable attentional effects between eye gaze and arrow stimuli. The shared component with arrows (that would lead to a standard congruency effect) seems to be reverted with gaze by a larger opposite effect, thus leading to the overall reversed congruency effect observed with gaze. The fact that gaze produces the same attentional orienting effect as nonsocial stimuli (as in the standard gaze cueing task) and an extra social attention effect has been reinforced by the finding that when the component shared with arrows is reduced by presenting the target surrounded by a background (Román-Caballero et al., 2021a), the reversed congruency effect observed with gaze is increased (Román-Caballero et al., 2021b). Similarly, when arrows and gaze are mixed within a block of trials, the gaze reversed congruency effect is increased after an arrow incongruent trial (Hemmerich et al., 2022), which is known to eliminate the standard congruency effect (Braem et al., 2014). The fact that the congruency effect observed for gaze (and that observed for arrows) is modulated by the previous gaze or arrow congruency shows that both social and nonsocial stimuli share a domain-general mechanism. However, as opposite congruency effects are observed for gaze and arrows, gaze must add a specific mechanism that reversed the final observed effect.

Figure 8

Illustration of the trial sequence of the main tasks that qualitatively differentiate between arrow and gaze stimuli.



Note. A) Double rectangle central cueing task (Marotta et al., 2012); B) Central cueing + Working Memory task (Gregory & Jackson, 2017); C) spatial interference task (social and non-social target; Marotta et al., 2018). The examples represent for each task a congruent trial with social stimuli as a cue (panels A and B) or as a target (panel C). An illustration of the non-social stimuli used in each task is represented at the bottom part of each panel.

Discussion

Considering the evidence reported above, in which qualitative rather than quantitative attentional differences between social and nonsocial stimuli are investigated, the possibility that only a domain-general attentional orienting mechanism is involved in processing both arrows and gaze stimuli appears to be challenged. Instead, the evidence seems to favor the idea that biologically relevant stimuli such as eye gaze convey qualitatively unique attentional processes. Thus, although both social and nonsocial cues similarly orient attention in the indicated/gazed at the direction, only when attentional orienting is triggered by gaze it is restricted to the gazed location. Indeed, when the social attention system is sufficiently matured, gazing, but not arrows, seems to induce the automatic selection of the object or part of the object, as to lead to an IOR effect. Finally, subsequently to target selection, other post-perceptual processing effects seem to be specifically triggered by eye gaze, such as better encoding in working memory or long-term memory. It is suggested that these specific attentional orienting effects triggered by eye gaze could be due to the attribution of intentions that we may automatically assign to other people's gaze (Marotta et al., 2012).

Automatic attribution of intention to gaze could also underlie the results reported in the spatial interference task mentioned above (Marotta et al., 2018). Although both social and nonsocial stimuli share the capacity to automatically direct attention, the automatic attribution of intentionality to eye gaze on congruent trials (i.e., eyes presented on the right looking to the right), could be orienting the focus of attention to a potential object of interest away from fixation, leading to a sort of "distraction" (e.g., slowdown of the response due to the active searching of the potential target). Alternatively, the fact that gaze is looking to the fixation point on incongruent trials (i.e., eyes presented on the right looking inwards), where the participant is also looking might generate an additional effect related to joint attention (Edwards et al., 2020). In any case, this additional effect triggered by gaze would revert the domain-general attentional effect produced by both arrows and gaze, as to produce the reported reversed congruency effect observed with gaze (Hemmerich et al., 2022).

General Discussion

Results of our meta-analysis clearly show that, in spite of generating a large amount of data and a notably increased interest in multiple fields of research (Dalmaso et al., 2020), the spatial cueing paradigm produces the same attentional effects for social directional cues, such as gaze, and nonsocial directional cues, such as arrows. This challenges the largely extended intuition that social stimuli are special in modulating human attention, with gaze cueing being the prototypical paradigm to measure this special nature of gaze compared to other nonsocial attention orienting cues. The large amount of data above meta-analysed clearly refutes this idea, which has led some researchers to postulate that gaze might rather trigger a domain-general attentional orienting mechanism (Santiesteban et al, 2014).

However, as Birmingham and Kingstone (2009b) proposed, an alternative explanation is possible: the supposed exceptionality of eye gaze as an attentional stimulus is correct, but the cueing paradigm may not be able to highlight the characteristics of the eyes that differentiate them from other nonsocial cues like arrows. Indeed, with the cueing paradigm, eyes and arrows have generally been compared with respect to a dimension in which they are very similar, namely their ability to communicate directional information (Gibson & Kingstone, 2006). This explains why the same variables that moderate the gaze cueing effect in the recent meta-analysis by McKay et al. (2022a) also moderate the spatial cueing effect in our meta-analysis, for both arrow and gaze cues. It will be important to investigate whether the age of participants, which seems to clearly modulate the gaze cueing effect (McKay et al., 2022b) also modulates the spatial cueing effect with arrows. Interestingly, other more social in nature variables, like the social status attributed to the face, seems to modulate the standard gaze cueing effect (Zhang et al., 2020), but such manipulation cannot be made with arrows.

This view that a similar gaze cueing effect is observed for gaze and arrows is supported by the growing literature showing that cueing effects similar to gaze cueing can be observed for different types of biological and non-biological stimuli carrying directional information. For instance, Liu et al. (2021) found that a brief presentation of a central point-light walker walking toward either the left or right direction produced reflexive attention effects that were indistinguishable from gaze cueing effects. Quadflieg et al. (2004) observed similar automatic orienting both in response to the eye direction of schematic images of animate faces (human, monkey, chimpanzee, and tiger) and in response to the direction of eyes embedded in inanimate objects (apple, glove). Ristic and Kingstone (2005) showed that cars with wheels that resembled eyes produced automatic shifts of attention when participants were told they contained eyes. It is also known that the magnitude of digit cues produces an attentional number line effect in cultures that read from left to right (Dehaene et al., 1993), so the perception of small numbers (e.g., 1 and 2) leads to faster response times for targets on the left than targets on the right side of fixation (Fischer et al., 2003; Ristic et al., 2007; but see Colling et al, 2020). Similar results have been observed for temporal cues meaning past and future actions (Ouellet et al., 2010). These findings seem to suggest that any stimulus carrying either direct or metaphorical directional information can elicit a spatial orienting of attention, and support the view according to which the orienting induced by social cues reflects a domain-general orienting mechanism in response to directional information rather than a specialized social cognition mechanism. However, this is like considering that a traffic officer and a traffic light are the same thing, i.e., have the same nature. They are the same in regulating traffic at a junction by means of a stop-and-go signaling system, but there is an intuition that they are not the same in many other ways. However, we should approach this question by asking them to do other things, i.e., those in which they are different by nature, to observe differences.

A qualitative approach to investigating social attention

Such a different approach to study whether eye gaze and arrows engage different attentional mechanisms would be to explore their qualitatively different effects on information processing. The logic here is that the attentional differences between gaze and arrow cues might be regarding the nature rather than the size of the attentional orienting induced by each cue type in a standard general cueing paradigm.

Indeed, eye gaze could have a dual nature. On the one hand, from a perceptual point of view, eye-gaze stimuli, just like arrows, indicate a certain spatial position in the surrounding environment. Therefore, it is not surprising that when used in the classic version of the cueing task, its behavioral and even neural effects are very similar to those observed in response to arrows (Brignani et al., 2010; Callejas et al., 2014). On the other hand, in a more complex social contexto and unlike arrows, eye gaze would represent the spatial indication of a social agent with his own intentions, interests, and desires, likely leading to additional specific effects.

Therefore, it seems reasonable to hypothesize the presence of social modulatory processes such as theory of mind, joint attention, the being watched phenomenon, and others, exclusively involved in attention to eye gaze (Stephenson et al., 2021). In other words, although attentional mechanisms elicited by arrows and eye-gaze stimuli might involve overlapping sets of processes (i.e., their ability to communicate directional information) and may manifest in similar behavioural profiles, they might also involve a non-overlapping set of processes, which might be distinguished through precisely targeted experimental designs.

For example, the above-reviewed evidence shown by several authors (Marotta et al., 2012; Vuilleumier, 2002; Wiese et al., 2013; & Chacón-Candia et al., 2022) suggest that when reference objects are presented on the scene, gaze-cues trigger an attentional orienting specifically to the exact gaze-at object or part of the object looked at. Following gaze, attention might not only be oriented in the indicated direction; the selection of the looked-at location or object might be completed following gaze, thus leading to the above-described specific benefits of gazing beyond perception, in long-term (Dodd et al., 2012) and working memory (Gregory and Jackson, 2017, 2018; see also Gregory and Kessler, 2021). Furthermore, once the looked-at object is de-selected, it will later capture less attention, thus leading to an IOR effect, as described above. These effects seem to reflect a "special" aspect of gaze attentional orienting that may be mediated by theory-of-mind processes, as a consequence of a specific intention automatically attributed to gaze but not to arrows. On the other hand, the results offered by Bayliss and colleagues (2006), when measuring how much participants liked the target shown in the cueing task, suggests that eye-gaze stimuli -unlike arrows- are interpreted as an intentional cue that may indicate interest and desire, influencing the perceived value of cued targets.

Perhaps the findings from the spatial interference task (Marotta et. al., 2018) are the ones that more clearly suggest the existence of both shared and dissociable attentional effects for eye gaze and arrow stimuli. As outlined above, on the one hand, shared processes linked to the stimulus' pointing direction and its spatial location would lead to either congruent or incongruent responses, therefore producing similar spatial conflict. On the other hand, additional "special" processes would take place in the case of eye gaze, reverting the nature of the spatial conflict. Several pieces of evidence are consistent with this view. First, it has been shown that variables that are known to reduce spatial conflict effects with arrows, such as the complexity of target background segregation (Román-Caballero et al., 2021a, 2021b), or the incongruence of the previous trial (Hemmerich et al, 2022), simultaneously increase the reversed congruency effects observed for gaze. Moreover, the developmental study by Aranda-Martín et al. (2022) showed that the classic congruency effect was present in 4-years-olds for both arrows and gaze. Thus, for children of that age gaze worked as arrows in this study. However, while the effect of arrows didn't change throughout childhood and adolescence, the reversion of the congruency effect of gaze seems to emerge progressively for gaze, becoming evident in early adolescence. Finally, electroencephalographic evidence using this task (Marotta et al., 2019) has shown similar modulation of early event-related components (P1, N1, and N170) and a subsequent opposite modulation over later components (N2 and P3). This suggests that earlier perceptual and developmental stages of stimuli processing tackle the conflict through similar mechanisms. However, later stages differ according to the type of stimulus generating the conflict, maybe as a consequence of a more sophisticated social interpretation of eyes, which is added in later processing and developmental stages to their initial processing as directional stimuli.

Eye-gaze stimuli trigger additional processes apart from the orienting of attention

Taking into consideration all the evidence reported in the previous section, it is difficult to maintain that social attention exclusively reflects the operation of domain-general mechanisms that only respond to stimulus directionality. The fact that eye gaze and arrows can modulate information processing differently when used as cues, and produce opposite spatial interference effects when used as targets, supports the view that these two kinds of stimuli might trigger different processes. However, although a strict interpretation of the domain-general account may be disregarded, there are several possibilities to explain the different effects triggered by eye gaze and arrows.

It might be that the two types of cues tap two attentional mechanisms that are completely different in nature and work quite independently of each other. However, contrary to this hypothesis is the existence of some commonalities among the processes triggered by both types of cues, as shown by our meta-analysis of the spatial cueing literature. Indeed, the presence of eye gaze and arrows may trigger similar orienting in order to indicate a certain spatial location in the environment around us.

An alternative framework could be the existence of both shared and dissociable attentional effects between these two types of stimuli, the main difference between the two being the fact that the eye gaze constitutes and/or is provided by a social agent. Due to inferring, mentalizing, and interpreting processes, which only occur in the case of eye-gaze stimuli, additional effects on information processing might be triggered by this type of stimuli, apart from the orienting of attention. Thus, although both nonsocial and social cues might trigger first-order processes related to the encoding of directionality of cues and subsequent attentional orienting, second- and third-order processes related to joint and shared attention mechanisms would be exclusively triggered by gaze (Stephenson et al., 2021).

The same reasoning has been applied to other types of social orienting, like the altercentric intrusion effect, i.e., the spontaneous adoption of an avatar's perspective and the subsequent orientation of attention in the same direction even when the aforementioned visual perspective is not relevant to the task (Capozzi et al., 2014). Here researchers questioned whether such interference of the avatar’s perspective is elicited by stimulus directionality (e.g., body orientation) or the interpretation of their visual perspective (what he sees or knows about the surrounding), and Capozzi and Ristic (2020) have proposed an integrated framework in which the attribution of mental states and the operation of domain-general attentional processes both contribute to altering centric intrusion effects.

In the case of the gaze cueing paradigm, we believe that once attentional control systems are initiated by the occurrence of either eye gaze or arrows cues, they may trigger a similar orienting process in order to select the spatial relevant location. However, once attention has been oriented towards the cued location, mentalizing processes may be exclusively triggered by eye-gaze stimuli modulating visual information processing. The involvement of mentalizing functions may represent a ‘‘special’’ feature because it may introduce, through precisely targeted experimental designs, a functional relation between the processing of observed eye gaze, observer characteristics, the contextual information, and/or the target, which with do not take place in the case of arrow stimuli.

Consistent with this view, some studies have shown that conservative, but not liberal, observers are more sensitive to the direction of gaze provided by the observed face of in-group political leaders than that provided by the face of out-group political leaders (Liuzza et al., 2011; see also Cazzato et al., 2015) and that this effect is reduced if the popularity of the group leader decreases (Porciello et al., 2016). Evidence also shows that even belonging to a certain racial group can influence gaze attentional mechanisms. In particular, a reduced gaze cueing effect for observed black faces has been observed in the white observer, being the different social status (typically higher for White than for Black individuals in Western countries) one of the principal causes of this race-based modulation of the gaze cueing effect (Pavan, et al, 2011; Weisbuch, et al., 2017; Zhang et al., 2020). These are only some evidence showing that mentalizing processes involving the relation between the observer and observed faces can modulate visual information processing (for a review, see Dalmaso et al., 2020).

As we stated above, these additional processes may contribute to the effects triggered by eye-gaze stimuli jointly with the orienting of attention. According to this view, studies reviewed in the previous section showed that attentional (i.e., response to gaze direction) and mentalizing (i.e., attribution of intention interest) processes can operate both simultaneously and independently. In particular, the majority of the tasks able to dissociate between eye gaze and arrows effects involved processes of inferring and interpreting the use of eye gaze, apart from the orienting of attention. Indeed, in these tasks, the eye gaze was 'functionally' related to the target objects in that it was a useful/ adaptive means of deducing desire, inference, and reference of the character. On the other hand, it is important to note that in the classic spatial cueing paradigm, the eye-gaze cue is only spatially related to the target object, and participants had simply to orient to the target and respond to it as fast as possible similarly to arrows and gaze. This may explain why similar effects between arrows and eye gaze have been generally observed by means of this task.

Consistent with the view according to which the cueing paradigm may not be picking up on social relevant characteristics of eyes, a preservation of social orienting measured by means of the classical gaze cueing paradigm, but an impairment ability to infer mental states and intentions from eyes have also been observed in a different clinical population with social cognition impairment such as autistic children (Rombough & Iarocci, 2013), individuals with Turner syndrome (Lawrence et al., 2003), bipolar patients (Marotta et al., 2015), and people at risk of depression (Bayliss et al., 2017).

Conclusion

In the present paper, we have considered a body of behavioral evidence that sought to examine the functional impact of directional eye gaze and arrow stimuli on attention. The meta-analyses of the cueing and perspective-taking paradigms literatures indicate that eye gaze and arrows produce equivalent attentional effects, which questions the potential utility of the classic cueing task in revealing social-specific attentional effects. On the other hand, growing evidence from literature investigating the nature and the qualitative differences of the attentional modulation induced by eye gaze and arrows seems to suggest the existence of both shared and dissociable attentional effects between these two types of stimuli. In particular, it has been suggested that shared processes are linked to their similar ability to communicate directional information, whereas "social-specific" processes exclusively involved in attention to eye gaze are probably related to its ability to convey intention from gaze and mentalizing phenomena.

Supplementary Material

Table S1. Characteristics of the studies using cueing tasks with classic and similar-to-classic designs.

Study	*N*	Age	Country	Design group	Type of task	Between-/ within-block	Between-/ within-participant	Cue duration	SOA	Eye-gaze complexity	Target complexity	Predictiveness	% catch trials	Distractor
Akiyama et al., 2006	15	53.3	Japan	Classic	Detection	Between	Within	Until response	100, 300, & 700	Schematic	Simple	Non-predictive (50%)	5.3	No
Akiyama et al., 2007	15	45	Japan	Classic	Detection	Between	Within	Until response	0, 100, & 500	Schematic	Simple	Non-predictive (50%)	5.3	No
Akiyama et al., 2008	22	51.2	Japan	Classic	Detection	Between	Within	Until response	100, 300, & 700	Schematic	Simple	Non-predictive (50%)	5.3	No
Bayliss & Tipper, 2005; Experiments 1 & 2	50	22	UK	Similar-to-classic	Detection	Within	Within	Until response	376	Realistic	Other	Non-predictive (50%)	14.3	Yes
Bayliss et al., 2005; Experiments 1 & 3	120	21.5	UK	Classic	Discrimination	Between	Between	Until response	100, 300, & 700	Realistic	Simple	Non-predictive (50%)	0	No
Blair et al., 2017; Experiments 1 & 2	50	20.3	Canada	Classic	Detection	Between	Within	Until response	300 & 700	Schematic	Simple	Non-predictive (50%)	6	No
Bonato et al., 2008	26	23.6	Italy	Similar-to-classic	Detection	Within	Within	150	200, 350, 550, & 800	Schematic	Simple	Non-predictive (50%)	15.8	No
Bonmassar et al., 2019; Experiments 1 & 2	40	24	Italy	Similar-to-classic	Discrimination	Between	Within	Until response	250 & 750	Realistic	Simple	Non-predictive (50%)	0	Yes
Bonmassar et al., 2021	25	29.5	Italy	Similar-to-classic	Discrimination	Between	Within	Until response	250 & 750	Realistic	Simple	Non-predictive (50%)	0	Yes
Capellini et al., 2019; Experiments 1 & 2	161	24	Italy	Classic	Discrimination	Between	Between	Until response	200	Realistic	Simple	Non-predictive (50%)	0	No
Catalano et al., 2020	29	46.6	USA	Similar-to-classic	Localization	Within	Within	150	150, 250, 350, & 750	Schematic	Simple	Non-predictive (50%)	0	No
Chacón-Candia et al., 2020	52	20.9	Spain	Classic	Discrimination	Within	Within	Until response	150, 300, & 600	Schematic	Simple	Non-predictive (50%)	0	No
Ciardo et al., 2019	32	23	Italy	Classic	Discrimination	Between	Within	Until response	200	Schematic	Simple	Non-predictive (50%)	0	No
Dalmaso et al., 2013	18	49	Italy	Classic	Detection	Between	Within	Until response	200 & 700	Schematic	Simple	Non-predictive (50%)	20	No
Dalmaso et al., 2015	23	25.4	Italy	Classic	Discrimination	Between	Within	Until response	200 & 700	Schematic	Simple	Non-predictive (50%)	0	No

Table S1 (continued). Characteristics of the studies using cueing tasks with classic and similar-to-classic designs.

Study	*N*	Age	Country	Design group	Type of task	Between-/ within-block	Between-/ within-participant	Cue duration	SOA	Eye-gaze complexity	Target complexity	Predictiveness	% catch trials	Distractor
Engell et al., 2010	16	25.8	USA	Similar-to-classic	Localization	Within	Within	600	300	Realistic	Simple	Non-predictive (50%)	33.3	No
Galfano et al., 2012; Experiments 1A, 1B, 2A, 2B, & 3	129	23.3	Italy	Similar-to-classic	Detection & Discrimination	Between	Between	Until response	100 & 1200	Schematic	Simple	Non-predictive (50%)	33.3 & 0	Yes
Green et al., 2013	14	22.5	USA	Classic & Similar-to-classic	Detection	Between	Within	Until response	0, 100, 300, & 500	Schematic	Simple	Non-predictive (50%)	10	No
Greene et al., 2009	10	24	USA	Similar-to-classic	Localization	Within	Within	125	25 & 825	Schematic	Simple	Non-predictive (50%)	0	No
Gregory & Jackson, 2021; Experiment 1	40	21	UK	Classic	Localization	Between	Within	Until response	150, 300, 500, 750, & 1000	Realistic	Simple	Non-predictive (50%)	0	No
Gregory et al., 2017; Pilots 1 & 2	44	University students	UK	Classic	Localization	Between	Between	Until response	150, 500, & 1000	Realistic	Simple	Non-predictive (50%)	0	No
Guzzon et al., 2010; Experiment 2	12	24.7	Italy	Similar-to-classic	Detection	Between	Within	100, 150, 200, & 250	50, 100, 150, & 200	Schematic	Simple	Predictive (80%)	5	No
Heimler et al., 2015; Experiments 1A & 2	37	26.3	Italy	Similar-to-classic	Discrimination	Between	Between	Until response	250 & 750	Realistic	Simple	Non-predictive (50%)	24	No
Hietanen et al., 2006	10	26	Finland	Classic	Detection	Between	Within	Until response	200	Schematic	Simple	Non-predictive (50%)	20	No
Ishikawa et al., 2021	26	22	Japan	Similar-to-classic	Localization	Within	Within	100, 300, & 700	100, 300, & 700	Realistic	Simple	Non-predictive (50%)	0	No
Joseph et al., 2014	20	20.2	USA	Classic	Localization	Between	Within	Until response	300	Realistic	Simple	Non-predictive (50%)	25	No
Ji et al., 2020; Experiments 4 & 5	32	22.2	China	Similar-to-classic	Localization	Between	Between	300	400	Realistic	Other	Non-predictive (50%)	0	No
Kawai, 2011; Experiments 1 & 2	27	University students	Japan	Classic	Localization	Between	Between	Until response	105, 300, 600, & 1005	Schematic	Simple	Non-predictive (50%)	0	No
Kuratomi et al., 2016; Experiments 1 & 2	40	21	Japan	Similar-to-classic	Localization	Between	Between	150	150 & 550	Realistic	Simple	Predictive (75%)	0	No
Langdon et al., 2005; Experiments 1, 2, 3, & 6	102	University students	Australia	Classic	Detection	Between	Between & within	Until response	100, 200, 300, 400, 500, 600, 800, & 1200	Realistic	Simple	Non-predictive (50%)	8	No

Table S1 (continued). Characteristics of the studies using cueing tasks with classic and similar-to-classic designs.

Study	*N*	Age	Country	Design group	Type of task	Between-/ within-block	Between-/ within-participant	Cue duration	SOA	Eye-gaze complexity	Target complexity	Predictiveness	% catch trials	Distractor
Langdon et al., 2017	28	34.1	Australia	Classic	Detection	Between	Within	Until response	100, 300, & 800	Realistic	Simple	Non-predictive (50%)	8	No
Lin, Ciu, Zeng & Huang, 2020; Low-AQ group & High-AQ group	47	20.8	China	Similar-to-classic	Detection	Between	Within	100	100 & 400	Realistic	Simple	Non-predictive (50%)	10	No
Liu et al., 2021; Experiments 1 & 2	40	24.5	China	Similar-to-classic	Localization	Between	Between	400 & 500	500 & 600	Realistic	Other	Non-predictive (50%)	0	No
Lockhofen et al., 2014	31	25	Germany	Classic	Detection	Within	Within	Until response	100 & 800	Realistic	Simple	Non-predictive (50%)	20	No
Marotta et al., 2012a; Experiments 1, 2, & 3	78	23	Spain	Classic	Discrimination	Between	Within	Until response	150, 300, & 600	Schematic	Simple	Non-predictive (50%)	4	No
Marotta et al., 2012b	48	23	Spain	Classic	Discrimination	Between	Within	Until response	150, 300, & 600	Schematic	Simple	Non-predictive (50%)	8	No
Marotta et al., 2014	20	26.3	Italy	Similar-to-classic	Discrimination	Between	Within	Until response	100, 350, & 850	Schematic	Other	Non-predictive (50%)	8	Yes
McDonnell et al., 2013; Experiments 2 & 4	89	University students	USA	Similar-to-classic	Detection	Between	Between	750	1250, 1500, 1750, & 2000	Realistic	Simple	Non-predictive (50%)	0	No
Morgan et al., 2014	20	University students	UK	Similar-to-classic	Detection	Between	Within	150	150	Schematic	Simple	Non-predictive (50%)	20	No
Narison et al., 2020	26	66.4	France	Classic	Localization	Between	Within	Until response	500	Realistic	Simple	Non-predictive (50%)	0	No
Pino et al., 2015	18	32.9	Italy	Similar-to-classic	Localization	-	Within	200	200	Realistic	Simple	Predictive (-)	0	No
Pruett et al., 2011; Experiment 1	26	23.9	USA	Classic	Detection	Within	Within	Until response	150 & 800	Schematic	Simple	Non-predictive (50%)	0	No
Quadflieg et al., 2004; Experiment 3	10	University students	USA	Classic	Discrimination	Within	Within	Until response	100	Schematic	Simple	Non-predictive (50%)	0	No
Sato et al., 2009	15	19.1	Japan	Similar-to-classic	Localization	Within	Within	300	300	Realistic	Simple	Non-predictive (50%)	0	No
Sato et al., 2010; Experiments 1 & 2	24	23.3	Japan	Similar-to-classic	Localization	Within	Within	100, 300, & 1000	100, 300, & 1000	Realistic	Simple	Non-predictive (50%)	0	No

Table S1 (continued). Characteristics of the studies using cueing tasks with classic and similar-to-classic designs.

Study	*N*	Age	Country	Design group	Type of task	Between-/ within-block	Between-/ within-participant	Cue duration	SOA	Eye-gaze complexity	Target complexity	Predictiveness	% catch trials	Distractor
Slessor et al., 2014; Studies 2 & 3: Young adults & Older adults	162	20.6 & 72.9	UK	Similar-to-classic	Localization	Between	Between	220	220	Realistic	Simple	Predictive (66.7%)	0	No
Stevens et al., 2008; Experiments 1A & 2A	31	University students	Canada	Classic	Discrimination	Between	Between	Until response	50	Schematic	Simple	Non-predictive (50%)	0	No
Uono et al., 2014	13	27.6	Japan	Classic	Localization	Between	Within	Until response	500	Realistic	Simple	Non-predictive (50%)	0	No
Vlamings et al., 2005	19	23.1	Netherlands	Similar-to-classic	Localization	Between	Within	400	400	Realistic	Simple	Non-predictive (50%)	0	No
Wang et al., 2019; Experiments 2 & 3	144	22.6	China	Similar-to-classic	Localization	Between	Within	300	400	Realistic	Other	Non-predictive (50%)	0	No
Wilkowski et al., 2009; Studies 1A & 1B	162	20	USA	Classic	Localization	Between	Between	Until response	50 & 600	Schematic	Simple	Non-predictive (50%)	0	No
Yan et al., 2016; Experiments 1A & 1B	82	21.3	China	Similar-to-classic	Localization	Between	Within	200	200	Schematic	Other	Non-predictive (50%)	6	No
Yokoyama et al., 2020	28	23	Japan	Similar-to-classic	Localization	Between	Within	Until response	300	Schematic	Other	Non-predictive (50%)	0	No

Table S2. Characteristics of the studies using cueing tasks with counterpredictive and other designs.

Study	*N*	Age	Country	Design group	Type of task	Between-/ within-block	Between-/ within-participant	Cue duration	SOA	Eye-gaze complexity	Target complexity	Predictiveness	% catch trials	Distractor
Borjon et al., 2011; Experiments 1 & 2	23	21.1	USA	Other	Localization	Between	Between	300	300	Realistic	Other	Non-predictive (50%)	0	No
Callejas et al., 2013; Behavioral & fMRI experiments	70	University students	USA	Other	Discrimination	Between	Within	Until response	1900	Realistic	Simple	Predictive (75%)	22.5	Yes
Dawel et al., 2015	75	19.8	Australia	Other	Categorization	Between	Within	Until response	300 & 700	Realistic	Other	Non-predictive (50%)	0	No
Friesen et al., 2004; Experiments 1 & 2	48	University students	USA	Counterpredictive	Detection	Between	Between	Until response	105, 600, 1200, & 1800	Schematic	Simple	Counterpredictive (8%)	8	No
Gregory & Jackson, 2021; Experiments 2 & 3	80	23.5	UK	Other	Localization & Discrimination	Between	Within	Until response	150, 300, 500, 750, & 1000	Realistic	Simple	Non-predictive (50%)	9	Yes
Gregory et al., 2017; Experiments 1 & 2	123	22.5	UK	Other	Working Memory	Between	Between	600	500	Realistic	Simple	Non-predictive (50%)	0	No
Guzzon et al., 2010; Experiment 1	12	23.9	Italy	Counterpredictive	Detection	Between	Within	100, 150, 350, & 550	50, 100, 300, & 500	Schematic	Simple	Counterpredictive (20%)	5	No
Ivanoff & Saoud, 2009; Experiments 1 & 3	47	-	Canada	Other	Go/No-go	Between	Between	Until response	100 & 600	Schematic	Simple	Non-predictive (50%)	0	No
Kuratomi et al., 2016; Experiments 1 & 2	40	21	Japan	Counterpredictive	Localization	Between	Between	150	150 & 550	Realistic	Simple	Counterpredictive (25%)	0	No
Manssuer et al., 2016; Experiments 1 & 2	81	22	UK	Other	Categorization	Between	Between	Until response	500	Realistic	Other	Non-predictive (50%)	0	No
Qian et al., 2020	24	24.6	China	Other	Detection	Within	Within	Until response	600	Realistic	Simple	Non-predictive (50%)	20	No
Ristic et al., 2007; Black-eyes, black-arrow, white-eyes, & white-arrow groups	80	-	USA	Other	Discrimination	Between	Between	105	315	Schematic	Simple	Non-predictive (50%)	0	No
Scheeren et al., 2007; Control parents, & parents with autistic child	50	42.8	Netherlands	Other	Go/No-go	Between	Within	400	400	Realistic	Simple	Non-predictive (50%)	0	No
Tipples, 2008; Experiments 1 & 2	59	21.1	UK	Counterpredictive	Detection	Between	Between	Until response	105 & 1200	Schematic	Simple	Counterpredictive (25%)	7	No
Zhao et al., 2014; Experiments 1 & 2	54	21.3	Japan	Other	Localization	Between	Within	Until response	200	Realistic	Other	Non-predictive (50%)	8	No

Table S2 (continued). Characteristics of the studies using cueing tasks with counterpredictive and other designs.

Study	*N*	Age	Country	Design group	Type of task	Between-/ within-block	Between-/ within-participant	Cue duration	SOA	Eye-gaze complexity	Target complexity	Predictiveness	% catch trials	Distractor
Zhao et al., 2015; Experiments 1A, 1B, & 2	75	21.4	Japan	Other	Localization	Between	Between & Within	Until response	200	Schematic	Other	Non-predictive (50%)	6	No
Zhao, Uono et al., 2017	21	23.7	Japan	Other	Localization	Within	Within	Until response	200	Schematic	Other	Non-predictive (50%)	8	No
Zhao, Li et al., 2017	22	23	Japan	Other	Localization	Within	Within	Until response	200	Schematic	Other	Non-predictive (50%)	0	No

Table S3. Characteristics of the studies using visual perspective tasks.

Study	*N*	Age	Country	Type of response	Between-/ within-block	Between-/ within-participant	Between-/within-block self-/other-perspective	Non-social Stimulus	Non-social stimulus type	Target stimulus	% filler trials
Conway et al., 2017; Experiments 1 & 3	100	24.5	UK	Yes/No	Between	Within	Only self-perspective	Arrow	Directional	Red & blue dots	7.7 & 4
Kronbichler et al., 2019	24	25.7	Austria	Count	Within	Within	Only self-perspective	Triangle	Directional	Colored boxes	11.1
Nielsen et al., 2015; Experiments 1 & 3	109	24.2	UK	Yes/No	Between	Between	Within	Arrow & dual-colored stick	Directional & Symbolic	Red dots	20
Samson et al., 2010	16	23.8	UK	Yes/No	Within	Within	Only self-perspective	Colored rectangle	Symbolic	Red dots	7.7
Santiesteban et al.,2014; Experiments 1 & 2	46	29.5	UK	Yes/No	Between & Within	Within	Within & Only self-perspective	Arrow	Directional	Red dots	0 & 7.7
Todd & Simpson, 2016; Experiments 2A & 2B	307	University students	USA	Yes/No	Between	Between	Within	Dual-colored stick	Symbolic	Red dots	0
Wilson et al., 2017; Experiments 1, 2, 3, & 4	128	University students	UK	Yes/No	Between	Between	Within	Arrow & Camera	Directional	Red dots	7.7

CHAPTER IV

Eye-Gaze direction triggers a more specific attentional orienting compared to arrows [4]

Abstract

Numerous studies have shown that eye-gaze and arrows automatically shift visuospatial attention. Nonetheless, it remains unclear whether the attentional shifts triggered by these two types of stimuli differ in some important aspects. It has been suggested that an important difference may reside in how people select objects in response to these two types of cues, eye-gaze eliciting a more specific attentional orienting than arrows. To assess this hypothesis, we examined whether the allocation of the attentional orienting triggered by eye-gaze and arrows is modulated by the presence and the distribution of reference objects (i.e., placeholders) on the scene. Following central cues, targets were presented either in an empty visual field or within one of six placeholders on each trial. In Experiment 2, placeholder-objects were grouped following the gestalt's law of proximity, whereas in Experiment 1, they were not perceptually grouped. Results showed that cueing one of the grouped placeholders spreads attention across the whole group of placeholder-objects when arrow cues were used, while it restricted attention to the specific cued placeholder when eye-gaze cues were used. No differences between the two types of cues were observed when placeholder-objects were not grouped within the cued hemifield, or no placeholders were displayed on the scene. These findings are consistent with the idea that socially relevant gaze cues encourage a more specific attentional orienting than arrow cues and provide new insight into the boundary conditions necessary to observe this dissociation.

Keywords: gaze cueing; arrow cueing; attentional selection; specific attentional orienting

[4] Chacón-Candia, J. A., Lupiáñez, J., Casagrande, M., & Marotta, A. Eye-Gaze direction triggers a more specific attentional orienting compared to arrows. Manuscript submitted for publication.

Introduction

The capacity to follow the focus of attention of another individual is of great importance for the development of social communication (Baron-Cohen, 1997; Tomasello, 1995).

In order to understand what others are paying attention to, we usually rely on information provided through non-verbal communication, such as gestures, postures, and the direction of the gaze (Langton et al., 2000). The perception, interpretation and evaluation of the information obtained through these sources help us inquire about other people's intentions and mental states and, consequently, anticipate their next step and increase the probability of successfully building social interactions (Capozzi & Ristic, 2018; Dalmaso et al., 2020; Emery, 2000). Together with other biologically relevant stimuli (Cooney et al., 2015; Langton et al., 200) averted gaze of another person can shift the observer's attention in the same direction as the observed gaze (e.g., Driver et al., 1999; Friesen et al., 2004; see Frischen et al., 2007 for review), allowing the establishment of "joint attention" (Butterworth & Jarrett, 1991). This behaviour has been considered highly beneficial to individuals and has been a crucial step in the development of social-communicative skills (Baron-Cohen, 1995; Bruner, 1958; Tomasello, 1995). For this reason, many studies have investigated the mechanisms underlying this phenomenon.

Friesen and Kingstone (1998) were the first to demonstrate that looking at eye-gaze will trigger the shift of our attentional focus into the gazed-at location. They used a variant of the classic visuospatial cueing paradigm (Posner, 1980) in which, at the centre of the screen, a schematic face appeared, gazing either straight ahead, left or right. The participants' task was to detect, locate or discriminate a target that would appear congruently at the gazed location or incongruently at the opposite one. They found that targets appearing at the congruent location were detected, located, or discriminated more quickly than targets appearing at the incongruent one. Since then, an increasing number of researchers have further studied this effect using the same or slight variations of this cueing paradigm. Results repeatedly demonstrated that even when gaze direction is not predictive of target location (e.g., Blair et al., 2017; Bonmassar et al., 2019; Marotta et al., 2012; Xu & Tanaka, 2015) or is counterpredictive (e.g., Driver et al., 1999), the gaze shift automatically directs the observer's attention to the same location indicated by it (see Frischen et al., 2007 for a review).

Based on these behavioural findings and the evolutionary and social significance of eye gaze (Emery, 2000), several authors have suggested that the attentional orienting triggered by the eye-gaze direction may represent a unique attentional process that can be differentiated from that produced by directional stimuli with no biological relevance, such as arrows (e.g. Friesen et al., 2004; Marotta et al., 2012, 2018) which have proven as well to facilitate attentional orienting, even if they are non-predictive (Hommel et al., 2001). In this regard, many studies have tried to answer whether arrow and gaze cues produce the same or different behavioural or neural effects, leading to mixed results, with some of them finding a significant difference between the two stimuli and others suggesting that the effect triggered by them is indistinguishable (e.g., Brignani et al., 2009; Guzzon et al., 2010; Hietanen et al., 2006; Joseph et al., 2015; Stevens et al., 2008).

However, clarifying this debate, recent meta-analytical evidence (Chacón-Candia et al. 2022, [under review]) has shown no behavioural differences between the attentional orienting triggered by eye-gaze and arrow cues. For instance, it remains unclear whether the attentional shifts induced by these two types of cues differ in some other important aspects. Recently, a study by Marotta, Lupiáñez, Martella, and Casagrande (2012) suggested that the source of a possible difference between eye-gaze and arrow attentional cues may lie in the dissimilar way people select objects in response to these two types of cues. In particular, they speculated that "biologically and socially relevant gaze cues may encourage more specific attentional orienting, compared to arrow cues, since a specific intention may be automatically attributed to gaze and not to arrows" (Marotta et al., 2012, p. 333). Consistent with this view, they found that when using eye-gaze as a cue, attention is directed specifically to the location or part of the object being looked at. In contrast, when using an arrow, attention spreads across the entire cued object.

The property of gaze cues to induce "specific" attentional orienting has also been corroborated by Wiese, Zwickel, and Müller (2013), showing that when previewed location placeholders were used, gaze cues induced a facilitation effect only when targets appeared inside the exact placeholder pointed at, but not when targets appeared in different spatially located objects within the cued hemifield. However, when no placeholders were presented, gaze cueing effects were detectable in response to the specific cued location but also spread across the entire cued hemifield. In light of these findings, another person's gaze may trigger a specific attentional orienting only when an object is presented in the visual scene.

Considering the importance of orienting attention to the same object of others' attentional direction to establish a social joint attention episode, this makes perfect sense. In other words, another person's gaze may induce a specific attentional orienting only when an object is present in the environment and can be interpreted as the goal of the gaze. However, this should not be observed in response to arrow cues since arrows have a directional property, like gaze, but no biological or social significance. However, to date, no studies have directly compared the attentional selection produced by these two types of stimuli in the presence or absence of placeholders within the visual field. To accomplish this aim, in the present study, we have used a paradigm very similar to that used by Wiese and colleagues (2013), in which, in response to gaze and arrow cues, participants had to respond to targets presented in one of three possible locations within a cued hemifield: 0° and +/- 60° from the horizontal meridian. Placeholder objects for the targets will be presented on half the trials (placeholder-present condition), while on the other half, no placeholders will be presented (placeholder-absent condition).

In the placeholder-present condition, we expected that gaze cues would elicit a specific attentional orienting benefit only for targets presented within the object (i.e., placeholder) looked at, but not for targets appearing in different spatial locations within the cued hemifield. Arrows should elicit a more general attentional benefit across the entire cued hemifield. As mentioned above, the cued object should be interpreted as the goal of another person's attention only in response to gaze cues (i.e., looked at object) but not in response to arrows. On the other hand, no difference between gaze and arrow attentional effect should be observed when no objects are presented on the scene (placeholder-absent condition), cueing effects spreading across the entire cued hemifield with both gaze and arrow cues.

Experiment 1

Method

Participants

Thirty-seven undergraduate students (24 female; mean age: 22 years) gave their informed consent before voluntarily participating in this research. There was no clear experiment of reference for computing the needed sample size in our first experiment, as this was the first time our paradigm was used. We could use as reference the study by Wiese et al., (2013), but they did not compare arrows and gaze, which was critical for our experiment. Instead, we could use Marotta et al. (2012) experiments, in which objects instead of group of objects (i.e., placeholders) were used, but they did compare gaze with arrow cues. Marotta et al. (2012) used samples of 24 and 30 participants, so we decided to use a minimum of 36 participants for Experiment 1. All participants had normal or corrected to normal vision and were unaware of the purpose of the experiment. In this and the following experiments, participants received course credits for their participation. All experiments were approved by the Ethical Committee of the University of Granada (175/CEIH/2017) and conducted in conformity with the ethical standards of the Declaration of Helsinki.

Apparatus and stimuli

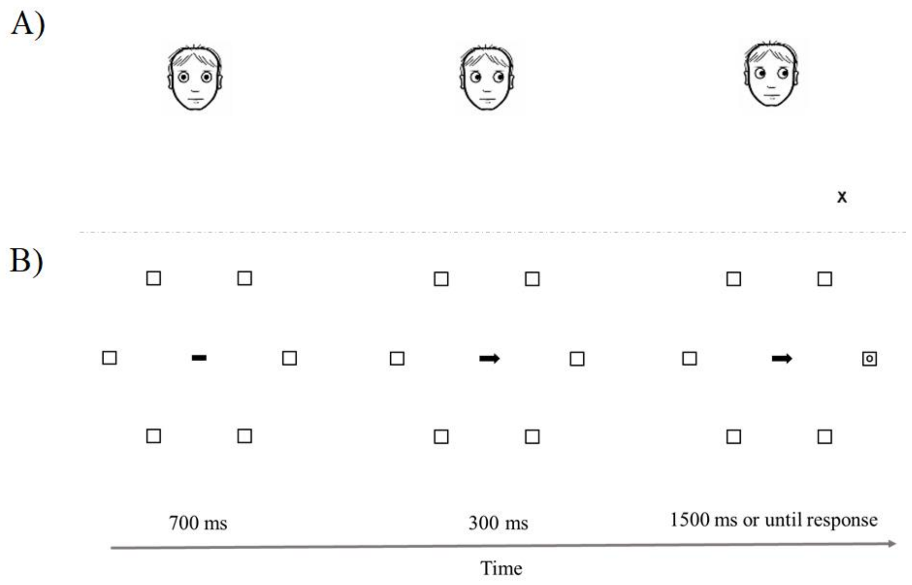
The cueing-discrimination task used in this experiment was presented on a 21-inch VGA colour monitor of a computer running E-Prime software (Schneider et al., 2002) to control the presentation of the stimuli, timing operations, and data collection. On the hemifield placeholder-present condition, the fixation display consisted of three placeholder boxes presented within each hemifield at 0° and +/-60° from the horizontal meridian; the central fixation stimuli changed depending on the cue type. For the arrow trials, a horizontal line was presented at the centre of the screen, and for the gaze trials, the display was a schematic face with the eyes looking straight. During experimental trials, the face pupils, or the appearance of an arrowhead, signalled left or right from fixation. Target stimuli were the letters “X” or “O”. The background of the screen was white, and all the stimuli were black.

Procedure

After giving their informed consent, participants were seated at about 55cm from a computer screen in a quiet, dimly lit room. Trials started with a fixation display that differed depending on the cue type. In gaze cueing trials, a schematic face with a straight gaze was presented as fixation, whereas, in arrow cueing trials, the fixation stimulus was a horizontal line centred on the screen. This display was presented for 700ms; then, a change was made to the arrow or eye gaze fixation points to indicate left or right on the horizontal meridian (importantly, no other position or placeholder was directly cued). Following the presentation of the cue, a target (either the letter “X” or “O”) appeared unpredictably in one of six possible locations (see **Figure 1**).

Figure 1

Schematic view of a trial sequence for both the gaze cue and the arrow cue conditions.



Note. The example represents: A) gaze-cue/placeholder-absent/same-hemifield condition, and B) arrow-cue/placeholder-present/same-location/same-hemifield condition.

Stimulus onset asynchrony (SOA) was 300ms. Cue and target remained on the screen until a response was given or for 1500ms in case of no response. Then, a blank display was presented for 700ms. Targets appeared either in one of the three placeholder boxes presented within each hemifield (placeholder-present condition) or at one of the same positions in an empty space when no placeholder boxes were presented (placeholder-absent condition).

Participants were required to discriminate the letter "X" or "O" by pressing either the "M" key (with the right hand) or the "Z" key (with the left hand) on the computer keyboard, depending on the target letter that was presented. Half of the participants pressed "M" for target "X" and "Z" for target "O", whereas the other half received the reversed mapping. They were also instructed to respond as quickly and accurately as possible and maintain central fixation throughout all trials. They were informed that the direction of the central stimuli did not predict the location of the target, so they should ignore it.

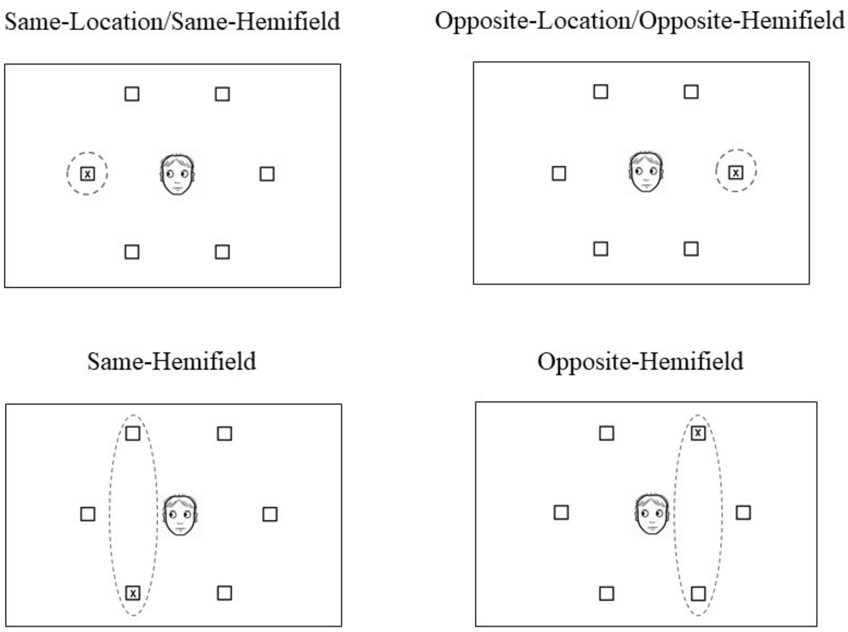
Cue direction, target stimuli, target location, and placeholder presence were randomly interspersed within each block of trials, whereas cue type was manipulated between blocks in a counterbalanced order. There were two experimental blocks of 288 trials each (one for each cue type), each preceded by a practice block of eight trials (where participants received feedback for their performance), summing up 592 trials in total.

Design

Three-factor repeated measure design was used to analyse an overall effect in this experiment, 2 (cue-type) x 2 (placeholder-condition) x 4 (validity). The cue-type had two levels, arrow and eye-gaze; placeholder-condition consisted of placeholder-present and placeholder-absent conditions, and the four validity levels were same-location/same-hemifield, opposite-location/opposite-hemifield, same-hemifield and opposite-hemifield trials. T-test analyses were performed separately for each placeholder condition to analyse the general-cueing effect (targets appearing at the left and right locations from the cue) and the hemifield-effect (targets appearing +/-60° from the horizontal meridian of the cue). For the general-cueing effect, the comparison of cue-target relations consisted of same-location/same-hemifield trials vs opposite-location/opposite-hemifield trials; for the hemifield-effect, the cue-target relation consisted of same-hemifield vs opposite-hemifield trials (see **Figure 2**).

Figure 2

Illustration of the four types of cue-target relation of Experiment 1.



Note. The images represent the gaze-cue in a placeholder-present condition. The cue-target relation for the placeholder-absent condition was the same, with the exception that no placeholder boxes were presented on the scene.

Results

For the reaction time analysis, trials with correct responses faster than 100ms or slower than 1200ms (0.5%), and incorrect response trials (5.69 %) were excluded. Mean RT, standard deviations, and error percentage for all conditions are shown in Table 1.

A cue-type (arrows vs. gaze) x placeholder-condition (placeholder-present vs. placeholder-absent) x validity (same-location/same-hemifield, opposite-location/opposite-hemifield, same-hemifield and opposite-hemifield) repeated measures ANOVA was performed to analyse an overall effect.

The analysis reported a main effect of placeholder-condition ($F_{1,36}$=21.33, p=<.001, η^2_p=0.372), showing that overall reaction times were faster when no placeholders were presented on the scene (M= 487, SD=63.36) than when placeholders were presented (M=502, SD=66.28). A main effect of validity was also found ($F_{3,108}$=30.24, p=<.001, $\eta^2_{p=}$0.457), showing that reaction times were faster when the target appeared at the same-location/same-hemifield (M=483, SD=63.65), followed by opposite-location/opposite-hemifield (M=495, SD=67.51), same-hemifield (M=499, SD= 63.26) and opposite-hemifield (M=502, SD=65.27) respectively.

The interaction of placeholder-condition X validity was also significant ($F_{3,108}$=6.20, p=<.001, η^2_p=0.147), showing that when the targets appeared at the same-location/same-hemifield, there were no differences related to the presence or absence of placeholders in the scene (p>.05), nonetheless when targets appeared at opposite-location/opposite-hemifield, same-hemifield and opposite-hemifield participants were significantly faster when no placeholder objects were presented (all ps<.05). No other interactions were significant in this analysis (all ps>.05).

Additionally, separate T-test analyses were conducted to analyse, on the one hand, the general-cueing effect (same-location/same-hemifield vs. opposite-location/opposite-hemifield) and, on the other, the hemifield-effect (same-hemifield vs opposite-hemifield), in both the placeholder-absent and the placeholder-present conditions. The results revealed that the general-cueing effect was significant for both the placeholder absent (t(36)=-3.889, p=<.001) and the placeholder-present conditions (t(36)=-4.719, p=<.001), showing that in general, reaction times were faster when targets appeared at the same-location/same-hemifield trials than at the opposite-location/opposite-hemifield trials regardless the presence of placeholders on the scene (see Figure 3). When analysing the hemifield-effect, no significant effect was found for any of the placeholder conditions (all ps>.05).

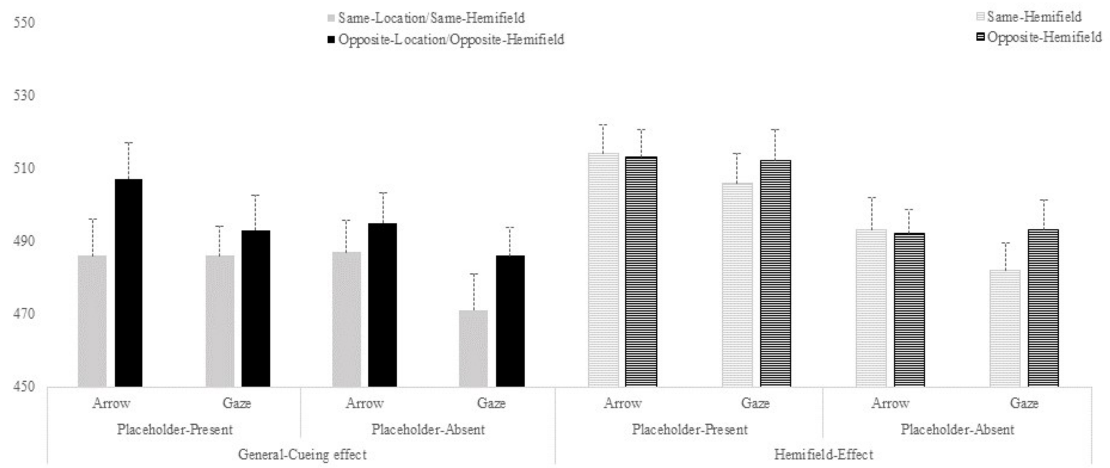
Table 1

Mean reaction times (RT), standard deviation (SD), and percentage of errors (%IR) as a function of the placeholder-condition, type of cue, and cue-target (CT) relation in Experiment 1.

	Placeholder-Present Condition						**Placeholder-Absent-Condition**					
	Arrow			**Gaze**			**Arrow**			**Gaze**		
CT relation	**RT**	***SD***	**%IR**	**RT**	***SD***	**%IR**	**RT**	***SD***	**%IR**	**RT**	***SD***	**%IR**
Same-Location/ Same-Hemifield	486	69.02	5.89	486	61.11	6.70	487	67.06	5.97	471	57.97	4.38
Opposite-Location/ Opposite-Hemifield	507	77.57	7.03	493	59.54	5.73	495	72.09	6.68	486	60.05	4.95
Same-Hemifield	514	70.52	6.07	506	55.6	5.65	493	64.92	5.22	482	58.93	4.9[illegible]
Opposite-Hemifield	513	70.29	7.30	512	62.79	5.88	492	64.76	4.88	493	62.55	5.3[illegible]

Figure 3

Reaction times (RTs) results from Experiment 1.



Note. Results are shown separately for the general-cueing effect and the hemifield-effect. Mean RTs presented for each type of cue as a function of the cue-target relation in the placeholder-present and placeholder-absent conditions. Error bars represent the standard error of the mean, computed following Cousineau’s (2005) method to eliminate variability between participants.

Discussion

This experiment tested whether eye-gaze attentional cues trigger more specific attentional orienting than arrows when placeholder objects are presented on the signalled hemifield. However, the results of this experiment showed that arrows and eyes triggered very similar attentional cueing effects in both placeholder-absent and present conditions. In particular, with both cues, a significant attentional benefit was only observed for targets appearing at the specifically cued location but not for targets appearing in different spatial locations within the cued hemifield.

At first sight, these findings seem to suggest that attention triggered by social and non-social cues is not modulated by the presence of placeholders on the scene, and they are consistent with the literature, which has generally reported similar behavioural cueing effects for gaze and arrows in the normotypical population (for review, see Birmingham & Kingstone, 2009). On the other hand, they seem to contrast with our hypothesis according to which attentional benefits should be observed only for targets presented in the specific object (or part of an object) when signalled by eye-gaze cues, and for all the targets, independently from their position in the cued hemifield, when signalled by arrows.

Indeed, we assumed that arrows should elicit a more general attentional benefit spreading across the cued hemifield, based on our previous findings showing that arrows, but not eye-gaze, allow attentional shifts to spread through to the entire surface of an object presented in the cued visual field. Nevertheless, given the specific paradigm we used in our previous experiment, an alternative explanation could be plausible. As shown in Fig. 2, the six objects were equidistant and distributed across the circle of objects that served as a background fixation display. Then it makes sense that only a general-cueing effect is observed for both arrows and gaze. It could then be possible that arrows trigger attentional orienting spreading the cued object's entire surface but not across the entire cued hemifield. This would explain why in the present experiment, an attentional effect was observed only for targets appearing at the specifically cued location or object, as both arrows and gaze similarly orient attention to the specifically cued signalled object. In the following experiments, we decided to modify the proximity between the objects within each hemifield so that participants would perceive one easily segregated group of objects.

Experiment 2

The goal of experiment 2 was to investigate whether, by manipulating the distribution of placeholders within the hemifield (i.e., following the gestalt's law of proximity; Han et al., 1999; Wagemans et al., 2012) cues would trigger attention not only to the specific cued object but also towards the entire group of signalled placeholder objects. In particular, since there is evidence that the attention system similarly treats perceptually grouped objects (Baylis & Driver, 1992; Dodd & Pratt, 2005), we expected that by grouping by proximity the placeholders, the attentional effect would be similar to the one found by Marotta and colleagues (2012): attention would spread to the whole group of placeholder objects only when using an arrow, while, when using eye-gaze, attention would be directed just to the specific cued placeholder. Moreover, we did not expect such an effect when no placeholders were presented on the scene.

Method

Participants

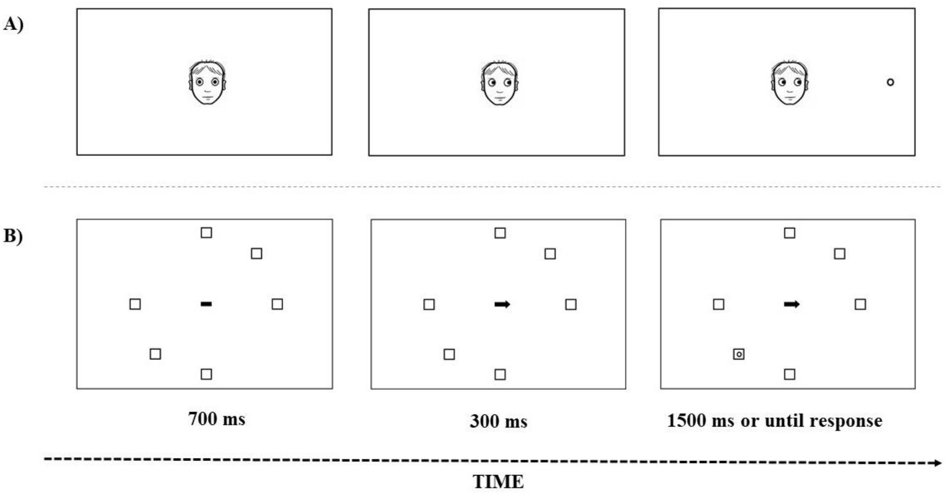
A new sample of seventy-five undergraduate volunteers (64 females; 18-35 years) were recruited through an experimental online platform from the University of Granada. Participants followed the protocol equally and had the same characteristics as those in experiment 1. Given the online collection of data we decided to double the sample size.

Apparatus and stimuli

Unlike Experiment 1, the cueing discrimination task was designed using the graphical experiment builder OpenSesame (Mathôt et al., 2012). As shown in Figure 4, the stimuli in this experiment were nearly the same as those used in the previous experiment, except for the placeholder boxes distribution. This time in the displays of the placeholder-present condition, the three placeholder boxes subtending within each hemifield were located at 0°, +/- 45° and +/-90° from the horizontal meridian and were randomly presented in two possible distributions (+/-45° from the vertical meridian). No other changes were made to the stimuli.

Figure 4

Schematic view of a trial sequence for both the gaze cue and the arrow cue conditions of Experiment 2.



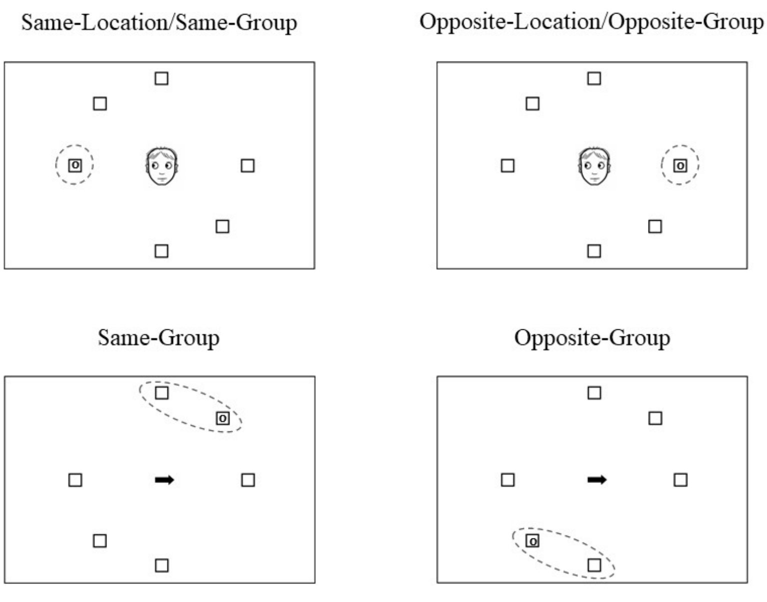
Note. The example represents: A) gaze/placeholder-absent/same-location/same-group condition, B) arrow/placeholder-present/opposite-group condition.

Procedure

Participants completed this experiment online. The procedure was similar to the one used in experiment 1, although some changes were made. First, the presentation of the placeholder-condition (present and absent) was separated into two blocks. Second, the order of spatial cues (arrow and gaze) was randomly interspersed within each block of trials. Third, as stated above, in the placeholder-present condition, the positions of the six placeholder boxes were grouped into quadrants, appearing at radial distances of 0°, +/- 45° and +/- 90° from the horizontal axis of a central stimulus (see, Figure 4) and were randomly positioned in two possible distributions (+/-45° from the vertical meridian). Finally, the six possible target positions were adapted as the distribution of the placeholder boxes described above (0°, +/- 45° and +/- 90° from the horizontal axis) for both placeholder-present and placeholder-absent conditions. The four critical cue-target relations for the analysis were almost equal to the previous experiment but just adapted to the new possible target positions (see, Figure 5). The remaining characteristics of the procedure were the same as in experiment 1.

Figure 5

Illustration of the four types of cue-target relation of Experiment 2.



Note. The placeholder-group tilted orientation shown here is -45° from vertical. The top images represent an example of gaze cue in a placeholder-present condition; the bottom images represent the arrow cue in a placeholder-present condition. The cue-target relation for the placeholder-absent condition was the same, with the exception that no placeholder boxes were presented on the scene.

Design

As in experiment 1, in this experiment, an overall effect was analysed by using a three-factor repeated measure design, 2 (cue-type) x 2 (placeholder-condition) x 4 (validity). Similar to experiment 1, the cue-type had two levels, arrow and eye-gaze; placeholder-condition had two levels, placeholder-present and placeholder-absent, and validity had four levels, now-called same-location/same-group, opposite-location/opposite-group, same-group and opposite-group. To analyse the general-cueing effect and the now called grouping-effect (targets appearing at +/- 45° and, +/- 90° from the horizontal meridian of the cue). T-test analyses were performed separately for each placeholder condition. For the general-cueing effect, the comparison of cue-target relations consisted of same-location/same-group trials vs opposite-location/opposite-group trials; for the grouping-effect, the cue-target relation consisted of same-group vs opposite-group trials. When no placeholders were presented, the cue-target relations corresponding to same-group and opposite-group conditions were created by distributing the up and down trials between those two types of cue-target relations. The order of blocks of each placeholder condition (present/absent) was counterbalanced across participants.

Results

Correct response trials with RT faster than 100ms or slower than 1200ms (0.8%) and incorrect response trials (6.29%) were excluded from the RT analysis. Mean RT, standard deviations, and error percentage for all conditions are shown in Table 2.

A cue-type (arrows vs. gaze) x placeholder-condition (placeholder-present vs. placeholder-absent) x validity (same-location/same-group, opposite-location/opposite-group, same-group and opposite-group) repeated measures ANOVA was performed to analyse an overall effect.

The analysis reported a main effect of placeholder-condition ($F_{1,74}$=26.86, p=<.001, η^2_p=0.266), showing that overall reaction times were faster when no placeholders were presented on the scene (*M*=527, SD=68.63) than when placeholders were presented (*M*=552, SD=79.88). A main effect of validity was also found ($F_{3,222}$=61.25, p=<.001, η^2_p=0.087), showing that reaction times were faster when the target appeared at the same-location/same-group (*M*=523 *SD=72.56*), followed by opposite-location/opposite-group (*M*=540, SD=75.96), same-group (*M*=546, SD=75.04) and opposite-group (*M*=550, SD=75.59) respectively.

The placeholder x validity interaction was also significant ($F_{3,222}$=18.07 p=<.001, η^2_p=0.196), showing that when the targets appeared at the same-location/same-group, no differences related to the presence or absence of placeholders in the scene were found (p>.05), nonetheless when targets appeared at the opposite-location/opposite-group, same-group and opposite-group participants were significantly faster when no placeholder objects were presented (all ps<.001). Finally, a three-way placeholders x cue type x validity interaction was also significant ($F_{3,222}$=7.11 p=<.001, η^2_p=0.088). When no placeholders were presented, as expected, only the main effect of validity was significant ($F_{3,222}$=9.75, p=<.001, η^2_p=0.016), whereas when placeholders were presented both the main effect of validity was significant ($F_{3,222}$=72.99, p=<.001, η^2_p=0.496), and the cue type x validity interaction ($F_{3,222}$=6.73, p=<.001, η^2_p=0.083), were significant.

Indeed, T-test analyses separately conducted for placeholder absent and placeholder present conditions, revealed that when placeholders were absent, it was possible to observe a general cueing effect for both gaze (t(74)=-2.376, p=0.02) and arrows (t(74)=-2.027, p=0.046); In this condition, no grouping effect was found for any of the cue types (all ps>.05). When placeholders were presented on the scene, the general cueing effect was also observed for both gaze (t(74)=-2.472, p=0.016) and arrows (t(74)=-6.247, p=<.001); Nevertheless, and importantly, in this condition, the analysis revealed a main effect of grouping but this was observed only when arrows were the cues (t(74)=-3.618, p=<.001); when gaze cues were presented, no grouping-effect was observed (p>.05; see Figure 6).

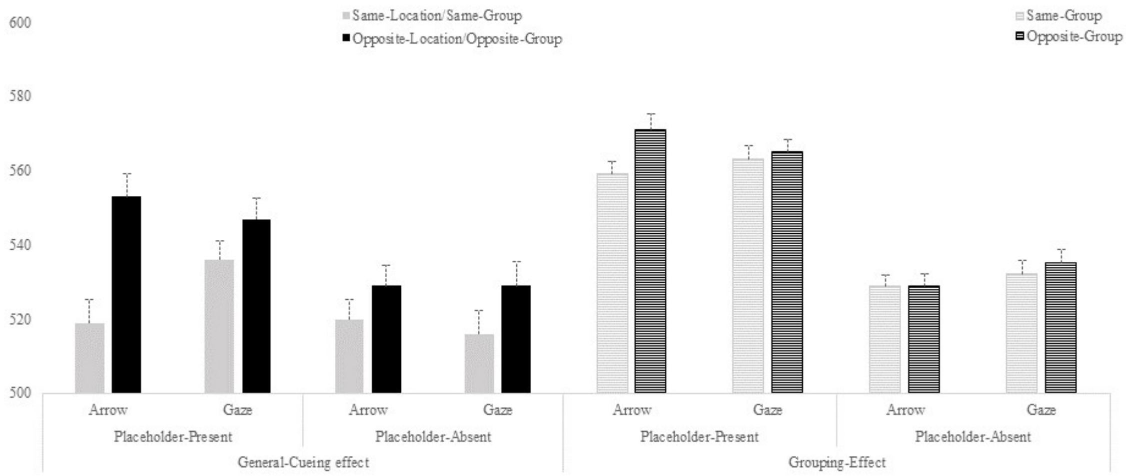
Table 2

Mean reaction times (RT), standard deviation (SD), and percentage of errors (%IR) as a function of placeholder-condition, type of cue, and cue-target (CT) relation in Experiment 2.

	Placeholder-Present Condition						Placeholder-Absent-Condition				
	Arrow			Gaze			Arrow			Ga	
CT relation	**RT**	***SD***	**%IR**	**RT**	***SD***	**%IR**	**RT**	***SD***	**%IR**	**RT**	***SD***
Same-Location/Same-Group	519	76	6.00	536	77.65	6.73	520	69.33	5.81	516	66.47
Opposite-Location/Opposite-Group	553	81.69	8.78	547	77.32	7.97	529	74.38	5.25	529	68.18
Same-Group	559	80.34	6.00	563	78.59	6.58	529	65.22	5.53	532	70.07
Opposite-Group	571	82.13	6.92	565	75.63	6.92	529	65.43	5.60	535	70.72

Figure 6

Reaction times (RTs) results from Experiment 2.



Note. Results are shown separately for the general-cueing effect and the grouping-effect. Mean RTs presented for each type of cue as a function of the cue-target relation in the placeholder-present and placeholder-absent conditions. Error bars represent the standard error of the mean, computed following Cousineau's (2005) method to eliminate variability between participants.

Discussion

As in the previous experiment, no facilitation effect was observed for any cue beyond the specifically cued location when no placeholder objects were presented. However, experiment 2 was conducted to assess whether attention would spread to an entire group of placeholders within a hemifield when using a central non-informative arrow cue and whether eye-gaze will trigger attention just to the specific location or placeholder of the group that is being signalled. Results showed that both arrow and gaze cues provoke attentional facilitation when targets appear at the exact object/location that is being pointed at (general-cueing effect). On the other hand, only arrows, but not eye-gaze, seemed to orient attention to targets appearing in the same group of objects but in a different position than the one indicated by the cue (grouping-effect/placeholder-present condition).

These findings can lead us to speculate that biologically relevant stimuli such as eye-gaze may trigger more specific attentional orienting than arrows due to the particular intention that we may attribute to the others' focus of attention. However, this specific gaze effect is only observed when measuring attentional facilitation beyond the specifically cued location/object, where a general-cueing effect is observed for arrows and gaze, consistently with the literature. Furthermore, in order for attention to spread to close objects, these must be perceptually organized into distinct groups of objects, as in this experiment, and differently from the previous one. Interestingly, attention spread to nearby objects within the group only with arrow cues even under these conditions. Conversely, when a gaze cue was used, attention was restricted to the specifically cued object within the group.

General Discussion

The present study aimed to explore through a series of two experiments whether the attentional orienting in response to non-predictive arrow and eye-gaze cues differs when placeholder objects are presented on the scene.

Results suggest that when several placeholders are grouped into a perceptual object as a function of Gestalt principles of proximity (Experiment 2), gaze and arrows cues elicit attentional effects similar to those first reported by Marotta and colleagues (2012; see Chacón-Candia et al., 2020 for replication). In particular, they showed that when objects were present in the display, eye-gaze cues directed attention to the specific part of the cued object, while arrow cues spread attention to the entire signalled object. Here, we extend these results to new displays in which no entire objects but groups of placeholders, grouped according to their proximity, were presented. In particular, it was observed that attention spread to the whole group of placeholder objects only when using an arrow, while it was restricted to the specific cued placeholder when eye-gaze cues were used.

On the other hand, when placeholder objects were not grouped within a cued hemifield, as in Experiment 1, arrows and eyes triggered very similar attentional cueing effects with a significant attentional benefit only for targets appearing at a specifically cued location or placeholder, but not for targets appearing in other spatial locations or placeholders. The fact that with arrow cues, the RT advantage for targets presented in the placeholders of the cued hemifield is not present when placeholders are not grouped suggests that arrows trigger attentional orienting spreading to the entire surface of a cued perceptual object but not across the entire cued hemifield, neither when different ungrouped objects are spread out in the hemifield (i.e., in the placeholders present condition in Experiment 1), nor in the absence of any object (in the placeholders absent condition in Experiments 1 and 2).

As a potential limitation, it is important to note that for the arrow cues, the horizontal line is present and then the arrowhead appears at cue onset, whereas for the gaze cues, the pupils are present and then move to the left or the right at cue onset. Also, eye movements were not controlled, which could allow for the differences observed between cue types. Note, however, that if these differences were due to these factors, they would be observed independently of the presence or absence of placeholders, and whether they could be easily grouped or not into two objects. However, the differences seem to be related to how the two cue types interact with attention to groups of objects.

Indeed, the present results have important implications for the perceptual grouping literature, as well as the social attention literature. Interestingly, the influence of Gestalt principles in attentional selection tasks had been previously established in earlier research using peripheral cues (e.g., Botta et al., 2013; Dodd & Pratt, 2005). The offered results extend these findings to central non-predictive non-social cues. It has been previously suggested that cueing a portion of an object spreads attention across the entire object when arrow cues are used, while it restricts attention at the specific portion of the cued object when eye-gaze cues are used. The present results extend this notion, suggesting that this attentional dissociation is also observed when grouped objects are cued by eye-gaze and arrow cues. The boundary conditions for this effect seem to be related to Gestalt laws of perceptual grouping, as no grouping-effect was observed in Experiment 1 when distance and similarity perhaps led to the perceptual segregation of the display on a single group of objects (i.e., the six placeholders) rather than into two groups of objects (one cued and the other uncued) as in Experiment 2.

Therefore, both peripheral cueing and the effects of symbolic non-predictive non-social cues seem to be triggered automatically and mediated by object-based processes. Importantly, although social directional cues like gaze might produce an effect of a similar nature, as the common effect observed with the standard gaze cueing paradigm and the general-cueing effect observed in our experiments, they must produce an extra effect that restricts attention to the specifically looked-at location. The idea that gaze triggers both an effect similar to the one induced by non-social cues (Chacón-Candia et al., 2022 [under review]) and an extra specific effect has also been shown with other paradigms. Indeed, Marotta and colleagues (2019), in a study in which both behavioural and electrophysiological data were collected, observed that arrows and gaze produce a similar effect at earlier event-related components (P1 and N1) but opposite effects at later components (N2 and P300).

Thereby, the present results seem to argue in favour of the idea that biologically relevant stimuli such as eye-gaze may trigger a unique attentional process, qualitatively distinct from the attentional process triggered by non-biologically relevant stimuli such as arrows. Marotta and colleagues (2012) suggested that this specific attentional orienting effect of eye-gaze might be mediated by the automatic attribution of intention to gaze and not to arrows. This notion seems to be supported by the present study results and by the observations of Vuilleumier (2002) and Wiese et al., (2013), showing that when reference objects are presented on the scene, gaze cues trigger a facilitation effect but only to the specific gaze-at object.

For decades, an eye-gaze major role in social communication has been of interest to many researchers (for reviews see Argyle & Cook, 1976; Emery, 2000; Kleinke, 1986). In particular, literature explains how eye-gaze is likely to be used to perceive and understand the emotional and mental states of others and subsequently how it may be a reliable source to anticipate their actions. Thus, rather than gaze-cue not being able to direct attention to a place other than the signalled location, participants may attribute a specific intention to the eye-gaze by retaining their attention specifically at the inferred-at location or the signalled placeholder and not to the entire hemifield or nearby placeholders. Consequently, if these social mechanisms are involved in the specific attentional orienting triggered by eye-gaze, it seems logical to expect that when the spatial cue is non-biologically relevant as an arrow, such a mechanism would not be activated, and attention would be rather spread to nearby objects or the other extreme of the object when larger objects are used (2012) following perceptual grouping laws.

Therefore, in order to investigate social attention, paradigms that measure qualitative rather than quantitative differences between biologically and non-biologically relevant stimuli should be used, since the standard gaze-cueing paradigm has proven not to be suitable to capture differences in the attentional orienting effect elicited by social and non-social cues (Chacón-Candia et al., 2022 [under review]). It will be interesting for future research to explore whether the aforementioned qualitative differences between eye-gaze and arrow cues can be observed in populations with reduced social abilities, such as people with autism spectrum disorder or schizophrenia. Perhaps, in these populations, no difference between social and non-social attentional cues may be observed.

CHAPTER V

Sex differences in attentional selection following gaze and arrow cues [5]

Abstract

Although most studies on social attention have shown undistinguishable attentional effects in response to eye-gaze and arrow cues, recent research has found that whereas the orienting of attention triggered by eye-gaze is directed to the specific position, or part of the object looked at, arrows unselectively elicit attention towards parts of the environment. However, it is unclear whether this dissociation between gaze and arrow cues is related to social cognitive mechanisms such as mental state attribution (Theory of Mind, ToM). We aimed at replicating the dissociation between gaze and arrow cues and investigating if the attentional object selection elicited by these two types of stimuli differs depending on the sex of observers. To make our research plan transparent, our hypotheses, together with the plans of analyses, were registered before data exploration. While we replicated the arrow-gaze dissociation, this was equivalent in the male and female population. These results seem to contradict the intuition that ToM skills can be associated with the differences observed between orienting to eyes and arrows since greater ToM abilities have been generally shown in females. However, this conclusion must be interpreted with caution, since in our sample was not possible to observe any differences in autistic quotient scores and ToM abilities between male and female participants. Further research is needed in order to clarify this issue.

Keywords: attentional selection; gaze-cueing; theory of mind; autistic quotient; sex differences

[5] Chacón-Candia, J. A., Lupiáñez, J., Casagrande, M., & Marotta, A. (2020). Sex differences in attentional selection following gaze and arrow cues. *Frontiers in Psychology*, *11*, 95. doi: 10.3389/fpsyg.2020.00095

Introduction

Past research has suggested that females generally outperform males on various tests of social abilities, such as cognitive and emotional perspective-taking, empathy, eye-contact, emotional expression detection, and 'mindreading' abilities (Alwall et al., 2010; Bosacki, 2000; Derntl et al., 2010; Suzuki et al., 2006; Voracek & Dressler, 2006). Spare research available concerning gender differences in selective attention thus far suggests this may be an important component of cognitive gender differences (Bayliss et al., 2005). The question we address in the current study is whether males and females differ in the attentional object selection elicited by eye-gaze direction.

The tendency to direct our attention to where other individuals are looking at has been the centre of interest of a large number of studies (Birmingham & Kingstone, 2009; Nummenmaa & Calder, 2009). This behaviour appears from an early age and represents a crucial step to develop social communication, since gaze offers several pieces of information about action goals, feelings, and beliefs of another person (Emery, 2000).

Such findings imply that the perceptual and attentional systems preferentially process eye-gaze direction and this preference has been generally considered to reflect the central role of gaze signals in the development of communicative competences including cultural acquisition, language learning, and mental state attribution (Baron-Cohen, 1995; Tomasello, 1995), with atypical developmental patterns frequently associated with social dysfunctions, such as autism (e.g., Baron-Cohen, 1995; Swettenham et al., 1998). Given this, it is not surprising that some authors have suggested that eye gaze cues are unique to shift attention (e.g. Farroni et al., 2002).

Thus, several studies have tried to distinguish between the attentional orienting triggered by social stimuli like gaze and non-social cues such as arrows employing the traditional gaze-cueing paradigm (Friesen & Kingstone, 1998), showing no robust behavioural differences between arrow and gaze cues (see, Birmingham & Kingstone 2009; Ristic et al., 2002; Galfano et al., 2012; Tipples, 2008). However, in recent years, the uniqueness of the eye-gaze for the human attentional system keeps being demonstrated in a growing number of investigations through distinct methodologies.

For example, using a visual memory task, Dodd and colleagues (2012) and Gregory and Jackson (2017) have studied the difference between gaze and arrow cues, showing an improvement in memory accuracy just when information is cued by a gaze but no when using an arrow. Moreover, Marotta and Cols. (2018) observed that eye-gaze and arrows yielded opposite spatial interference effects when used as targets in a spatial interference task: whereas arrows elicited the usual spatial stroop effect, i.e., faster reaction times when its position was congruent with the direction, eye-gaze produced the opposite effect, i.e., faster responses when it was incongruent. Another stream of studies showed dissociations between gaze and arrows within clinical populations, such as schizophrenia, or ADHD (e.g., Dalmaso et al., 2015; Marotta et al., 2014, 2017).

Relevantly, research by Marotta, Lupiañez, Martella, and Casagrande (2012) have also shown different forms of attentional selection between eye-gaze and arrows even with a gaze cueing paradigm. Authors displayed two rectangles, in which one end or another of one of them was cued by a central non-informative directional eye gaze or arrow cue, and then succeeded by a target presented in one end of those rectangles. It was found that arrows triggered attentional orienting that spread to the entire object (i.e., even to the other end of the rectangle), whereas gaze triggered attentional orienting exclusively to the rectangle end specifically looked at. On the basis of these results, the authors proposed that whereas arrow-cueing is truly stimulus-driven, the attentional orienting to eye-gaze may be mediated by mental state attribution. In particular, according to Marotta et al., (2012) view, "The specific location-based effect observed with eye-gaze cues seems consistent with the idea that gaze reflects 'social' processing and that an intention is attributed to the gaze to look at a specific location. […] Hence, we jointly orient our attention specifically to the inferred location within the object of interest, not to the entire object. In contrast, the object-based effect of arrow cues may be triggered by a more unspecified directional code that automatically orients attention through the entire placeholder object" (p. 333).

However, it is important to note that the study of Marotta et al., (2012) was the first that ever assessed the type of attentional selection elicited by eye-gaze and arrow cues and that most of the participants of the study were female. For this reason, assuming the natural variations in the effect triggered by gaze cues across individuals, the interpretation of the findings observed in their study must be cautious and should not be necessarily extended to the general population. Indeed, some individuals could be oriented strongly towards social stimuli, while others may not. Some studies, for example, have shown, that the gaze cueing effect is weaker in individuals reporting autistic-like traits (Alwall et al., 2010; Bayliss et al., 2005) and more robust in observers with low self-esteem (Wilkowski et al., 2009).

Importantly, Bayliss et al., (2005) observed that the sex of participants also counts as part of the individual differences found in the gaze-cueing effect. In particular, they reported that females had a stronger gaze-cueing effect than male participants and that there was a negative correlation between cueing effects and Autism Spectrum Quotient scores (AQ; Baron-Cohen et al., 2001). Thus they speculate that, across gender, people who have more social skills tend to show a larger gaze-cueing effect.

Based on the natural variations of the gaze attentional effect across individuals and the gender differences observed in the studies mentioned above, the aims of the present study were the following:

We firstly tried to replicate Marotta et al.'s (2012) dissociation between gaze and arrow attentional orienting: attention will be directed to the entire object (not only the indicated end of the rectangle) with arrow cues, while it will selectively be oriented to the specific position or part of the object where eye-gaze cues are looking at.

Secondly, we investigated if this dissociation is only observed in female participants or it can be generalized regardless of sex. Since it has been generally observed that females outperform males in social abilities and cognition (Alwall et al., 2010; Bosacki, 2000; Derntl et al., 2010; Suzuki et al., 2006; Voracek & Dressler, 2006), we expect that the dissociation between gaze and arrows will be particularly evident in female participants.

Thirdly, we looked for associations between this dissociation and autistic traits (as measured by the AQ; Baron-Cohen et al., 2001) and theory of mind skills (as measured by the Yoni Task, Shamay-Tsoory & Aharon-Peretz, 2007), the hypothesis being that people with more autistic traits and/or low theory of mind would not show a dissociation between gaze and arrow cues.

The hypotheses for this experiment, together with the plans of analyses, were registered before data exploration in Open Science Framework (osf.io/tvmk2).

Materials and Method

Participants

Fifty-two university students provide their informed consent before voluntarily participating in this study; 26 males (mean age=21.73), and 26 females (mean age=20.03). All of them had normal or corrected-to-normal vision and were naïve about the purpose of the research. A minimum of 24 participants per group (24 men and 24 women) was intended as in the original study by Marotta et al. (2012). Although no power analysis was performed a priori, a sensitivity analysis using G*power (Faul et al. 2007), showed that with our final sample size ($N = 52$) the minimum effect size that could have been detected for $\alpha = 0.5$, and $1 - \beta = 0.95$, for 2 groups and 4 within participants conditions (for each of the critical CT relation × Type of Cue analyses) is $f = 0.40$ (minimum detectable effect).

Measures

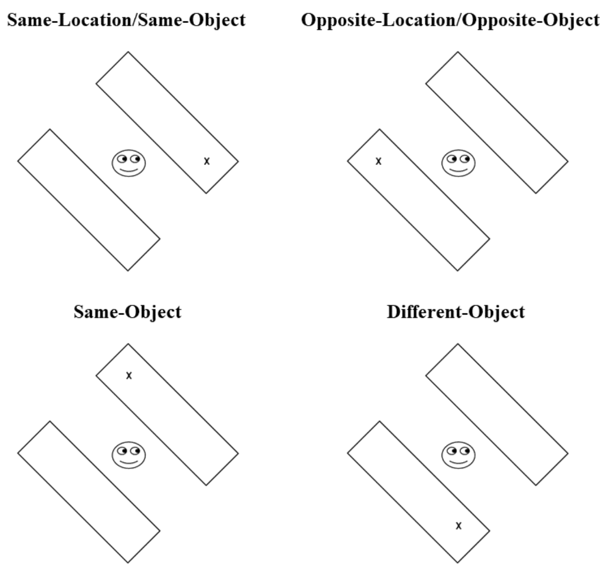
Double Rectangle Task

The double rectangle task used in this study was very similar to the one used by Marotta et al. (2012) in their experiments 1 and 2, although some changes were made to the procedure. More specifically both the rectangle orientation (+45º or -45º tilted from the vertical meridian; see, Figure 1) and the type of cue (arrows and eye gaze) were randomly interspersed in each of the three experimental blocks of trials, whereas one of these variables was blocked in the original study. These changes were made to ensure that differences between eye-gaze and arrows are due to different selection mechanisms rather than to different between-block strategies. Each trial began with a central fixation stimulus and two rectangular objects (subtending 10.5° × 3° of visual angle) that appeared in one of the two possible orientations. The fixation stimuli changed depending on the cue type. As in the Marotta et al. (2012) study, in gaze cueing trials, the fixation was a central schematic happy face[6] (3° × 2.5°) with the pupils straight, whereas, in arrow trials, the fixation was a central cross (0.5° × 2°). This display was presented for 700 ms; then a change was made either to the arrow or eye gaze cue to indicate one end of the two rectangular objects. The target followed after 150, 300, or 600 ms in one of four rectangles end according to the 4 critical cueing conditions (see, Figure 1): at the cued direction (and object) indicated by the cue (same-location/same-object trials), in the opposite object and direction to which the cue was directed (opposite-location/opposite-object trials); at the uncued location of the same object (same-object trials) or at the uncued location in the other object (different-object trials). Participants were asked to respond promptly to target stimuli (the letter "X" or "O") by pressing eider the "C" key (with the left hand) or the "M" key (with the right hand) on the computer keyboard, depending on the presented target letter. Half of the participants pressed "C" when the letter "X" appeared as a target and "M" when the letter "O" appeared, whereas the other half received the reverse mapping. This task consisted in 4 blocks of trials; one of them was a practice block with just 10 trials; the other three were the experimental blocks with 192 trials each, summing up 576 experimental trials in total, with 72 observations per experimental condition. Target location, Cue direction, type of cue, and the object orientation were randomised within each block of trials.

[6]Research on whether gaze direction and facial expression interact in orienting attention has provided mixed results. While some studies have shown that gaze cueing effects are independent of facial expression (Graham et al.,, 2010; Galfano et al., 2011; Hietanen & Leppänen, 2003), others have reported greater gaze cueing effects when faces show emotional expressions, such as fear or happiness expression (Bayless at al., 2011;Galfano et al., 2011; Hori et al., 2005). However, the impact of the different facial expression has never compared between male and female participants. Further research will be necessary to shed light upon this issue.

Figure 1

Illustration of the four cue-target (CT) relation conditions.



Note. The display orientation depicted here is -45° from vertical (Marotta et al., 2012).

Yoni Task

The "Yoni task" (Shamay-Tsoory & Aharon-Peretz, 2007) is a computerized task inspired by Baron-Cohen (1995), which measures the ability to attribute mental states based on the eye direction of a cartoon face ("Yoni") and verbal cues. This task is designed to separately assess cognitive and affective ToM. In the cognitive conditions the verbal cue and Yoni's facial expression are emotionally neutral, and in the affective one, those same cues offer affective information. In each trial, Yoni's face surrounded by four colored objects or faces is presented in the middle of screen and an incomplete sentence is presented at the top of the screen. Participants are required to read the sentence and click the cursor, using a mouse, on the image that they believe Yoni is referring to. The cognitive and affective conditions require either a first or a second-order inference. In the first-order ToM conditions, participants were required to infer the mental state of "Yoni". In the second-order ToM condition, participants were asked to understand Yoni beliefs about others' beliefs and desires.

The Autism-Spectrum Quotient (AQ)

The AQ is a 50-item self-report questionnaire designed for measuring autistic traits in the general population (Baron-Cohen et al., 2001). In particular, it assesses five different domains relevant for autistic traits: social skills, attention to detail, attention switching, communication and imagination. A Spanish version (retrieved from https://www.autismresearchcentre.com/arc_tests; see Appendix) of this instrument has been used specifically for quantifying where are participants situated on the continuum from autism to normality.

General Procedure

All participants were first required to perform both the Double Rectangle and the Yoni tasks; then the AQ questionnaire was administered. The order of tasks was counterbalanced across participants. The study was conducted in accordance with the ethical standards of Declaration of Helsinki and was approved by the ethical committee of the University of Granada (175/CEIH/2017). All participants gave written informed consent before testing.

Data Analysis

Given the specific hypotheses for the Double Rectangle task, separate two-factor repeated measure designs were used in order to analyze "general cueing" and "object-based cueing" effects, respectively for targets appearing at the right and left locations, and for targets appearing at the bottom and top locations. Cue-Target (CT) relation consisted of four trial types: same-location/same-object trials and opposite-location/opposite-object trials, for the analysis of the general cueing effect; same-object trials and different-object trials for the object-based cueing effect. As in Marotta et al. (2012) study, and anticipating irrelevant differences between vertical and horizontal target locations, this approach was taken because opposite-location/opposite-object trials were always paired with a horizontal target, whereas same-object/different-object trials were always paired with a vertical target. Type of Cue had two levels: eye gaze and arrow[7]. Sex had also two levels: male and female. Planned comparisons were used for the analysis of interactions.

To analyze participants' social abilities, one-way analyses of variance (ANOVA) considering the SEX (male/female) as an independent variable were performed both on the AQ score and on the Yoni test cognitive and affective accuracy scores. Data from one of the participants were excluded from the analysis of the Yoni test due to a technical error. Finally, to test the associations between cueing effects and autistic traits and ToM skills

[7]Although it is not germane to the questions addressed in this article, the effect of SOA on cueing effects may be of interest to some readers, and for this reason, it was examined first. Neither the interaction SOA × CT relation ($F<1$), nor the SOA × Cue Type × CT relation interaction ($p=.335$) was significant. The remaining analyses were therefore collapsed across this factor.

Pearson correlations were calculated. Pearson correlations were also calculated between the index of the arrow/gaze object dissociation (measured as a difference between the object-cueing effect for arrow and the object-cueing effect for gaze cues) and autistic traits and ToM skills.

To get additional support for the obtained effects, we also computed their Bayes Factors. By convention, when Bayes factor is above the value of 3 it can be taken as substantial evidence for the tested hypothesis, whereas when values are less than 1/3, these should be considered as substantial evidence for the contrasting hypothesis (Lee & Wagenmakers, 2014).

Results

Double Rectangle Task

Mean response times, standard deviations and error percentages are presented in Table 1. RTs faster than 100ms or slower than 1000ms (.2%) and incorrect response trials (4%) were excluded from the RT analysis in all conditions.

General-Cueing effect

The ANOVA revealed a main effect of CT relation ($F_{1,50}$=39.22; p<.001, $\eta^2 p$=.44) showing that RTs were faster on same-location/same-object trials (M=499ms) than in opposite-location/opposite-object trials (M=513ms). Importantly, the CT relation × Type of Cue interaction was not significant, ($F_{1,50}$=1.15). The Sex × Type of Cue interaction was significant (F1.50=6.48; p=.014, $\eta^2 p$=.11): female participants showed slower RTs for gaze than arrow cues (F1.50=4.26; p=.044), while male participants showed no differences in overall RTs between the two types of cues (F1.50=2.36; p=.131).However, neither the interaction Sex × CT relation (F<1), nor the Sex × Cue Type × CT relation interaction (F<1; Figure 2) was significant.

Bayes factor analyses were conducted to seek evidence in favor of the alternative hypothesis by contrasting models containing the effect to equivalent model stripped of the effect of interest. These analysis revealed at least anecdotal evidence in favor of the null hypothesis for Sex × Cue (BF10 = 0.88), Sex × CT relation (BF10 = 0.35) and Sex × Cue × CT relation (BF10 = 0.21).

The analyses of error rate expose a significant effect of Cue Type relation ($F_{1,50}$=4.24; p=.045, η^2p=.07), showing that participants made more errors on valid (4.5%) than on invalid trials (3.9%). No other effects were significant.

Table 1

Mean Reaction times (RT), Incorrect Rate (IR%) and Standard Deviation (SD) as a function of Sex, Type of Cue and CT relation on the General-Cueing effect (same-location/same-object trials [SamLoc] and opposite-location/opposite-objecttrials[OppLoc]) and the Object-Based effect (same-objecttrials[SamObj] and different-object trials[DifObj]).

	General-Cueing Effect							Object-Based Effect						
		Gaze			Arrow				Gaze			Arrow		
	CT relation	RT	SD	IR(%)	RT	SD	IR(%)	CT relation	RT	SD	IR(%)	RT	SD	IR(%)
Male Group	SamLoc	491.0	46.55	4.5%	491.4	44.52	4.4%	SamObj	500.2	47.97	3.8%	503.9	50.49	4.5%
	OppLoc	499.2	52.06	3.6%	506.7	51.42	4.5%	DifObj	496.4	50.23	3.3%	510.4	48.75	4.5%
Female Group	SamLoc	509.9	52.90	4.5%	503.2	49.50	4.5%	SamObj	519.3	47.97	2.8%	520.2	52.76	3.3%
	OppLoc	524.6	52.71	4.0%	520.8	56.20	3.4%	DifObj	519.3	48.23	3.5%	529.6	50.63	4.0%

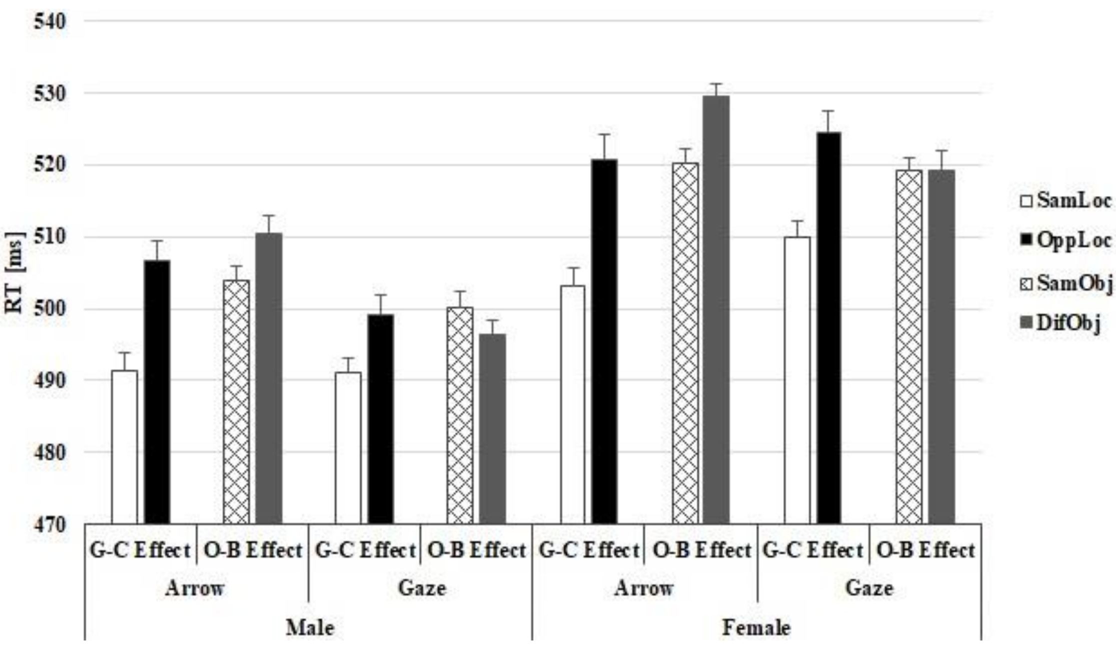
Object-Based effect

The ANOVA showed a main effect of the Cue Type ($F_{1,50}$=12.68; p<.001, η^2p=.20), with longer RTs for the arrow cue (M=516ms) than for the gaze cue (M=509ms) condition. The main effect of the CT relation was also significant ($F_{1,50}$=4.07; p=.049, η^2p=.07). Importantly, the CT relation × Cue Type interaction was significant ($F_{1,50}$=10.49; p=.002, η^2p=.17). As can be observed in Figure 2, RTs were faster on same-object trials than on different-object trials, when using arrows as cues ($F_{1,50}$=14.59; p=<.001, η^2p=.22). However, when eye gaze was used, no differences was evident between same-object and different-object trials (F<1). Finally, neither the Sex × CT relation interaction nor the Sex × Cue Type × CT relation interaction were significant (all Fs<1; see, Figure 2). Again, Bayes factor analyses showed moderate evidence supporting the null hypothesis for Sex × Cue (BF_{10} = 0.31), Sex × CT relation (BF_{10}=0.22) and Sex × Cue × CT relation (BF_{10}=0.25) interactions.

In the analyses of error rate, only the main effect of Cue Type approached significance ($F_{1,50}$=3.99; p=.051, η^2p=.07), indicating that participants made slightly more errors on the arrow (4%) than on the gaze condition (3.3%). No other effect or interaction was significant.

Figure 2

Reaction times (RT) results shown separately for male and female.



Note. Mean RTs presented for each cue type condition (gaze and arrow) as a function of cue-target relation (CT) in the General-Cueing effect (G-C Effect) and the Object-Based effect (O-B Effect). Error bars represent the standard error of the mean for each condition, computed following Cousineau's (2005) method to eliminate variabilitybetween participants.

Sex Differences in Social skills

AQ scores and ToM accuracy (as measured by the Yoni Task) were not different in the two groups of participants. Mean (± SD) and T-test results are reported in Table 2. Note that there were no Sex differences for any of the measured variables (AQ, female range 17 (6-23), male range 17 (7-24); ToM accuracy female range 0.33 (0.66-1), male range 0.33 (0.66-1). Correspondent Bayes factor analysis were also computed to assess how much support we have for the alternative hypothesis, specifying that female have higher social skills than men. As can be observed in Table 2, most BF10 were below 1 or close to it.

Table 2

Means, standard deviations (SD) and T-test results to assess differences between Male and Female participants on social skills considering AQ scores and Yoni test accuracy.

	Male		**Female**				
	Mean	**SD**	**Mean**	**SD**	**t**	**p**	**BF10**
AQ Total	13.46	4.38	13.84	4.68	0.306	0.761	0.35
Affective 1	96.40	8.30	98.10	8.30	0.721	0.474	0.51
Cognitive 1	94.60	11.10	97.80	4.40	1.353	0.182	1.05
Affective 2	87.30	11.80	86.00	13.30	-0.352	0.726	0.22
Cognitive 2	82.90	13.10	75.40	18.40	-1.665	0.102	0.12

Correlations

To test the associations between cueing effects on the one hand, and autistic traits and ToMabilities on the other, Pearson correlations were performed. In general, no correlation reached significance. The results are reported in Table 3.

Table 3

Pearson correlations between the index of the arrow/gaze object dissociation (measured as a difference between the object-cueing effect from arrow and the object-cueing effect from gaze), autistic traits (AQ_Total) and ToM skills (Affective1; Cognitive1; Affective2; Cognitive2).

		Arrow/Gaze Object Dissociation
AQ Total	Pearson's r	0.065
	p-value	0.647
Affective 1	Pearson's r	0.258
	p-value	0.067
Cognitive 1	Pearson's r	0.238
	p-value	0.092
Afective 2	Pearson's r	0.003
	p-value	0.985
Cognitive 2	Pearson's r	-0.039
	p-value	0.785

Discussion

Marotta et al., (2012) demonstrated that when arrows were used as cues, attention was spread across the entire spatial extent of objects, whereas when gaze was used, it was selectively oriented toward the specific position or part of the cued object. The present study confirmed this dissociation. Both types of stimuli elicited general cueing effects, while only arrow cues produced object-based effets. No such effect was observed with gaze, which seems to restrict attentional orienting to the part of the object looked at, avoiding the spread of attention across the whole object.

The dissimilarities in the encoding and function of the two types of cue may be the origin of this difference. In particular, Marotta et al., (2012) suggested that a more specific attentional orienting may be triggered by biologically relevant cues. Humans are very accurate in determining where another individual is looking with a direction estimation error ranging from 0.5° to 4° of visual angle (Bock et al., 2008; Wiese et al., 2012). This ability provides important cluesfor understanding where another person is focusing, helping us to predict their mental states and future actions (Emery, 2000). However, it is not known whether and how the dissociation in attentional selection observed between gaze cues and arrow cues is effectively related to social abilities.

We hypothesized that these differences might be particularly evident in female participants since it has been generally observed that females outperform males in social abilities and cognition. For example, females tend to be more accurate than males at detecting emotional expressions (Suzuki et al., 2006) and to maintain eye contact more frequently and for longer durations (Alwall et al., 2010). However, in the current study, no sex difference was observed in the attentional selection, and the same dissociation between gaze and arrows was observed in female and male participants. These results seem to contradict the intuition that social skills can be associated with the different forms of attentional selection observed between eye-gaze and arrow cues.

However, this conclusion must be interpreted with caution since it was not possible to observe any differences regarding ToM abilities and autistic quotient scores when comparing male and female population in our sample. Thus, this may explain the absence of gender differences observed in the cueing task. It is important to note that most of the participants included in the present study were psychology students. Therefore, although our data are apparently in contrast with studies reporting that female score higher than male on ToM (Kirkland et al., 2013) and lower on the AQ (Baron-Cohen et al., 2001), they are coherent with studies showing that independent of sex, social sciences students have in general greater social skills than students of more "mathematical" sciences (Groen et al., 2018). This would explain the lower scores on the AQ observed in our sample as compared to the general population (13.6 versus 16.9; see, Ruzich et al., 2015), and the absence of sex differences.

On the other hand, only in female participants, arrows were processed faster in comparison to eye-gaze cues. This result is coherent with previous studies and suggests that eye-gaze coding requires some additional time than the coding of arrows (Hietanen et al., 2006; Marotta et al., 2018; Vlamings et al., 2005). It should be noted that schematic faces differ from no-social stimuli such as arrows not just in terms of social significance but also in their complexity. Therefore, it could be argued that a possible explanation for the increase of reactione times for eye-gaze stimuli may reflects their perceptual complexity. However, for the first time, in the present study, we showed that this result could not be extended to the male population since male participants showed no differences in overall reaction time between the two types of stimuli. Therefore, this is more coherent with the "extreme male brain" hypothesis of autism (Baron-Cohen, 2002) according to which male information-processing system is less well adapted for the interpretation and processing of social stimuli than is the female brain. In support of this view, Vlamings and coworkers (2005) showed that RTs are slower after eye-gaze than after arrow stimuli in typically developed individuals, but not in individuals with autism. However, we only observed the interaction with sex in the analysis of the general cueing effect. Furthermore, as mentioned above, no sex differences in AQ scores were observed in the present study. Therefore, further research is undoubtedly needed to shed light on this issue.

Finally, we tested the hypothesis that the differences between eye-gaze and arrow cues on attentional selection might be related to the individual differences observe on AQ or ToM scores. However, the correlations between gaze-arrow dissociation and both the overall AQ and the ToM scores were non-significant. The fact that the majority of our participants scored low on AQ might at least in part account for these results. Previous studies do not yield a consistent pattern of correlation between AQ and social attention. While some studies suggest a negative correlation between AQ score and gaze-cueing effect (Bayliss et al., 2005; Lassalle & Itier, 2015), another study shows no correlation (Zhao et al., 2015). Further studies will be necessary to shed light on this issue.

Conclusion

The present study is the first to examine sex differences in attentional object selection triggered by gaze and arrows. The results confirm the existence of distinct modes of attentional selection between these two types of stimuli; in fact, consistent with a previous study (Marotta et al., 2012) both types of stimuli elicited general cueing effects, while only arrow cues produced object-based effects, gaze restricting attentional orienting to the part of the object looked at. However, these differences were not unique to female participants, as no sex differences were observed on attentional effects. Finally, regarding the question of whether the dissociation between gaze and arrows related to social mechanisms, our conclusions are limited, and new research are surely necessary to shed light on this issue.

Appendix

COCIENTE DEL ESPECTRO AUTISTA PARA ADULTOS (AQ)

S. Baron-Cohen, S. Wheelwright, R. Skinner, J. Martin and E. Clubley, (2001)

Instrucciones

A continuación encontrará una lista de frases.

Por favor, léalas atentamente y seleccione la respuesta que considere más apropiada en base a las siguientes opciones.

1 - Nada de acuerdo

2 - Un poco de acuerdo

3 - Bastante de acuerdo

4 - Totalmente de acuerdo

Comenzaremos con cuatro ejemplos para que se familiarice con la dinámica. Posteriormente deberá de contestar a todas las preguntas que se le presenten.

E1. Me gusta correr riesgos.

E2. Me gusta jugar a juegos de mesa.

E3. Me resulta fácil aprender a tocar instrumentos musicales.

E4. Me fascinan otras culturas.

1. Prefiero hacer las cosas con otras personas en lugar de hacerlas sólo.

2. Prefiero hacer las cosas siempre de la misma manera.

3. Cuando trato de imaginarme algo, me resulta fácil crear la imagen en mi mente.

4. Frecuentemente me concentro tanto en una cosa que no presto atención a otras cosas.

5. A menudo escucho ciertos sonidos que las otras personas no oyen.

6. Normalmente presto atención a las matrículas de los coches, u otras informaciones similares.

7. Las otras personas frecuentemente me dicen que lo que yo digo es maleducado, aunque yo en realidad no creo que sea así.

8. Cuando estoy leyendo un libro me resulta fácil imaginarme como son los personajes de la historia.

9. Me interesan mucho las fechas.

10. Cuando estoy en una reunión me resulta fácil seguir varias conversaciones a la vez.

11. Las situaciones sociales me resultan fáciles.

12. Suelo prestar atención a detalles que otras personas no ven.

13. Prefiero ir a una biblioteca en lugar de ir a una fiesta.

14. Me resulta fácil inventar historias.

15. Me siento más atraído por las personas que por las cosas.

16. Suelo tener un fuerte interés por ciertas cosas y me molesta si no puedo realizarlas.

17. Me gusta charlar.

18. Cuando yo hablo apenas dejo hablar a los demás.

19. Me interesan mucho los números.

20. Cuando leo un cuento me resulta muy difícil interpretar las intenciones de los personajes.

21. No disfruto especialmente con los libros de ciencia ficción.

22. Me resulta difícil hacer nuevos amigos.

23. Siempre descubro patrones en las cosas.

24. Prefiero ir al teatro que a un museo.

25. No me molesta si mi rutina diaria se modifica.

26. Frecuentemente noto que me cuesta mantener una conversación con otra persona.

27. Me resulta fácil "leer entre líneas" o captar el doble sentido, cuando alguien me está hablando.

28. Normalmente me concentro más en el todo que en los detalles.

29. No soy bueno para recordar números de teléfono.

30. Normalmente no noto pequeños cambios en una situación o en el aspecto de una persona.

31. Me doy cuenta cuando una persona con la que estoy hablando se aburre.

32. Me resulta fácil hacer más de una cosa a la vez.

33. Cuando hablo por teléfono me cuesta darme cuenta de cuando es mi turno para hablar.

34. Me gusta hacer las cosas espontáneamente (sin planificar).

35. A menudo soy el último en entender una broma.

36. Me resulta fácil imaginarme lo que una persona puede estar pensando o sintiendo sólo con mirarla a la cara.

37. Puedo retomar lo que estaba haciendo después de una interrupción.

38. Soy bueno charlando.

39. La gente me dice que suelo hablar siempre de un mismo tema.

40. Cuando era más pequeño me gustaba jugar con los demás a juegos de imaginación.

41. Me gusta recabar información sobre clases de cosas (por ejemplo, tipos de coches, de pájaros, de trenes, de plantas, etc.).

42. Me resulta difícil imaginarme como sería ser otra persona.

43. Me gusta planificar cuidadosamente las actividades en las que participo.

44. Disfruto de las reuniones sociales.

45. Me resulta difícil identificar las intenciones de las otras personas.

46. Las situaciones nuevas me ponen ansioso.

47. Me gusta conocer gente nueva.

48. Soy bastante diplomático.

49. No soy muy bueno para recordar fechas de cumpleaños.

50. Me resulta fácil jugar a juegos de imaginación con niños.

CHAPTER VI

Individual differences in social attention: Associations with sex, social skills and academic background

Abstract

The literature has shown that the attentional orienting effects elicited by eye-gaze and arrow cues are not quantitatively different from each other. However, recent research has found some qualitative differences in attentional orienting triggered by these so distinct in nature stimuli, which can only be observed when using some specific metodology. In particular, it has been found that while eye-gaze retain the orienting of attention to the specific location that is being looked at, arrows elicit attention to spread towards more extended parts of the environment following object-based rules. However, to date it is still unclear whether this dissociation between these social and non-social stimuli may be directly related to individual differences in personal attributes like gender or sex, which are usually associated with higher or lower social skills. The aim of the present manuscript was, first, to replicate the dissociation in the attentional orienting between eye-gaze and arrow cues, and second, to explore whether this dissociation differed among observers as a function of their sex, sex-role, academic background and/or the scores on self-reported measures of social skills. Our results show the expected dissociation between eye-gaze and arrow cues. However, this dissociation was found to be equivalent regardless of participants' sex, sex-role, academic background and social skills scores. These results seem to contradict the intuition that the observed dissociation between eye-gaze and arrow orienting effects may be associated with individual differences in social cognition. However, these findings should be interpreted with caution, since the measure of social attention used may not be sufficient to capture the more emotional aspects of social cognition. Further research is needed to clarify this matter.

Keywords: gaze-cueing; social attention; social skills; individual differences

Introduction

The ability to perceive other individuals' gaze and understand that it can reflect their internal states have proven to be an essential skill for appropriate human development. Several researchers have found that from just a few hours from birth, infants already manifest a particular interest in other individuals' eyes (see, Batkia et al., 2000; Farroni et al., 2002). Indeed, from at least three months old, humans will already orient their spatial attention towards another individuals' gaze direction (Hood et al., 1998). Therefore, the intuition that the focus of attention on others is a default concern for humans has driven over the years the research on social attention (Birmingham & Kingstone, 2009).

To investigate whether individuals are biased to attend to the focus of attention of another person, a variant of the Ponser's (1980) attentional cueing paradigm has been used. In this variant. Instead of peripheral cues, this variant presents a central face gazing either to the left or to the right. After the appearance of the cue, a target is presented at the cued location (congruent trials) or the opposite position (incongruent trials). Results show that participants are faster to detect, discriminate or locate the target in congruent than in incongruent trials, even when told that the gaze direction did not predict the location where the target would appear (for a review, see Frischen et al., 2007). These findings lead us to believe that eye-gaze triggers automatic orienting of attention.

Some researchers have suggested that at least some aspects of our personality can modulate our social attention abilities. For instance, by using the gaze-cueing paradigm, variations in the cueing effect have been found across individuals. For example, Wilkowski and colleagues (2009) found that individuals with low self-esteem report an increased gaze cueing effec. The authors suggested that this increased effect in individuals with low levels of trait self-esteem (assessed through the self-esteem scale of Rosenberg, 1965), reflected their need to be reconnected with others, which is a core need of human beings (e.g., Baumeister & Leary, 1995). In another experiment, they also reported a similar pattern in a sample of individuals undergoing a manipulation aimed at activating rejection-related thoughts. Specifically, prior to the gaze cueing task, the participants were asked to write for 5 minutes about times in their life when they had felt to be either socially accepted or rejected. This suggests that both inner self-esteem characteristics and internal induced states can restrain the gaze-cueing effect, probably be due to the increased social monitoring when low self-esteem is involved. In the same vein, Dodd et al. (2011) and Carraro et al. (2015) found that orienting of attention towards a social stimulus can be modulated by political temperament. In general, they found that conservatives tend to have a more reduced gaze cueing effect than liberals, suggesting that these results might be due to conservative people being more self-centred and less susceptible to being influenced by others than liberal people.

Interestingly, besides the aforementioned personality states, individual differences in social cognition have also been shown to influence the gaze-cueing effect. For instance, several authors have indicated that some populations with atypical development report different patterns than controls when orienting attention toward social stimuli such as eye-gaze. For example, Ristic and colleagues (2005) found that no automatic orienting effect was observed when using non-predictive gaze cues with a sample of young adults with high functioning autism. On the other hand, Akiyama et al., (2008) and Dalmaso et al., (2013) reported that patients with schizophrenia also show a decrease in the gaze cueing effect when compared with healthy controls.

Of relevance for the present study, Bayliss et al., (2005) showed that the sex of participants could also account for part of the individual differences in the gaze cueing effect. In particular, the authors showed that female participants reported a stronger gaze cueing effect than males and that these results were inversely associated with scores of the self-reported measurement "Autism Spectrum Quotient" (AQ; Baron-Cohen, 2001). This leads to the speculation that across sex, individuals who are more socially skilful tend to orient attention towards social stimuli strongly.

These results are supported on the one hand by the "extreme male brain" theory of autism (Baron-Cohen, 2002), which suggests that normotypical developed male individuals tend to show more autistic-like traits than normotypical females; and, on the other hand, by the associated "empathising-systemising" theory (Baron-Cohen et al., 2002), according to which sex differences can be reflected by two dimensions: empathy (understood as "the drive to identify another person's emotions and thoughts, and to respond to these with an appropriate emotion" allowing to "predict a person's behaviour, and to care about how others feel", Baron-Cohen et al., 2003, p.361) and systematisation (understood as "the drive to analyse the variables in a system, to derive the underlying rules that govern the behaviour of a system" allowing to "predict the behaviour of a system, and to control it", Baron-Cohen et al., 2003, p.361). More precisely, this theory suggests that males tend more to systemise than females, and females empathise more than males.

However, the above reviewed evidence has been generally gathered with the standard gaze cueing paradigm. This task has been criticized for perhaps measuring domain-general rather than a social-specific attention (see Brignani et al., 2009; meta-analytic evidence consistently lead to the same conclusion, Chacón-Candia et al., 2022, [under review]). Furthermore, in this line of research, it is still not clear whether these differences in social skills between males and females are due to their inner natural variations or could be due to gender-stereotypical traits. Indeed, Hsu and colleagues (2021) found that across studies, there seems to be a consistency with the "social role" theory (Eagly, 1987; Wood & Eagly, 2012), which suggest that male tend to have more agency (self-determined actions) and females tend to have more communion (sense of having a place in society; see Bakan, 1966). The meta-analytic review offered by Hsu et al., (2021) showed that even when these sex differences have been decreasing over the years, it is still clear that the tendency to follow these gender-stereotypical traits remains in place. However, it is important to notice that in this last-mentioned study, authors found that using moderators such as age, occupational segregation, sexual orientation or when sampled in couples (vs alone), seems to interfere in the enlargement or decrement of the gender gaps in this gender-stereotypical traits. Therefore, it may be interesting to understand how these stereotypical traits are associated with ability-related beliefs and how these stereotypes and personal beliefs can influence individuals' decisions such as the choosing a university career (see Moè et al., 2021).

Taking into account the above reviewed literature, which suggests that males can tend to have reduced social skills compared to females and that reduced social skills may be reflected in differences in the gaze-cueing effect, the aims of the present study were the following: We firstly looked for a dissociation between social and non-social attention in all participants, thus by using a behavioural cueing-discrimination task that compares the orienting of attention following social and non-social directional cues (Chacón-Candia et al., 2022 [under review]): attention will be directed to an all group of placeholders when using an arrow as a cue, and when eye-gaze is used, attention will selectively focus on the specific placeholder that is being directly signalled.

Secondly, we investigated whether the social vs non-social dissociation was only observed in female participants or it can be rather extended to the male population. We did not expect significant differences when just taking into account the sex of the participants, thus, as shown by Chacón-Candia and colleagues' (2020) previous research where no sex differences were observed when measuring social attentional selection.

Thirdly, we also investigated a possible effect of individuals that choose technology, engineering and mathematics-related careers and/or score higher in the short form of the self-reported measures of the Autism Spectrum Quotient (AQ-10; Allison et al., 2012) or/and the Systemizing Quotient (SQ-R-10; Greenberg et al., 2018) will show reduced differences between social and non-social attention. We based this hypothesis on previous findings (Baron-Cohen et al., 2001), in which the authors report that scientists scored higher on autistic traits than students of humanities and social sciences, thus suggesting that autistic-like traits may be associated with scientific abilities.

Finally, we looked for associations of the sex-role of participants, as measured by a short version of the Bem Sex-Role Inventory (BSRI; Bem, 1974; Páez et al., 2003), expecting that the sex-role categorization of participants will correlate with social vs. non-social attention. We expect that, independently of biological sex, individuals scoring high in "masculinity" and low in "femininity" dimensions will show reduced differences between social and non-social attention.

Materials and Method

Participants

In total, 185 participants (95 female; mean age: 23.01 years, SD: 4.40) were recruited online and gave their informed consent before voluntarily participating in this research. All participants were unaware of the purpose of the study, had normal or corrected to normal vision and received an economic reward for their participation. Two participants were excluded because of the large number of errors they made in the behavioural task (ACC<20%). Of the remaining 183 participants, 92 individuals (45 female) were either graduated or undergraduates from technology, engineering, and mathematics-related careers. The remaining 91 participants (48 female) were graduated or are still enrolled in a humanities or social science careers. The minimal sample size needed for this study was calculated from the effect size of interaction between cueing and the type of stimulus (social vs. non-social) observed in a previous study with the same procedure ($\eta^2_{p=}$0.09) (Chacón-Candia et al., 2022 [under review]). Power analysis with G*power 3.1 (Faul et al., 2009) revealed that at least 36 participants were necessary to observe such an effect with a power of 1-β = .95 and α = .05 in every group.

Measures

Cueing-Discrimination Task

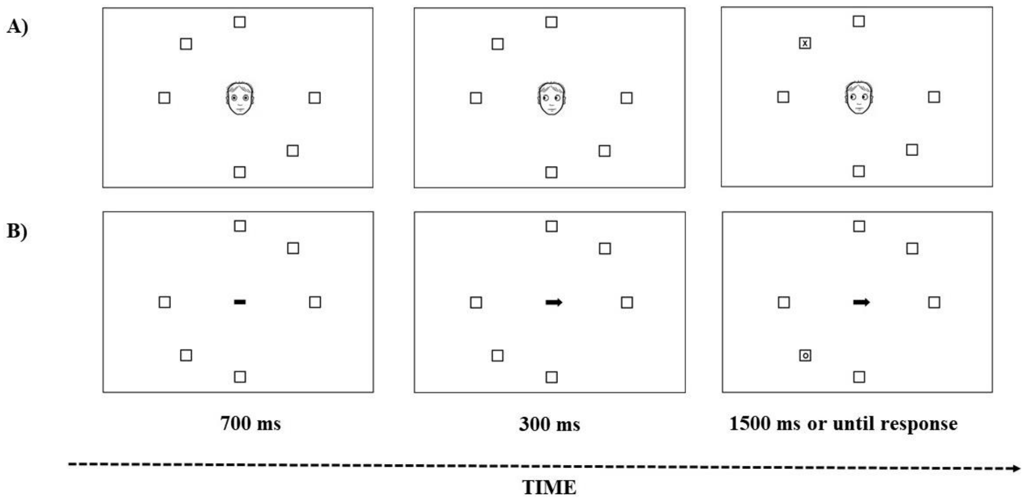
The cueing-discrimination task used in the present study is similar to the one used in the study of Chacón-Candia (2022, under review) in experiment 2, with the exception that just the placeholder-present condition is used. Each trial starts with a display of three placeholder boxes subtending within each hemifield (0°, +/- 45°, and +/-90° from the horizontal meridian) and a central fixation point that differs depending on the cue type (either eye-gaze or arrow). In eye-gaze cueing trials, the central fixation point consisted of a schematic face gazing forward, whereas when an arrow was the cue, the fixation display consisted of a horizontal line. These neutral stimuli were presented for 700ms; then, a change was made either to the eye-gaze or arrow to indicate left or right. After 300ms (SOA) from the appearance of the cue, a target letter was unpredictably displayed (either “X” or “O”). Targets appeared inside one of the six placeholder boxes presented on the scene. Cue and target remained on the screen until the participant responded or until 1500ms elapsed. Then, an empty display was presented for 700ms before the next trial started (e.g. of the procedure is represented in Figure 1).

The task of participants was to discriminate the target letter (“X” or “O”) by pressing on the computer keyboard either the “M” key (using their right hand) or the “Z” key (using their left hand). The corresponding key for each target was counterbalanced across participants. Half of them used the “M” key to answer to “X” and the “Z” key to answer to “O”, and the other half received the reverse instruction. Participants were instructed to maintain central fixation and respond as quickly and accurately as possible throughout all trials. Before starting, participants were told that any information provided by the central stimuli was not relevant to their task, so they should try to ignore it.

Cue type, cue direction, target location, and placeholder-groups distribution (+/-45° from the vertical meridian) were randomly interspersed within each block of trials. There were two blocks of trials. One practice block of eight trials (where feedback was given to the participants based on their performance) and one experimental block of 288 trials. In total, participants had to complete 296 trials.

Figure 1

Schematic view of a trial sequence for both the gaze and arrow cueing conditions.



Note. The example represents: A) gaze-cue/congruent-group condition, and B) arrow-cue/incongruent-group condition.

Self-Reported Measures

Trait measures: The AQ-10 (Allison et al., 2012), which is a short version of the 50-item "Autism Spectrum Quotient" (Baron-Cohen et al., 2001). Containing ten items, this self-report questionnaire was developed to briefly screen autistic traits in the general population. The EQ-10 (Greenberg et al., 2018), is a short form of 10-items from the 40-item "Empathy Quotient" questionnaire (Baron-Cohen & Wheelwright, 2004), which aims to assess the cognitive and affective empathy in adults. Finally, the SQ-R-10 (Greenberg et al., 2018), a short version of 10-items from the 40-item "Systemizing Quotient" (Baron-Cohen et al., 2003), that consists of a self-report questionnaire designed for measuring systemizing traits, understood as the desire to analyse and control a system. In this study a Spanish[8] version of this instrument has been used (see Appendix A,B,C).

Bem Sex-Role Inventory (BSRI): The BSRI (Bem, 1974) is a self-report instrument designed to categorize people as either schematic or non-schematic concerning gender. Based on the scores, it differentiates between female, male, androgynous or undifferentiated individuals. The version used in this study was a Spanish adaptation of the original (Páez et al., 2003). This version contained 18 items that have to be answered in three different dimensions (characteristics that: describe the typical man; describe the typical woman; describe oneself). Notice that for the analyses in this study, only the dimension of how individuals described themselves has been taken into account (see Appendix D).

Additional measures: The Barkley Adult ADHD Rating Scale-IV (BAARS-IV; self-report rating scale for the adult assessment of symptoms of attention-deficit/ hyperactivity disorder; Barkley, 2011). The Spontaneous and Deliberate Mind Wandering Scales (SDMWS; self-report questionnaire that measures de tendencies to have spontaneous and deliberate mind wandering on a daily bases; Carriere et al., 2013). The Short Dark Triad scale (SD3; self-report 27-item instrument, that assessed three personality aversive traits in the general population: machiavellianism, narcissism, and psychopathy; Jones & Paulhus, 2014). The beliefs questionnaire (self-reported measure that assesses participants' gender stereotypes and their conviction to modify certain abilities that are stereotypically male or female favouring; Moè et al., 2009). These additional measures were also taken as part of a larger study with a sample of 1000 participants, thus including the ones reported in the

[8] The Spanish versions were taken if available from the website https://www.autismresearchcentre.com/. Otherwise, the corresponding items from the full Spanish versions offered by the same source were adapted.

present study (note that only participants who additionally performed the behavioural cueing-discrimination task are part of the current research).

General Procedure

This experiment was conducted online. The cueing-discrimination task was designed using the graphical experiment builder OpenSesame (Mathôt et al., 2012). The self-reported measures were collected using the open-source software Lime Survey (https://www.limesurvey.org/). Participants had to complete all the questionnaires before contacting the experimenter to get a personal link to perform the behavioural task. This study was approved by the Ethical Committee of the University of Granada (175/CEIH/2017) and conducted in conformity with the ethical standards of the Declaration of Helsinki.

Design

Two-factor repeated measure design 2 (cue-type) X 4 (cue-target relation) was used to analyse the overall effect of the cueing-discrimination task. The cue-type had two levels, arrow and eye-gaze; cue-target (CT) relation consisted of four levels, same-location/same-group, opposite-location/opposite-group, same-group and opposite-group trials. T-test analyses were performed to analyse the interactions of the CT relation for the general-cueing effect (targets appearing at the left and right locations from the cue) and the grouping effect (targets appearing at +/- 45° and +/- 90° from the horizontal meridian of the cue). For the general-cueing effect, the comparison of CT relations consisted of same-location/same-group trials vs opposite-location/opposite-group trials; for the grouping effect, the cue-target relation consisted of same-group vs opposite-group trials (see, Figure 2 for an illustration).

In order to see the interactions of the grouping-effect with sex, sex-role and career of participants, a two-factor repeated measures design analysis was made, 2 (CT relation) X 2 (cue-type), considering sex, sex-role and career as a between-subject factors. CT relation had two levels, same-group vs opposite-group; cue-type had two levels, arrow and eye-gaze; sex had two levels, male and female; sex-role had four levels, masculine, feminine, androgynous and non-specified and career had two levels, technology/engineering/mathematics-related careers and humanities/social-science careers.

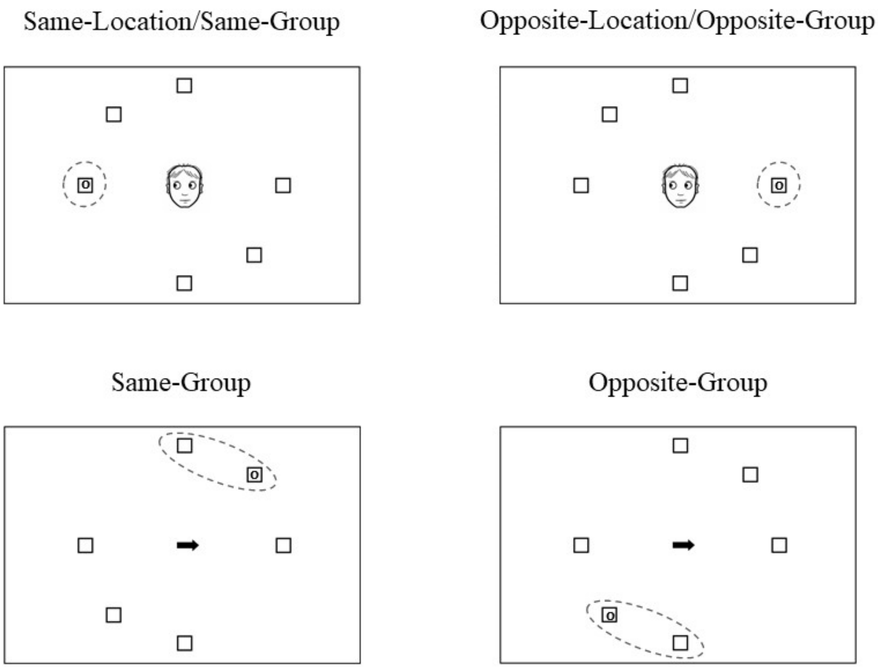
Pearson correlations were calculated to analyse the interaction between participants' grouping effect, sex, rex-role, career and the different trait measures applied

(AQ-10, EQ-10, SQ-R-10). To this end, an *index* of the grouping effect was computed (measured as the difference between the grouping effect for arrow and the grouping effect for gaze). Larger indexes indicate a larger dissociation between social and non-social attention (thereby, we will refer to this index as "social attention"). The index of the Bem Sex-Role Inventory was calculated as the difference between the participant's feminine and masculine scores (as higher the index, the more feminine-role scores).

Errors and trial reaction times faster than 100 ms or slower than 1200ms were excluded from the analysis.

Figure 2

Schematic image of the four types of cue-target relation.



Note. The images represent in the upper part the gaze-cue condition and in the bottom the arrow cue condition.

Results

Cueing-Discrimination Task

For the analysis of the cueing-discrimination task trial with Reaction Times (RT) faster than 100ms or slower than 1200ms (0.8%) and incorrect responses (5.69%) were excluded from the Reaction Time analysis. Mean response times, standard deviations, and error percentages in all conditions are shown in Table 1.

A cue-type (arrows vs. gaze) x CT relation (same-location/same-group, opposite-location/opposite-group, same-group and opposite-group) repeated measures ANOVA was performed to analyse an overall effect.

The analysis reported a main effect of cue-type ($F_{1,182}$=13.846, p=<.001, η^2_p=0.071), showing that in general, participants were faster responding to arrow cues (M=525, SD=77.81) than to eye-gaze cues (M=530, SD=75.5). CT relation also reported significance ($F_{1,182}$=156.82, p=<.001 η^2_p=0.433), showing that reaction times were faster when the target appeared at the same-location/same-group (*M*=507 *SD=72.20*), followed by opposite-location/opposite-group (*M*= 523, SD=75.03), same-group (*M*= 537, SD=76.16) and opposite-group (*M*=542, SD=78.55) respectively.

The cue-type X CT relation interaction was also significant ($F_{1,82}$=22.17 p=<.001, η^2_p=0.109), showing that when the targets appeared at the same-location/same-group, the differences between eye-gaze and arrow stimuli were more pronounced (p<.001) than when targets appeared at any other position (all ps>.05).

In order to analyse separately the corresponding CT relations of the general-cueing effect and the grouping-effect, T-test analyses were conducted. Results revealed a general-cueing effect (same-location/same-group vs opposite-location/opposite-group trials) for both gaze (t(82)=2.467, p=.015) and arrows (t(82)=10.124, p=<.001); Interestingly when analysing the grouping-effect (same-group vs opposite-group trials), a main effect was found but only when arrows have been used as a cue (t(82)=4.507, p=<.001); when gaze cues were presented, no grouping-effect was observed (p>.05; Figure 3).

Table 1

Mean reaction times (RT), standard deviation, and percentage of errors (%IR) as a function of the type of cue and cue-target (CT) relation in the Cueing-Discrimination task.

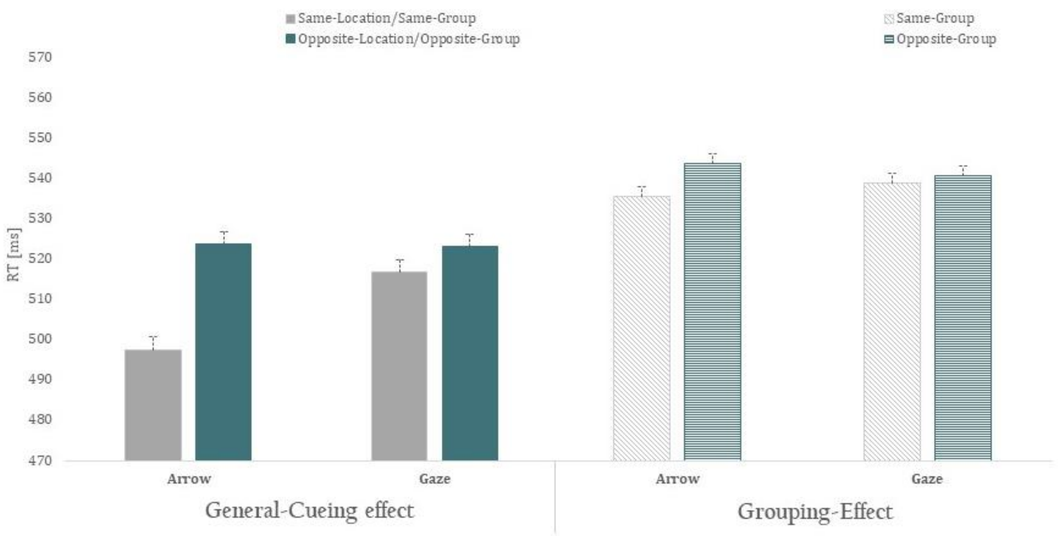
	Arrow			Eye-Gaze		
CT relation	**RT**	***SD***	**%IR**	**RT**	***SD***	**%IR**
Same-Location/Same-Group	497.33	73.76	5.21	516.62	77.42	5.84
Opposite-Location/Opposite-Group	523.74	80.04	6.31	522.91	75.96	5.69
Same-Group	535.48	81.09	5.56	538.90	80.68	5.46
Opposite-Group	543.54	85.31	5.61	540.68	80.89	5.87

The Grouping-Effect among Sex, Sex-Role and Career

A repeated two-factors measures ANOVA was performed to analyse the Grouping-Effect when additionally including sex, sex-role and career as between-subject factors. Results reported as expected from the previous analysis, a main effect of CT relation ($F_{1,182}$=12.241, p=<.001, η^2_p=0.065) showing that in general, participants responded faster at the same-group (M=537, SD=) that at the opposite-group of trials (M=542, SD=). The interaction of cue-type X validity also reached significance, showing a facilitatory effect just when arrows were used as a cue ($F_{1,182}$=20.31, p=<.001, η^2_p=0.100), when eye-gaze was used, no significant effect was found (p<.05). Contrary to our hypothesis, neither the main effect of CT relation, nor the cue-type x CT relation interaction were modulated by sex, sex-role or career of participants (all *ps*>.05; Figure 4).

Figure 3

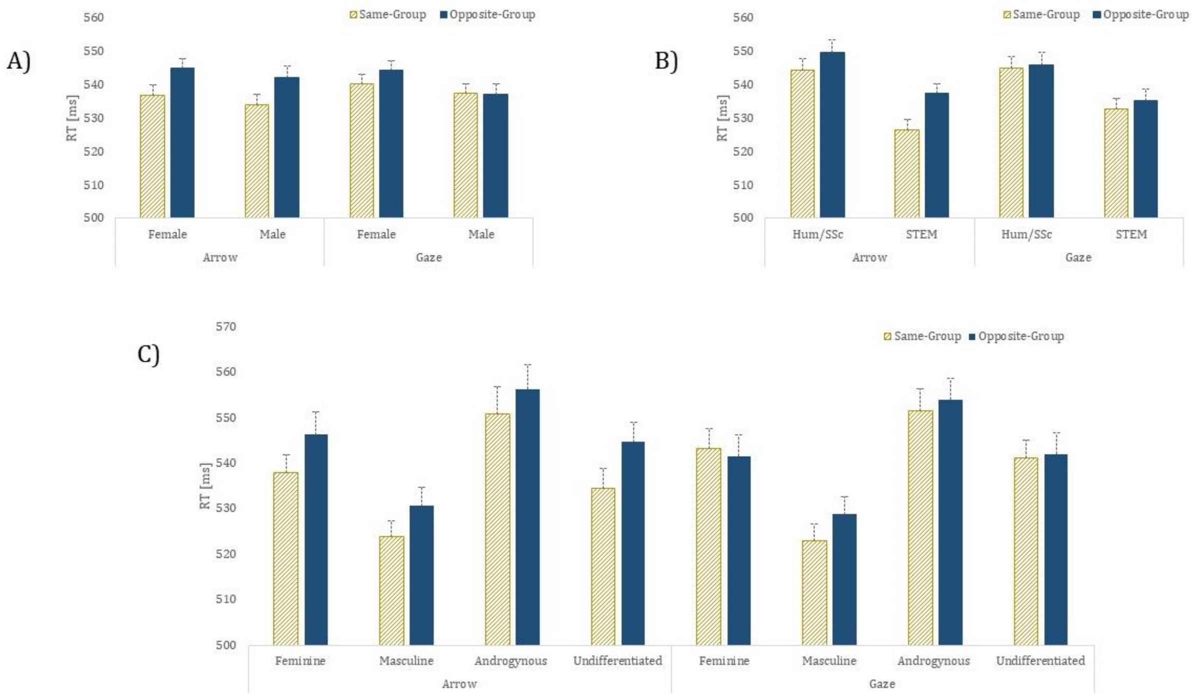
Reaction times (RT) result from the Cueing-Discrimination task.



Note. Results are shown separately for the general-cueing effect and the grouping-effect. Mean RTs are presented for each type of cue as a function of the Cue-Target relation. Error bars represent the standard error of the mean, computed following Cousineau's (2005) method to eliminate variability between participants.

Figure 4

Reaction times (RT) result from the Cueing-Discrimination.



Note. Results are presented as: A) Sex (female-male); B) Career (Humanities/Social-sciences [Hum/SSC] - Technology/Engineering/Mathematics-related [STEM]); C) Sex-Role. Results reflect the grouping-effect. Mean RTs are presented for each type of cue as a function of the Cue-Target relation. Error bars represent the standard error of the mean, computed following Cousineau's (2005) method to eliminate variability between participants.

Correlations

Pearson correlations were performed to test associations between the participants' social attention[9], sex, sex-role, career and personality traits (AQ-10, EQ-10, SQ-R-10). Results showed that the sex of participants was positively correlated with sex-role [r(181) = 24, p=.001], indicating that female participants scored higher than males at the feminine than the masculine role. The sex of participants also correlated with the scores of the EQ-10, showing that female participants generally scored higher in empathy than male participants [r(181) = .308, p=<.001. Additionally, a positive correlation was found when

[9] To test correlations with social attention, an arrow/gaze dissociation index was computed. Thus, measuring the difference between the arrow grouping-effect and the gaze grouping-effect.

observing the Sex-Role[10] of participants and the EQ-10 scores [r(181) = .41, p < .001], indicating that individuals who score higher in femininity tend to report more empathy skills than those scoring higher in masculinity. The career of participants has shown as well to be correlated with the scores of the EQ-10 [r(181) = -.22, p=.003], indicating that participants belonging to humanities and social sciences related careers reflect more empathy skills than participants belonging to technology, engineering, and mathematics-related careers. The EQ-10 scores were negatively correlated with AQ-10 [r(181) = -.45, p < .001], showing that as higher the empathy, the fewer the autistic traits. Moreover, the AQ-10 scores correlated positively with the SQ-R-10 scores [r(181) = .17, p <.02], indicating that to more autistic traits, the higher the systemizing in individuals. No other significant correlations were observed for any of the variables. The results are reported in Table 2.

Table 2

Pearson correlations between social attention, sex, sex-role, career, and personality traits (AQ-10, EQ-10, SQ-R-10).

		Pearson's r	p
Social Attention	- Sex	0.077	0.299
Social Attention	- Sex-Rol	0.080	0.285
Social Attention	- Career	0.059	0.429
Social Attention	- AQ-10	0.046	0.532
Social Attention	- EQ-10	-0.027	0.721
Social Attention	- SQ-R-10	0.040	0.595
Sex	- Sex-Rol	0.236 **	0.001
Sex	- AQ-10	0.035	0.634
Sex	- EQ-10	0.308 ***	< .001
Sex	- SQ-R-10	-0.013	0.864
Sex-Rol	- Career	-0.127	0.086
Sex-Rol	- AQ-10	-0.072	0.334
Sex-Rol	- EQ-10	0.407 ***	< .001
Sex-Rol	- SQ-R-10	-0.113	0.128
Career	- AQ-10	0.125	0.092
Career	- EQ-10	-0.222 **	0.003
Career	- SQ-R-10	-0.070	0.346

[10] To test correlations with the Bem Sex-Role Inventory, a sex-role index was calculated. Thus, measuring the difference between femininity and masculinity scores.

		Pearson's r	p
AQ-10	- EQ-10	-0.450 ***	< .001
AQ-10	- SQ-R-10	0.177 *	0.016
EQ-10	- SQ-R-10	0.047	0.530

* p < .05, ** p < .01, *** p < .001

Discussion

Several studies have shown that socially and non-socially relevant stimuli such as eye-gaze and arrows trigger reflexive attentional shifts into the signalled location. However, qualitative differences have recently been observed between the attentional responses triggered by these two types of stimuli of such a distinct nature. For instance, Marotta and colleagues (2012) showed that when using an arrow as a cue, attention will spread across the entire surface of an object, and when using eye-gaze, attention seems to selectively orient towards the specific location or part of the object that is being signalled. Furthermore, Wiese et al., (2013) showed that when placeholder objects were presented in the context, gaze direction also induced attentional shifts specifically to the exact signalled reference object, similar results that have been observed in a recent study by Chacón-Candia et al., (2022; [under review]), in which it was found that when a group of placeholder were positioned on the scene, arrows will trigger attention to the entire group of placeholders within the signalled hemifield, and when eye gaze is used, attention get trapped into the specific placeholder that is being looked by the cue.

Therefore, these findings seem to argue in favour of the idea that, besides from just directing attention, eye-gaze may trigger a unique attentional process qualitatively different from the attentional process triggered by non-biological stimuli such as arrows. This argument makes all the sense, since the ability to be interested (see Maurer, 1985; Batki et al., 2000; Farroni et al., 2002) and then actually follow another individuals' eyes can be observed from a very early age (i.e., Hains & Muir, 1996; Hood et al., 1998; D'Entremont et al., 1997; Gredebäck et al., 2010).

Assuming that the dissociations found between the attentional shifts produced by biologically relevant and non-biologically relevant stimuli indicate a process of social cognition, it seems of interest to understand whether or not this phenomenon could be modulated by the individuals' social abilities.

We hypothesized that stronger dissociation between social and non-social attention should be more evident in individuals with high empathy, fewer autistic traits and less systematic quotient scores. In the same way, based on the results obtained by Chacón-Candia and colleagues (2020), which shows no differences between social and non-social attention in relation to biological sex, we also investigate how the range in which individuals position themselves within sex-role stereotypes can be another modulator of social attention.

Finally, the last of our main interests was to try to understand how individuals' choice of academic career may also be reflected in their performance of the social attention task and how this, in turn, may be related to their social abilities. For example, it is being found that people with scientific academic profiles show significantly lower social skills than individuals with humanities or social sciences academic backgrounds (Baron-Cohen et al., 2021; Groen et al., 2018).

However, in the current study, even though we manage to behaviourally dissociate between social and non-social triggers of attention, no differences between this dissociation and any of the individuals' measured characteristics were found.

Our data support the conclusion that sex, career, and sex role are related to self-reported cognitive style. In particular, female participants, individuals scoring high in femininity, and participants belonging to humanities and social sciences generally scored higher in empathy (EQ-10 scores). However, they do not substantially differ in our performance measure of social attention. This seem to point against the idea that suggests that the differences in the attentional selection triggered by eye-gaze and arrows may be associated with individual differences in social skills. However, these conclusion must be considered with caution.

At first, although female superiority in social abilities has been generally observed (Groen et al., 2015; Christov-Moore et al., 2014), a growing literature has been showing that females have an advantage in the more emotional and automatic aspects of the theory of mind (affective theory of mind), but that sex differences are minimal for the more controlled and reasoned aspect theory of mind, including perspective taking and mentalizing (cognitive theory of mind) (see for a detailed review Christov-Moore et al., 2014). The measure for social attention in the current study requires a more cognitive mentalizing ability, regarding logical reasoning about the eye-direction and intention of the face cue. This may explain why it was not sensitive for detecting sex, career or sex role differences. This may mean that although the dissociation between the attentional selection triggered by eye-gaze and arrows cues is due to social/mentalizing processes, these are no sensitive to sex differences and/or sex-role stereotypes. Moreover, another explanation for the differences between self-report and performance measures on the cueing task is that beliefs about cognition and behaviour might be different from objectively assessed cognitive performance and behaviour, because self-reports are more susceptible to social and cultural expectations (Christov-Moore et al., 2014).

Conclusion

The present study aimed to explore some individual differences in attentional selection triggered by social and non-social stimuli. The findings support the idea of distinct modes of attentional selection triggered by eye-gaze and arrows, showing that both stimuli produce an automatic orienting effect, but only eye-gaze seems to restrict the attentional selection to the placeholder that is being looked at. However, at least in this study, this gaze/arrow dissociation was found to be unrelated to individuals' sex, sex-role, academic background, or social abilities.

Appendix

A) COCIENTE DEL ESPECTRO AUTISTA PARA ADULTOS (AQ-10)

Allison, C., Auyeung, B., & Baron-Cohen, S., (2012)

Instrucciones

A continuación, encontrará una lista de afirmaciones.

Por favor, lea cuidadosamente cada una de ellas y juzgue en qué medida estas le describen. Seleccione la respuesta que considere más apropiada en base a las siguientes opciones.

1 – Fuertemente de acuerdo

2 – Ligeramente de acuerdo

3 – Ligeramente en desacuerdo

4 – Fuertemente en desacuerdo

----

1. Con frecuencia percibo pequeños sonidos cuando los demás no lo hacen.

2. Usualmente me concentro en toda la película en lugar de pequeños detalles.

3. Se me facilita hacer más de una cosa a la vez.

4. Si hay una interrupción, puedo volver inmediatamente a donde estaba.

5. Se me facilita “leer entre líneas” cuando alguien me habla.

6. Puedo decir cuando alguien me está escuchando o cuando se está aburriendo.

7. Cuando estoy leyendo una historia, se me dificulta identificar las intenciones de los personajes.

8. Me gusta coleccionar información acerca de categorías de cosas (ejemplo: tipos de autos, de aves, de trenes, tipos de plantas, etc.).

9. Se me facilita saber lo que alguien está pensando o sintiendo simplemente mirándole a la cara.

10. Se me dificulta distinguir las intenciones de la gente.

* https://www.autismresearchcentre.com/

B) COCIENTE DE EMPATIA PARA ADULTOS (EQ-10)

Greenberg, D. M., Warrier, V., Allison, C., & Baron-Cohen, S., (2018)

Instrucciones

A continuación, encontrará una lista de afirmaciones.

Por favor, lea cuidadosamente cada una de ellas y juzgue en qué medida estas le describen. Seleccione la respuesta que considere más apropiada en base a las siguientes opciones.

1 – Fuertemente de acuerdo

2 – Ligeramente de acuerdo

3 – Ligeramente en desacuerdo

4 – Fuertemente en desacuerdo

----

1. Soy bueno prediciendo como se sentirá alguien.

2. La gente me dice que soy bueno comprendiendo como se sienten y qué están pensando.

3. Me cuesta entender por qué algunas cosas enfadan tanto a las personas.

4. En seguida me doy cuenta de que quiere hablar la otra persona.

5. No siempre puedo entender por qué alguien se puede sentir ofendido por un comentario.

6. Sintonizo rápida e intuitivamente con cómo se siente otra persona.

7. La gente me dice a menudo que soy insensible, aunque no entiendo siempre por qué.

8. En una conversación suelo centrarme en mis pensamientos en lugar de lo que puede estar pensando el otro.

9. Mis amigos suelen contarme sus problemas porque dicen que soy muy comprensivo.

10. Me resulta difícil saber qué debo hacer en situaciones sociales.

*https://www.autismresearchcentre.com/

C) COCIENTE DE SISTEMATIZACIÓN PARA ADULTOS - REVISADO (SQ-R-10)

Greenberg, D. M., Warrier, V., Allison, C., & Baron-Cohen, S., (2018)

Instrucciones

A continuación, encontrará una lista de afirmaciones.

Por favor, lea cuidadosamente cada una de ellas y juzgue en qué medida estas le describen. Seleccione la respuesta que considere más apropiada en base a las siguientes opciones.

1 – Fuertemente de acuerdo

2 – Ligeramente de acuerdo

3 – Ligeramente en desacuerdo

4 – Fuertemente en desacuerdo

----

1. Cuando aprendo sobre una nueva categoría me gusta comprender en detalle las pequeñas diferencias entre los distintos miembros de la misma.

2. Cuando estoy en un avión no pienso en la aerodinámica.

3. Me interesa saber el recorrido de un río desde su fuente hasta el mar.

4. Cuando viajo en tren, suelo pensar en cómo están coordinadas exactamente las redes viales.

5. Cuando escucho el pronóstico del tiempo no me interesan mucho los patrones meteorológicos.

6. Disfruto mirando los catálogos de productos, viendo y comparando los detalles de cada producto.

7. Cuando veo una montaña, pienso en cómo se formó.

8. Cuando miro un mueble, no me fijo en los detalles de su construcción.

9. Cuando aprendo un idioma, me intrigan sus reglas gramaticales.

10. Cuando escucho una pieza de música, siempre noto la forma en la que está estructurada.

* https://www.autismresearchcentre.com/

D) INVENTARIO DE ROLES SEXUALES DE BEM (BSRI Sex-Role)

Adaptación: Páez, D., Fernández, I., Ubillos, S. & Zubieta, E., (2003)

Instrucciones

En el siguiente cuestionario tu tarea consiste en responder en una escala del 1 al 7 que tanto te identificas con las siguientes características.

1 – Nunca … 7 – Siempre

- ◊ Atlético/a, deportivo/a
- ◊ Cariñoso/a
- ◊ Personalidad fuerte
- ◊ Sensible a las necesidades de los demás
- ◊ Desea arriesgarse, amante del peligro
- ◊ Comprensivo/a.
- ◊ Compasivo/a
- ◊ Dominante
- ◊ Cálido/a, afectuoso/a
- ◊ Tierno/a, delicado/a, suave
- ◊ Agresivo/a, combativo/a
- ◊ Actúa como líder
- ◊ Individualista
- ◊ Amante de los niños
- ◊ Alguien que llora fácilmente
- ◊ Duro/a
- ◊ Sumiso/a
- ◊ Egoísta

CHAPTER VII

General Discussion

An experimental approach to social attention

From a very early age, humans show a special sensitivity to another individual's face, first manifesting interest in their eyes (Maurer, 1985; Batkia et al., 2000; Farroni et al., 2002) and not long after by actually following their focus of attention through their gaze (i.e., Hains & Muir, 1996; Hood et al., 1998; D'Entremont et al., 1997; Gredebäck et al., 2010). Furthermore, this phenomenon of social interaction has been shown to be very important for the development of social communication and to support fundamental processes of human social cognition such as language acquisition and cultural learning. (Bruner, 1983; Tomasello, 1995; Tomasello et al., 1993).

Research in social cognition has demonstrated that under some experimental conditions is possible to observe how eye-gaze reflexively triggers the observer's attention towards the looked-at location (see Frischen et al., 2007 for a review). However, for many years it have not been clear whether the attentional shifts triggered by such biologically relevant stimuli were unique to this type of stimuli or rather indistinguishable from the attentional shifts also automatically triggered by other non-biologically relevant stimuli such as arrows.

Several authors have tried to answer this question finding mixed results. Some authors reported significant differences between the two stimuli, whereas others observed an undistinguishable orienting effect between them (i.e., Brignani et al., 2009; Guzzon et al., 2010; Hietanen et al., 2006; Joseph et al., 2014; Ristic et al., 2002; Stevens et al., 2008; Tipples et al., 2002).

Therefore, the first aim of the present manuscript was to search for an answer to this debate. Thus, in chapter 3 we systematically reviewed, and meta-analysed the existing literature reporting quantitative differences in the attentional orienting triggered by directional eye-gaze and arrows and examined the different variables across studies that can modulate such effect. Overall, the meta-analytical results showed that non-biologically relevant directional stimuli, such as arrows, produce an effect almost identical to eye-gaze, leading to the potential conclusion that attentional orienting triggered by social cues may reflect a domain-general orienting rather than a specialised mechanism of social cognition.

Apart from the meta-analyses of quantitative differences between social and non-social cues, in this chapter we also review the literature regarding studies using other paradigms rather looking for qualitative differences between gaze and arrows. In this case, clear differences (opposite in some cases) are observed between social and non-social attention orienting stimuli. Therefore, when taken into account the whole literature, that idea that these stimuli orient attention through a very similar if not the same mechanism seems untenable. Alternatively, we suggest that eye-gaze might share this domain-general orienting mechanism with non-social directional stimuli; however, in addition to it, gaze might also trigger extra higher-order orienting processes, which are more related to its ability to transmit intentions to others. We argue that these "socially specific" processes may only be trapped with more sophisticated experimental procedures that aim at analysing qualitative rather than quantitative differences between the attentional orienting triggered by these two types of stimuli.

Understanding social attention from a qualitative perspective

Indeed, several studies have demonstrated that besides the quantitative similitude of the attentional orienting triggered by social and non-social stimuli such as eye gaze and arrows, it is possible to find qualitative different effects on the way individuals process information in response to them (i.e., Bayliss et al., 2006; Gregory & Jackson 2017; Marotta et al., 2012; Marotta et al., 2018). This qualitative approach suggests that, besides its capacity to orient in space, eye-gaze additionally represents a tool that helps us to interpret the intentions, interests, and desires of others.

In this regard, the second aim of the present work was to explore through several experimental series whether the attentional orienting triggered by eye gaze and arrows could be qualitatively differentiated when referenced objects (i.e., either looked at or indicated by arrows) were presented on the scene. We based the mentioned aim on previous findings that suggest that the presence of referential objects could modulate the attentional selection triggered by eye gaze (Marotta et al., 2012; Wiese et al., 2013). In three different studies (Chapters 4, 5 and 6) we manipulated the presence of objects in the scene, which acted as placeholders where targets could be presented, after being looked at or indicated by non-social (i.e., arrows) or social (i.e., eye gaze) cues. When attentional orienting was triggered by eye gaze attention seemed to focus on the specific looked-at object or location within the object, whereas when triggered by arrows attention rather seemed to spread across the entire referenced object or the indicated group of object-placeholders.

Therefore, we managed to replicate the findings of Marotta et al., (2012) study. Specifically, in our second experimental series (chapter 5), we found that when large rectangle objects were displayed on the scene and an arrow was presented as a cue, the participants' attention would spread to the whole signalled rectangle, not only the indicated end. In sharp contrast, when eye gaze was the orienting cue, attention focused just on the specific part of the object that was looked at.

Furthermore, besides using an existing paradigm, in experimental series 1 and 3 (chapter 4 and 6) we decide also to develop a new task, thus merging the logic behind Marotta et al., (2012) and Wiese et al., (2013) cueing paradigms. In this case, several small groups of objects were presented as potential placeholders where the target could be presented. Importantly, in the critical experiments, the different objects could be automatically grouped in two different groups. We hypothesise that participants' attention would spread across the whole group of indicated placeholders when an arrow was used as orienting cue. In contrast, when using eye gaze as cue, we hypothesized that attention would focus on the specific looked-at placeholder, thus avoiding the spreading of attention across the whole group of objects. In accordance with previous findings, results showed, as expected, that arrows seem to spread the attentional focus in an object-based manner, whereas eye-gaze restricts the focus of attention to the specific looked at object or specific location within the looked-at large object.

Our findings therefore seem to corroborate that an additional "special process" appears to occur when we orient our attention following biologically relevant cues such as eye gaze, helping us to interpret the intentionality of the people looking, which we use to uncover their intentions, interests, and desires. We thus used these paradigms, which have been shown to be suitable to reveal qualitative differences between social and non-social cues, both the previously developed doble rectangle paradigm (Marotta et al., 2012) and the one newly developed in this thesis (Chapter 4), to carry out the third important goal of the thesis: to investigate sex differences in social attention.

Sex differences in the processing of social attention

Understanding that the qualitative dissociation found between the attentional shifts produced by biologically relevant and non-biologically relevant stimuli indicates a process of social cognition, which is specific to gaze but not to non-social cues, we speculated that the observers' social abilities should modulate this dissociation.

For instance, several researchers have found that people with atypical development in social cognition, such as individuals with high functioning autism (Ristic et al., 2005) or patients with schizophrenia (Akiyama et al., 2008; Dalmaso et al., 2013) show a different pattern of results in paradigms measuring social attention. When orienting attention in the direction of other people's gaze, these participants show a decrease in the facilitation effect typically produced by this social stimulus. Interestingly, other researchers also found that in a normotypical population, some characteristics such as self-esteem (Wilkowski et al., 2009) and political temperaments (Dodd et al., 2011; Carraro et al., 2015) can modulate our social attention abilities.

In this vein, the final aim of this dissertation was to explore whether a natural human aspect, such as our biological sex, can influence how we process social stimuli. Thus, based on previous evidence showing that females tend to outperform males in social skills (i.e., Alwall et al., 2010; Bosacki, 2000; Derntl et al., 2010); similarly, they also show a stronger attentional effect when orienting toward an eye-gaze direction, being these results inversely associated with autistic traits (Bayliss et al., 2005).

In our experimental series 2 (chapter V) we explored, through the cueing discrimination task used by Marotta et al. (2012), whether the dissociation between social and non-social attention could be found just in females or whether it extends to the male population and how this dissociation, if any, could be related to social cognitive mechanisms such as Theory of Mind (measured with the "Yoni Task"; Shamay-Tsoory & Aharon-Peretz, 2007). We also explore the correlation of the expected dissociation with participants' scores of autistic traits (measured with "The Autism-Spectrum Quotient [AQ]"; Baron-Cohen et al., 2001). However, contrary to our hypotheses, no differences between males and females were found in this study, neither for the dissociation between social and non-social attention, nor for the differnet social skills measured such as, autistic traits or theory of mind abilities.

We pointed to several possible limitations from this previous study, which culd explain the absence of differences between male and female participants in social attention abilities. One possible limitation was that the majority of the sample scored low in autistic traits, perhaps due to the fact that all of the participants were psychology students (previous findings report that individuals with a humanities or social sciences academic background tend to have higher social abilities than people with a scientific background [Baron-Cohen et al., 2021; Groen et al., 2018]). Another possible limitation was that we just explored the inner natural variations between males and females and not the individual differences in gender-stereotypical traits. Indeed, the supposed male-female differences might be related to gender-stereotypical traits rather than to sex. Interested in a social and caring-oriented degree such as Psychology, male and female students in our study reported in chapter 5 might indeed share gender-stereotypical traits that would mask possible sex differences. Therefore, we opted to conduct a different study in which these limitations were dealt with.

In experimental series 3, we investigate whether dissimilar processing of social and non-social stimuli could be found when, besides biological sex, we further measured the range in which individuals are positioned within sex-role stereotypes. Furthermore, to clarify whether or not academic preferences could be related to social skills, and in turn to social attention, in this experimental series, we ensured that the whole sample could be divided, apart from sex, evenly into two academic profiles (humanities and social sciences on the one hand, and mathematics, engineering and related careers on the other).

Results show that sex, career, and sex-role of participants are related to self-reported cognitive style. Female participants tended to score high in femininity, and individuals with a humanities or social sciences academic background generally scored higher in empathy. However, no differences between any of the self-reported cognitive measures were found to be related to the participant's performance in our social attention task.

Therefore, altogether data found in our experimental series (2 and 3) seems to indicate that the differences in the attentional selection triggered by social and non-social stimuli may not necessarily be associated with individual differences in social skills. However, this conclusion must be taken with caution since it has been observed that females can outperform males in the emotional aspects of theory of mind but not as clearly in the more cognitive ones (for a review, see, Christov-Moore et al. 2014), which are required to perform our measure of social attention (for example, regarding logical reasoning about the eye-gaze direction and intention of the face). Therefore, this fact that may help to explain why our task was not sensitive to detecting sex, sex-role stereotypes, or career differences. In any case, our well powered study allowed us to conclude that, at least when emotional components of theory of mind are not involved, male and female do not differ in social attention abilities, when measured whit a paradigm that allows specifically measuring social attention.

Importantly, this absence of male-female differences in social attention, could not be due to the sample of participants, and clear differences in self-reported measures of social abilities were observed between the two genders, and between participants with humanities/social sciences vs. those sciences background. Nevertheless, since self-reports measures are more susceptible to social and cultural expectations (Christov-Moore et al. 2014), a further explanation for the inconsistency between behavioural performance and self-reported measures could be that individuals' self-beliefs about cognition may be different from when objectively assessing their cognitive performance and behaviour. Objective measures of social attention, like the ones used in the present thesis, seems to be immune to possible gender differences regarding the believed stereotype, which indeed include social skills.

Conclusions

The findings of the present dissertation suggest that even when no quantitative differences can be found in the attentional orienting triggered by social and non-social stimuli such as eye-gaze and arrows, other methods can be used to highlight qualitative differences in the attentional orienting elicited by those stimuli of such a different nature; these methods should therefore be favored as a more effective and poorer measure of social attention.

Nevertheless, when we used these methods to investigate differences in social attention between populations usually suggested to have dissimilar social abilities, such as males and females, no significant differences were still observed. Furthermore, when trying to understand whether or not the outcomes of the social attention measurement could be related to social cognition regardless of the sex of participants, again, the findings show no differences in the behavioural task performance between populations that self-reported higher or lower social skills.

Therefore, the results reported in this dissertation seem to point against the association between the differences in attentional selection triggered by eye-gaze and arrows and the usually reported sex differences in social cognition. However, the presented conclusion must be taken with caution since we should consider that empathy is composed of emotional and cognitive components that are suggested to be somehow independent of each other (Christov-Moore et al., 2014), and the tasks used in this work to measure social attention involve more logical reasoning about the eye direction and the intentions of the face cue, rather than a more emotional aspect when interpreting the gaze intentionality (the latter being the empathy component in which females have been observed to outperform males). Such a fact could explain why the tasks used in the present dissertation were not sensitive to detect sex differences and/or differences between higher or lower self-reported social skills. Future research should add an emotional component to the gaze cueing pocedures to investigate the relationship between individual differences related to social cognition and attentional orienting by social and non-social cues.

CHAPTER VIII

Resumen

Atención social: un enfoque experimental

Desde muy temprana edad, los seres humanos mostramos una sensibilidad especial por el rostro de otras personas, manifestando primero el interés por sus ojos (Maurer, 1985; Batkia et al., 2000; Farroni et al., 2002) y no mucho tiempo después siendo capaces de seguir su foco atencional a través de su mirada (Hains & Muir, 1996; Hood et al., 1998; D'Entremont et al., 1997; Gredebäck et al., 2010). Este fenómeno de interacción social ha demostrado ser de gran importancia para el correcto desarrollo de la comunicación social y los procesos fundamentales de cognición social, como la adquisición del lenguaje, la inserción cultural y la capacidad para interpretar las intenciones y emociones de nuestro interlocutor. (Bruner, 1983; Tomasello, 1995; Tomasello et al., 1993).

La investigación sobre la cognición social ha demostrado que, bajo algunas condiciones experimentales, es posible observar cómo la mirada provoca que automáticamente la atención del observador se dirija hacia el lugar señalado por la misma (Frischen et al., 2007). Sin embargo, durante años de investigación no se ha conseguido responder a la pregunta de si la atención provocada por este estimulo se debe a su relevancia biológica, o si esta se puede comparar con la orientación atencional provocada por otros estímulos que no tienen dicha relevancia, como lo son las flechas.

Varios autores han tratado de responder a esta pregunta encontrando resultados contradictorios. Algunos han reportado diferencias significativas entre estímulos de naturaleza social y no social, y otros han observado un efecto de orientación indistinguible entre ellos (Brignani et al., 2009; Guzzon et al., 2010; Hietanen et al., 2006; Joseph et al., 2014; Ristic et al., 2002; Stevens et al., 2008; Tipples et al., 2002).

En base a lo anterior, el primer objetivo de la presente tesis doctoral ha sido encontrar una respuesta a este debate. En el tercer capítulo, hemos realizado una revisión sistemática y un meta-análisis de la literatura existente que compara cuantitativamente la orientación atencional desencadenada tanto por la mirada como por las flechas. De igual forma, hemos examinado las distintas variables dentro de los estudios que podrían estar modulando dicho efecto. En general, los resultados del meta-análisis mostraron que los estímulos no sociales, como las flechas, producen un efecto atencional casi idéntico al desencadenado por la mirada, llevándonos a la posible conclusión de que la orientación atencional desencadenada por este estimulo biológicamente relevante puede estar reflejando una orientación más generalizada y no un mecanismo especializado de cognición social.

En este capítulo también se ha revisado la literatura relativa a los estudios que han utilizado otros paradigmas o variaciones del mismo, en donde se han encontrado diferencias cualitativas, más que cuantitativas, de la orientación desencadenada por estos estímulos de diferente naturaleza. Ello sugiere que la mirada podría compartir un mecanismo de orientación de dominio general con estímulos no-sociales, pero que aparte de esto podría estar desencadenando procesos de orientación de un orden superior, que a su vez están más relacionados con la capacidad de este estimulo social de transmitir intenciones, intereses y deseos. Por ello concluimos que para poder capturar estos componentes "sociales" específicos de la mirada es necesario utilizar procedimientos experimentales más sofisticados y no el clásico paradigma de orientación atencional de la mirada, el cual ha sido mayormente utilizado hasta la fecha como herramienta para estudiar la atención social.

Partiendo de esta base, el segundo objetivo de este trabajo ha consistido en explorar a través de distintos experimentos si la orientación atencional desencadenada por la mirada y las flechas podían diferenciarse cualitativamente al manipular el contexto en el que se presenta el estímulo.

Con este fin, en el capítulo 4 hemos desarrollado un nuevo paradigma basado en la lógica de las tareas utilizadas en los estudios de Marotta et al., (2012) y Wiese et al., (2013). En estos estudios, se colocaban objetos de referencia en el contexto de la tarea que señalaban las distintas posiciones en donde el objetivo buscado por los participantes podría aparecer. Ambos autores encontraron que cuando utilizaban una mirada como clave de orientación, los participantes enfocaban su atención específicamente al objeto o parte del objeto que estaba siendo señalado. Sin embargo, cuando una flecha era la clave de orientación la atención de los participantes ya no solo se enfocaba en el punto exacto señalado, sino que se expandía dentro de todo el objeto o grupo de objetos al que apuntaba (Marotta et al., 2012).

Siguiendo esta línea, en nuestra tarea hemos utilizado tanto la mirada como la flecha como claves de orientación central. En el contexto hemos posicionado dos grupos de tres objetos indicando las posibles localizaciones donde aleatoriamente el objetivo podría aparecer. Nuestra hipótesis se sostenía en que cuando la clave de orientación fuera la mirada, la atención de los participantes se enfocaría en el objeto especifico que estaba siendo “mirado” por la clave, y cuando la clave fuera una flecha, la atención se expendería hacia todo el grupo de objetos señalados.

Los resultados observados en nuestra tarea apoyaban nuestra hipótesis inicial ya que cuando la clave de orientación era social (mirada), la atención de los observadores se dirigió únicamente al objeto señalado, y cuando se trataba de una clave no social (flecha), la atención se extendió hacia todo el contexto indicado.

Por lo tanto, nuestros resultados parecen corroborar la idea de que aparentemente un "mecanismo especial" adicional se desencadena cuando orientamos nuestra atención hacia la mirada, y que este proceso es el mismo que puede estar ayudándonos a interpretar las intenciones, intereses y deseos de los demás.

Así pues, contando ya con las herramientas que han mostrado ser efectivas para diferenciar cualitativamente la orientación atencional desencadenada por estímulos sociales y no sociales (atención social), nos hemos enfocado a continuación en el tercer y principal objetivo de la presente tesis: investigar si hay diferencias entre sexos en la atención social.

Diferencias entre sexos en el procesamiento de la atención social

Entendiendo que la disociación en la orientación atencional producida por la mirada y la flecha indican procesos de cognición social, en este trabajo partimos de la idea de que entonces las habilidades sociales de los observadores deberían modular esta disociación.

Varios investigadores han encontrado que las personas con un desarrollo atípico en la cognición social, como los individuos con autismo de alto funcionamiento (Ristic et al., 2005) o los pacientes con esquizofrenia (Akiyama et al., 2008; Dalmaso et al., 2013) muestran un patrón de resultados diferente en los paradigmas que miden la atención social. Al orientar la atención en la dirección de la mirada de otras personas, estos participantes muestran una disminución del efecto de facilitación típicamente producido por este estímulo social. Curiosamente, otros investigadores también encontraron que en la población normotípica, algunas características como la autoestima (Wilkowski et al., 2009) y la ideología política (Dodd et al., 2011; Carraro et al., 2015) pueden también modular nuestras capacidades de atención social.

Siguiendo esta línea, el objetivo más relevante de esta tesis ha sido explorar si un aspecto tan humanamente natural, como lo es el sexo biológico, puede influir en la manera en que procesamos los estímulos sociales. En base a la literatura que sugiere que las mujeres tienden a superar a los hombres en habilidades sociales (i.e., Alwall et al., 2010; Bosacki, 2000; Derntl et al., 2010), y que incluso parecen tener un mayor efecto de orientación atencional cuando un estímulo biológicamente relevante como la mirada es la clave de orientación(Bayliss et al., 2005), en el capítulo 5 de esta tesis, hemos explorado por medio del paradigma utilizado por Marotta et al., (2012), si la disociación entre la atención social y no social se encuentra sólo en las mujeres o si ésta se extiende también a la población masculina. De igual manera, investigamos cómo esta disociación podría relacionarse con mecanismos cognitivos sociales como la Teoría de la Mente (medida con la tarea "Yoni"; Shamay-Tsoory & Aharon-Peretz, 2007). En este capítulo, también exploramos la correlación de la disociación esperada con las puntuaciones de los participantes en rasgos típicos del autismo (medidos con "The Autism-Spectrum Quotient [AQ]"; Baron-Cohen et al., 2001). Finalmente, en contra de nuestras hipótesis, los resultados no reflejaron diferencias significativas entre hombres y mujeres, ni en la disociación entre atención social y no social, ni en las diferentes habilidades sociales medidas como los rasgos autistas o Teoría de la Mente.

Señalamos varias posibles limitaciones de este estudio, que podrían explicar la ausencia de diferencias entre los participantes masculinos y femeninos en las habilidades de atención social. Una posible limitación ha sido que la mayoría de la muestra puntuó bajo en rasgos autistas, pudiendo deberse al tipo de muestra empleada, al ser todos los participantes estudiantes de Psicología (los hallazgos anteriores informan de que los individuos con una formación académica en humanidades o ciencias sociales tienden a tener mayores habilidades sociales que las personas con una formación en ciencias puras; Baron-Cohen et al., 2021; Groen et al., 2018). Otra posible limitación fue que solo exploramos las variaciones naturales internas entre hombres y mujeres y no las diferencias individuales en los rasgos estereotipados de género. Estos resultados podrían indicarnos que quizás las supuestas diferencias entre hombres y mujeres podrían estar más relacionadas con los rasgos estereotipados de género que con el sexo biológico.

Con el objetivo de abordar las mencionadas limitaciones, en el capítulo 6 investigamos si se podía encontrar un procesamiento diferente de los estímulos sociales y no sociales cuando, además del sexo biológico, se medía el rango en el que los individuos se posicionan dentro de los estereotipos de rol de género (para este fin utilizamos una adaptación del inventario de roles de género BSRI; Bem, 1974; Páez et al., 2003). De igual manera, para aclarar si estos roles de género y la atención social podrían relacionarse con las preferencias académicas de los participantes, en esta serie experimental nos aseguramos de que toda la muestra se dividiera equitativamente, aparte de en el sexo biológico, en diferentes perfiles académicos (humanidades y ciencias sociales por un lado, y matemáticas, ingenierías y ciencias afines por otro). Para medir las habilidades sociales los participantes completaron una serie de cuestionarios que median tanto la empatía (EQ-10; Greenberg et al., 2018; ver Baron-Cohen & Wheelwright, 2004 para la versión original), como el cociente del espectro autista (de AQ-10; Allison et al., 2012; ver Baron-Cohen et al., 2001 para la versión original), y el cociente de sistematización (SQ-R-10; Greenberg et al., 2018; ver Baron-Cohen et al., 2003 para la versión original), siendo estas habilidades sociales algunas de las que han mostrado diferencias significativas entre sexos (Baron-Cohen et al., 2002; 2004), género (Hsu et al., 2021) y perfiles académicos (Moè et al., 2021).

Los resultados de este estudio han reportado una relación entre el sexo, la inclinación académica y el rol de genero de los participantes, mostrando que las mujeres tendían a puntuar más alto en feminidad que los hombres (BSRI; Bem, 1974; Páez et al., 2003), y que los individuos con formación académica en humanidades o ciencias sociales generalmente puntuaban más alto en empatía que quienes tenían un perfil en ciencias puras. Sin embargo, no se encontraron diferencias significativas entre ninguna de las medidas de autoinforme y el rendimiento de la muestra en nuestra tarea de atención social.

Los resultados encontrados en los capítulos 5 y 6 parecen indicar que las diferencias en la selección atencional desencadenada por los estímulos sociales y no sociales pueden no estar necesariamente relacionadas con las diferencias individuales en habilidades sociales ni el rol de género. Sin embargo, esta conclusión debe tomarse con cautela, ya que aparte de que las medidas de autoinforme parecen ser susceptibles a las expectativas sociales y culturales (Christov-Moore et al., 2014), se ha observado también que las mujeres pueden superar a los hombres pero en los aspectos más emocionales de Teoría de la Mente, ventaja que no se ha visto tan clara al comparar los aspectos más cognitivos de esta habilidad social (para una revisión, véase, Christov-Moore et al. 2014), siendo estos últimos evidentemente necesarios para la realización de nuestra tarea comportamental utilizada para medir la atención social (por ejemplo, para el razonamiento lógico sobre la dirección de la mirada y su intencionalidad). Así pues, ésta podría ser una posible explicación de por qué nuestra tarea no fue sensible para detectar las diferencias en atención social en función del sexo, los estereotipos de rol de género, o el perfil académico. En cualquier caso, este trabajo nos ha permitido concluir que, al menos cuando los componentes emocionales de la teoría de la mente no están involucrados, los hombres y las mujeres no difieren en las habilidades de orientación atencional cuando estas se miden con los paradigmas aquí utilizados para estudiar la atención social.

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