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BRIEF REPORT

REVISED Gaze cues and arrow cues modulate accuracy of recall of verbal items in a working memory task

[version 2; peer review: 2 approved, 1 approved with reservations, 1 not approved]
Previously titled: Gaze improves working memory for verbal items

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Abstract

Background

Previous studies have shown that items that another individual looks at are better remembered than items that are not looked at, whereas the same effect has rarely been observed for non-social cues such as arrows. This pattern of results has been taken as an indication that joint attention improves memory. However, these previous studies have differed in the type of memory being tested and the type of content that is to be remembered: while effects of joint attention on long-term memory were tested with verbal items and non-verbal items, effects on working memory have only been tested with non-verbal items such as colour. Thus, the aim of the current study was to extend these previous findings and investigate whether joint attention influences working memory for verbal items.

Methods

In Experiment 1, participants were first presented with an image of a face with eyes that gazed either to the left or to the right. A grid of 4 letters (2x2) was then shown either on the side cued by gaze or on the opposite side. After a retention interval (1000 ms), participants were shown a letter in the centre of the screen and judged whether this letter was part of the grid shown before. In Experiment 2, we followed the same general procedure but one group was presented with gaze

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cues, and the other group was presented with arrow cues.

Results

Across two experiments, our results revealed that participants had better recall of letters that had been cued than letters that had not been cued, regardless of cue type. In contrast, participants' reaction times were not influenced by whether the letter had been cued.

Conclusions

Our findings suggest that both social and non-social cues can modulate recall of verbal items such as letters in a working memory task.

Keywords
gaze cueing, working memory, joint attention, attention orienting



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REVISED **Amendments from Version 1**

The main change from version 1 is that we conducted a second experiment, in which we assessed the specificity of the gaze cueing effect on recall of verbal items in working memory observed in the original experiment (now experiment 1). For this, we tested two new groups of participants: one in which the orienting cue was a gaze cue (social cue) and one in which the orienting cue was an arrow cue (non-social cue). The results of this second experiment showed that recall of verbal items was modulated both by the gaze cue– thus representing a direct replication of experiment 1 – and the arrow cue.

In addition, the revised version contains the following changes:

1. Expansion of the Introduction section: The revised version provides a broader overview of the literature and explicitly discusses the proposed mechanisms underlying the cueing effects on memory observed in previous studies.

2. Further information given in the Methods section: Based on reviewers' comments, the revised version includes detailed information on the age ranges of the participants, final sample sizes, and randomisation of trials.

3. Expanded Discussion section: The revised version includes an expanded discussion, in which we first discuss that our combined results across the two experiments may be explained by shifts in spatial attention, followed by a discussion regarding the differences in our study to the most related previous studies on cueing effects on recall of items in working memory. Finally, we discuss avenues for future research that are opened up by the current results.

4. Additional figures have been added, required because of the second experiment (Figure 3, Figure 4), and the labels on Figure 2 have been updated.

5. Throughout the whole manuscript, minor language edits have been made to improve consistency of terminology and clarity of the writing.

Any further responses from the reviewers can be found at the end of the article

Introduction

The physiology of human eyes with their large white sclera and dark iris helps provide a clear signal of the direction in which an individual is looking (Kobayashi & Kohshima, 1997). A large body of research using manipulations to face and eye images that reflect shifts in the iris position relative to the sclera have demonstrated that humans are remarkably sensitive to the direction of another's gaze. Already 3-month old infants shift their own attention in the direction signalled by images of eyes looking to the left or right placed on an image of a face (Hood *et al.*, 1998). For adults, such shifts in attention appear to have some degree of automatization, appearing in situations where gaze fails to predict a target's location and when participants are placed under cognitive load (Friesen & Kingstone, 1998; Visser & Roberts, 2018).

This sensitivity to the direction of another's gaze further allows two individuals to coordinate their attention toward the same external stimulus. The benefits of such 'joint attention' have been the subject of extensive discussion (Kwisthout *et al.*, 2008; Moore *et al.*, 2014; Tomasello, 1995). One strand of research on the downstream consequences of joint attention focuses on processes that have played key roles in the discussion about the evolution of joint attention – such as the impact of joint attention on word learning (Hirotani *et al.*, 2009) and on conveying information about preferences (Bayliss *et al.*, 2006; Bayliss *et al.*, 2007). A second strand of research investigates the impact of joint attention on domain-general processes that could be affected by an individual's previous level of attention, such as working memory (Gregory & Jackson, 2017, 2019) and long-term memory (Dodd *et al.*, 2012; Ishikawa & Yoshioka, 2025).

Dodd *et al.* (2012) demonstrated the effect of gaze cues on recall of items stored in long-term memory. Participants first saw a schematic face that did not have pupils/irises. Then, the pupils/irises were shown, making the face appear to look to the left or to the right. Finally, a word was shown either to the left or to the right side of the face, such that the word appeared either on the side that the eyes were looking toward (cued words) or on the opposite side (uncued words). When asked to recall the words at the end of the experiment, participants remembered words better when they had appeared in the location that the central face had been looking at, suggesting that gaze cues may improve long-term memory of written words. Complementing these results, Gregory and Jackson (2017) found that participants showed higher accuracy of recall for cued items than for uncued items in a working memory task. Here, participants were presented with a grid of 4, 6 or 8 coloured squares either on the side that a central face gazed toward or on the opposite side. There were thus two critical differences between these two studies. First, in Dodd *et al.* (2012), the to-be-remembered items were words, and in Gregory and Jackson (2017), they were square patches of colour – such that in the former, the memory test was based on verbal information, and in the latter, the memory test was based on non-verbal information. Second, in Dodd *et al.* (2012), the test was conducted at the end of the presentation of all to-be-remembered items, and in Gregory and Jackson (2017), the test was conducted 1000 ms after the offset of the to-be-remembered items – such that in the former, accuracy in

recalling items stored in long-term memory was assessed, and in the latter, accuracy in recalling items in working memory was assessed. Critically - based on a wider debate within the gaze cueing literature regarding the specificity of the underlying mechanism (Capozzi & Ristic, 2020; Chacón-Candia *et al.*, 2023; Hietanen *et al.*, 2008; Marotta *et al.*, 2012; Ristic *et al.*, 2002) - both studies also tested whether a non-social stimulus that can orient attention, namely an arrow cue, would improve participants' recall (Experiment 4 in Dodd *et al.*, 2012; Experiment 2 in Gregory & Jackson, 2017). In both cases, the accuracy of recall was not affected, suggesting that the effect on recall may be specific to social cues such as gaze.

Following these two original studies investigating cueing effects on recall of items in long-term memory and in working memory, several follow-up studies have extended the initial findings and some of them employed further tests of the specificity of the gaze cueing effect. For recall of items stored in long-term memory, apart from Dodd *et al.* (2012), only one study investigated the effects of cueing. Ishikawa and Yoshioka (2025) tested 7- to 10-year-old children following a similar procedure to Dodd *et al.* (2012) using fractal patterns instead of words as the to-be-remembered items. Like in Dodd *et al.* (2012), here too, gaze cues, but not arrow cues improved recall of patterns, suggesting that gaze cues also improve recall of *non-verbal* content stored in long-term memory. For items in working memory, for which more studies have been conducted, the results of purely behavioural measures are more mixed. One recent study that only used gaze cues failed to replicate the cueing effect on recall (Experiment 1: Foglino & Wykowska, 2025). Most other studies reported cueing effects on recall that were specific to the gaze cue or only tested the effect of gaze on recall (Gregory & Jackson, 2019; Gregory & Kessler, 2022). Additionally, in the original study by Gregory and Jackson (2017), one experiment used a motion cue (a vertical line that shifts in space along a horizontal line) as the non-social cue, thus showing that the lack of an effect on recall was not specific to the use of an arrow as the non-social cue. In contrast, a study that used a 3D environment found that recall of information about an object was improved both by a gaze cue and a moving non-social cue (Gregory *et al.*, 2022). Critically, however, the authors report a difference in the change in theta power between cued and uncued items at the time in which the items were encoded between the two cue types. This was interpreted as evidence that the cueing effects observed at the behavioural level may be differently implemented at the neural level. Taken together, for both long-term memory and working memory, the majority of empirical findings thus support the notion that gaze cues have a specialized role in improving recall.

This notion of a specialized effect of gaze cues on recall is strengthened by results indicating that participants also process information that is unique to social agents. Gregory and Jackson (2019) demonstrated that the effect of gaze was modulated by whether the depicted eyes could see the target. Here, barriers that prevented sight - placed between the gaze cue and the target location - abolished the influence of gaze cues on recall. However, the effect of gaze on recall of items in working memory was found when the barriers had a window in them which allowed the target to be seen from the position of the gaze cue. Furthermore, due to modulation of memory being related to what can be seen from the position of the gaze cues, the authors concluded that this effect may be driven by mentalising (for a review of the links between gaze cueing and mentalising, see Capozzi & Ristic, 2020).

This hypothesized specialized role of gaze cues in improving recall of cued items stands in contrast to results of standard detection tasks, in which both gaze cues and arrow cues orient attention towards a specific location such that participants are faster at responding to cued vs. uncued items (for a meta-analysis, see Chacón-Candia *et al.*, 2023). The results from such detection tasks thus suggest that there is no notable difference in the amount of spatial attention that is being affected by social and non-social cues even if the exact mechanisms underpinning the effects may differ (e.g., Galfano *et al.*, 2012; Ristic *et al.*, 2002). Consequently, because the effect appears to be independent of the influence that gaze and arrows have on attention, most authors interpret the effect of gaze cues on recall as a 'memory effect'. This interpretation appears to be in line with findings from studies where gaze cues were presented not before but *after* the to-be-remembered item (in this case, a complex polygon shape) was presented and thus encoded in working memory (Nie *et al.*, 2018; Zhang *et al.*, 2023). These studies found that retroactive gaze cues, but not retroactive motion cues improve recollection – findings that cannot be explained by changes in external spatial attention because the to-be-remembered items are no longer visible.

Before all these results from studies on long-term memory and working memory can be taken as an indication that orienting cues (whether social orienting cues like gaze specifically, or orienting cues more generally) produce improvements to working memory for different types of memory across different stimuli, it is crucial to consider that processes involved in storing verbal and non-verbal information in working memory are commonly proposed to be separate (Baddeley, 2003). Verbal information is likely being stored within the phonological loop, with information decaying rapidly unless subject to a maintenance process such as subvocal rehearsal (Camos *et al.*, 2009; although see Oberauer, 2019). In contrast, non-verbal information is thought to be stored in the visuo-spatial sketchpad and is also maintained through maintenance strategies that may involve allocating attention – in the absence of the stimulus – to the spatial location of stimuli that need to be remembered (Awh *et al.*, 2006). Considering the results of research into the effects of

orienting cues on recall, this raises the question of whether for verbal content, orienting cues improve recall only for items stored in long-term memory or whether the improvement is also seen for items in working memory. We investigated this question across two experiments using a modified procedure of Gregory and Jackson (2017). In Experiment 1 we tested whether accuracy of recall of verbal content in working memory is improved by a gaze cue. In Experiment 2 we tested whether this improvement in recall of verbal content was specific to a social cue (gaze cue) or whether it would also occur for a non-social cue (arrow cue).

Experiment 1

Methods

Participants

A power analysis using the R package 'pwrrs' indicated that a sample size of 34 was needed to detect a medium sized effect (cohen's d = 0.5) with a power of 0.8 using a paired sample t-test with the significance level set at .05. Thirty-six participants with a mean age of 38 (SD = 11.4, range = [19-60]) years were recruited using prolific.com and were compensated £2.25 for taking part in the study. Data files were available for all participants, but two participants were excluded due to deviations in their reaction time or accuracy data (see analysis section). Thus, the final sample was 34 participants. The study was approved by the Ethics Committee for Research at the Faculty of Humanities and Social Sciences, University of Rijeka [640-01/20-01/71]. All participants gave written informed consent by filling in an electronic form.

Materials

The experiment was built using jsPsych (de Leeuw *et al.*, 2023) and the jspsych-psychophysics plugin (Kuroki, 2021). The information sheets and debrief sections of the experiment were built using surveyJS (https://github.com/surveyjs) and custom JavaScript.

Images of three male and three female faces from the Chicago Face Database (Ma *et al.*, 2015) were selected. Potential directional cues elicited by peripheral facial features or hair were removed by masking the entire image aside from a central oval area and turning the image to grayscale. Iris position and the lightness of the sclera was manipulated by modifying the original images using GIMP (GIMP version 2.10; https://www.gimp.org/) to create 3 images – where the face appeared to look straight ahead, look to the left and look to the right. The images were presented with a width of 180px.

The letters presented were consonants that appear with medium to high frequency in English (B, C, D, F, G, H, K, L, M, N, P, R, S, T; previously used by Yeaton & Grainger, 2022). Letters were always capitalized and presented in 'Open Sans' font with a font size of 48px and a font weight of 800.

All stimuli were presented within a HTML5 canvas element 800px by 450px. The code used to create the experiment can be found at https://github.com/elegg/gaze-cueing-wm-verbal-experiment. The experiment itself was deployed using JATOS (Lange *et al.*, 2015) and hosted at https://mindprobe.eu/.

Procedure

At the start of each trial, a central black fixation cross was displayed for 1000 ms. This was followed by a face with direct gaze (central iris position) shown for 750 ms. An image of the same face with the position of the irises in each eye shifted either to the left or right of their previous position - to indicate a change in gaze direction - was presented for 500 ms in the absence of any other stimuli. This image continued to be displayed for a further 150 ms[1] during which a 2x2 grid of letters appeared to either the left or the right of the face. Next, a central black fixation cross was displayed for 1000 ms. The display of this fixation cross acted as the retention interval before a single black letter (probe item) was presented in the centre of the screen. This letter was presented for a maximum of 3000 ms or until participants made a response. A response was made either using the up-arrow key to indicate that the letter had been present in the previously presented letter grid or the down-arrow key to indicate that the letter had been absent from the grid. Participants then received feedback for 500 ms depending on whether they had answered correctly, incorrectly or had not made a response within 3000 ms (see Figure 1).

Participants first received 12 practice trials. They then received a total of 192 trials divided into 4 blocks of 48 trials. In half of the trials, the letter grid was presented in the same direction that the eyes on the central face looked toward (*cued*

[1]This differs from Gregory and Jackson (2017) who displayed colour patches for 100ms. However, when piloting our study, participants perceived this duration to be too short such that we extended the duration to 150ms.

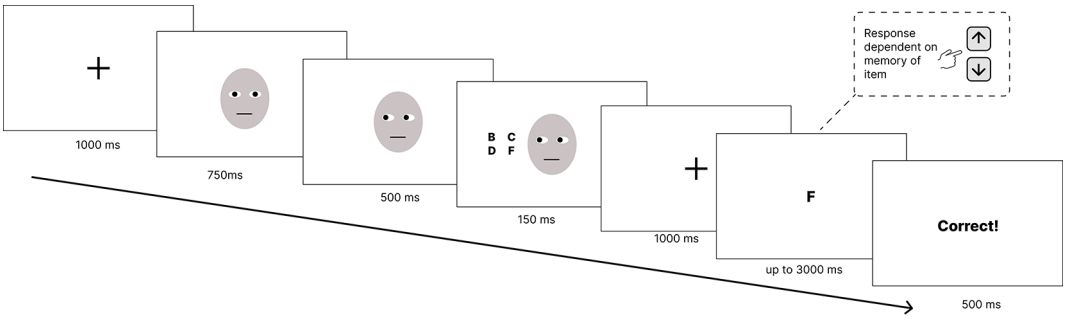


Figure 1. Example trial sequence. *Note:* An example of a trial. First a fixation cross is shown, then a face with eyes facing directly at the participant. The eyes on the face are then shown looking to the left or right and after a 500 ms stimulus onset asynchrony a grid of 4 letters appeared for 150 ms. This was followed by a 1000 ms retention interval before a probe item appeared for up to 3000 ms or until the participant made a response. Participants then received feedback based on their response. *Please note that due to restrictions on distributing images from the Chicago Face Database (Ma et al., 2015) a schematic image of a face has been used in place of the images used in the experiment.*

condition; 'valid condition' sensu Gregory & Jackson, 2017) and in the other half, the letter grid was presented in the other direction (*uncued* condition; 'invalid condition' sensu Gregory & Jackson, 2017). Further, in half of trials the probe item judged by participants had been present in the letter grid. Forty-eight trials were used per block because this reflects all possible combinations of 6 faces, 2 gaze directions, 2 locations for the letter grid and 2 options for whether the probe item had been presented or not. The grid of letters was constructed for every trial by randomly sampling (without replacement) from the 14 consonants. On the 50% of trials where the probe had been present in the grid, one of the four letters was randomly selected to be the probe. In the other 50% of trials, a fifth letter was sampled from the remaining consonants. The order of these 48 trials was randomised within each of the 4 blocks.

Analysis

Our primary measure of interest was the discriminability index d' as an indicator how well participants could detect whether the item presented at test (probe item) was one of the items they had previously been shown based on both hits (correct detections) and misses (false detections). We calculated d' as

$$Z\,(\text{proportion of correct detections}) - Z\,(\text{proportion of false detections})$$

For each participant, we calculated d' for all trial types together as well as separately for trials in the *cued* condition and for trials in the *uncued* condition. Following Gregory and Jackson (2017), we excluded any participants whose d' score was not within 2.5 median absolute deviations (see Leys *et al.*, 2013 for an explanation of the benefits of using median absolute deviation to remove outliers) of the pooled median. This led to data from one participant being excluded from the final analysis. A paired sample t-test was used to compare participants' d' scores between the *cued* condition and the *uncued* condition.

For a secondary measure, we also analysed participants' response times. This was done primarily to ensure that any potential difference in the participants' accuracy between the two conditions was not due to a speed-accuracy trade off. For this analysis, we first removed all trials that had incorrect responses. For each participant, we calculated their median overall response time and their median response time for the *cued* condition and the *uncued* condition. Data from participants whose median response time was not within 2.5 median absolute deviations of the pooled median were excluded. This led to data from one participant being excluded from the final analysis. A paired sample t-test was used to compare participants' median response times between the *cued* condition and the *uncued* condition.

After exclusion of participants based on d' scores and reaction times, the final sample size for all analyses was 34.

Results

Accuracy - d'

Participants were better able to detect whether they had seen the letter before in the *cued* condition (M = 2.04, SD = 0.79) than in the *uncued* condition (M = 1.58, SD = 0.0.78; t(33) = 5.72, p <001, d = 0.58; Figure 2A).

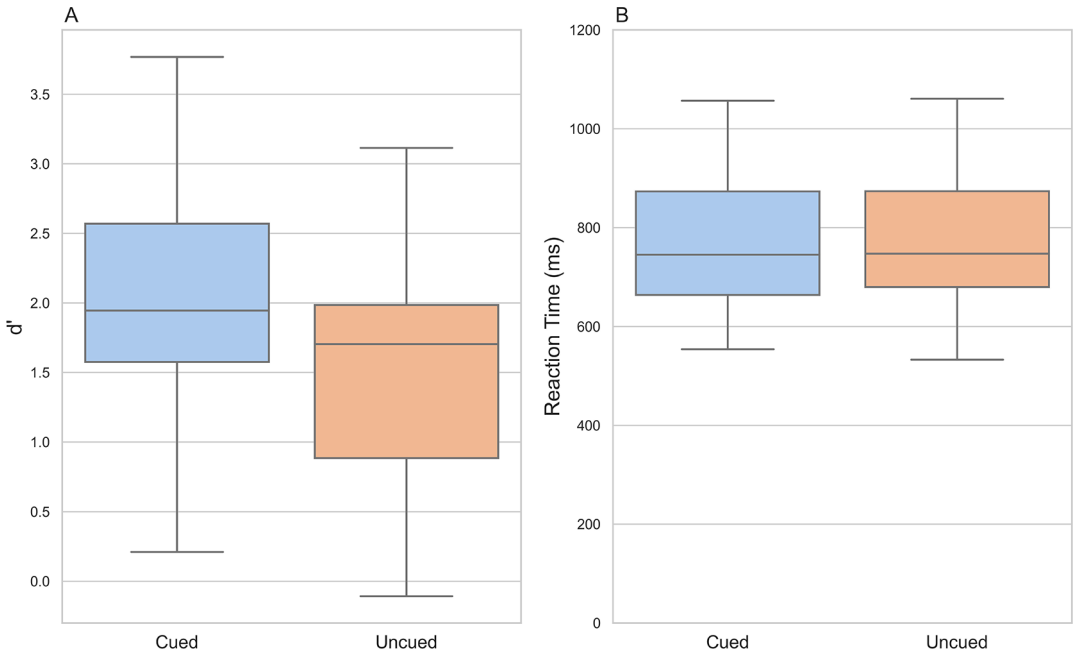


Figure 2. Discriminability index d' and reaction times in the *cued* and conditions. *Note*: **A**) Box and whisker plots showing median and interquartile range of d' for the *cued* and *uncued* conditions. **B**) Box and whisker plots showing median and interquartile range of participants' reaction times on correctly answered trials for the *cued* and *uncued* conditions.

Reaction times

We did not detect a statistically significant difference in the time it took participants to respond between the two conditions (t(33) = 0.967, p =.34, d = 0.05; *cued* condition: M = 770.00 ms, SD = 131.00 ms; *uncued* condition: M = 762.00 ms, SD = 133.00 ms; Figure 2B).

Discussion

Our main results in Experiment 1 showed that participants were more accurate in judging whether they had previously seen a letter when - at the time it was presented - a gaze cue was directed towards it (*cued* condition) than when the gaze cue was directed away from it *(uncued* condition). Thus, the results regarding the effect of gaze cueing on participants' recall of letters found in our study closely resembles the results found by Gregory and Jackson (2017) for colour squares.

As a secondary result, we found no statistically significant effect of gaze cueing on the time it took participants to respond to whether they had previously seen the probe item. This contrasts with the findings by Gregory and Jackson (2017), where participants were not just more accurate but also faster to respond to the probe item when it had been cued. This divergence in findings may be explained by the differences in the type of the to-be-remembered content (verbal content in our study and non-verbal content in Gregory and Jackson (2017)) or differences in the working memory load (our study used only 4 to-be-remembered items, whereas Gregory and Jackson (2017) used 4, 6, and 8 items). The most plausible explanation, however, is that this effect is weak and not found in the current study due to lower statistical power of the statistical test than needed to detect such an effect. The current study was powered to detect a mid-sized effect, as expected for an effect of the gaze cue on the main measure of interest (d'). This interpretation is further supported by the lack of an effect on reaction times in other follow-up studies to the original Gregory and Jackson (2017) study (e.g., Gregory & Jackson, 2019). Critically, the effect of the gaze cue on participants' reaction times to a probe item has limited bearing on our main question of whether gaze cues influence working memory. This is because here, like in previous studies, the primary concern with reaction times is that participants may trade speed for accuracy. The absence of any such pattern of results in the current study and the inverse effect found by Gregory and Jackson (2017) suggest that such a trade-off is unlikely to explain the observed difference in recall accuracy.

In conclusion, the findings of Experiment 1 suggest that gaze cues may not only increase recall of non-verbal content (Gregory & Jackson, 2017) but also of verbal content. However, in light of the debate about whether such an improvement of recall may be based on spatial attention or is directly related to changes in working memory itself and in light of

previous studies highlighting that the effect for non-verbal items may be specific to social, gaze cues, (Dodd *et al.*, 2012; Gregory & Jackson, 2017, 2019; Ishikawa & Yoshioka, 2025) it was necessary to test to what extent the effect observed in Experiment 1 was specific to the gaze cue. In Experiment 2, we thus tested two groups of participants, one in which the cue was social (gaze cue) – this group thus acted as a direct replication of Experiment 1 – and one in which the cue was non-social (arrow cue).

Experiment 2

Methods

Participants

A power analysis using the R package 'pwrrs' indicated that a sample size of 152 was needed to detect the estimated effect size of partial η^2 of 0.051 with a power of 0.80 using a 2x2 ANOVA with one between-subject and one within-subject factor. The estimated effect size was based on the size of the interaction found by Gregory and Jackson (2019) between barrier type (transparent vs. opaque) and consistency. This size of the cueing effect is substantially smaller than the effect size found for the interaction between cue type and consistency by Ishikawa & Yoshioka (2025) partial η^2 of 0.366. A total of 168 participants with a mean age of 41.4 (SD = 10.7, range= [20-60]) years were recruited using prolific.com and were compensated £2.25 for taking part in the study. Data files were missing from two participants, and nine participants were excluded due to deviations in their reaction time or accuracy data (see analysis section). Thus, the final sample was 157 participants. The study was approved by the Ethics Committee for Research at the Faculty of Humanities and Social Sciences, University of Rijeka [640-01/20-01/71]. All participants gave written informed consent by filling in an electronic form.

Materials

The experiment was built using the same procedure as in Experiment 1. The same 6 face stimuli used in Experiment 1 were used as orienting cues for the gaze version of the task. For the arrow version of the task, six different arrows in different styles were created using Figma (figma.com; see Figure 3) to provide the non-social orienting cues. In addition, six squares in corresponding styles to the arrows were used to provide non-directional stimuli for the non-social cues equivalent to the initial presentation of the face with direct gaze. The letters presented were the same and followed the same procedure as in Experiment 1.

Like in Experiment 1, all stimuli were presented within a HTML5 canvas element 800px by 450px. The code used to create the experiment can be found at https://github.com/elegg/gaze-cueing-wm-verbal-experiment. The experiment itself was deployed using JATOS (Lange *et al.*, 2015) and hosted at https://mindprobe.eu/.

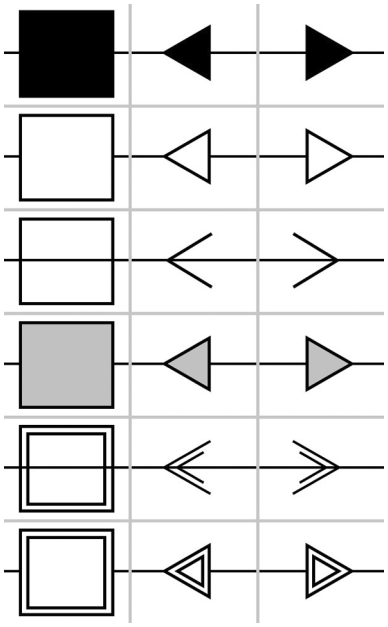


Figure 3. Arrow Exemplars. *Note:* The six exemplars of arrows presented during the study as non-social cues. The square in the left column represents the non-directional image, the central column represents the left pointing arrows and the right column the right pointing arrows.

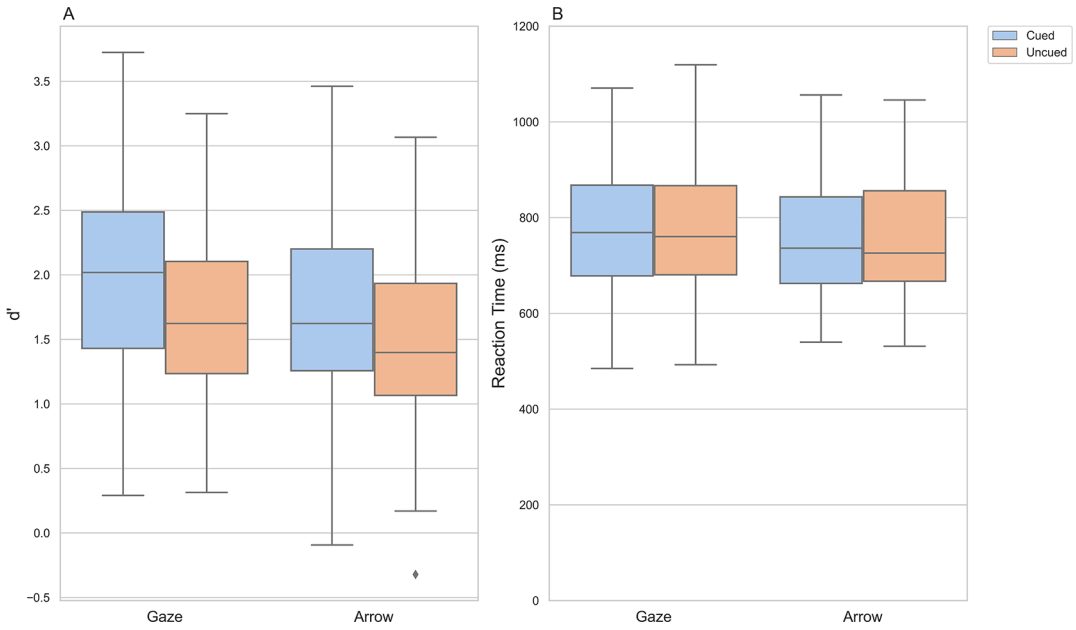


Figure 4. Discriminability index d' and reaction times in the *cued* and *uncued* conditions. *Note*: **A**) Box and whisker plots showing median and interquartile range of d' for the *cued* and *uncued* conditions. **B**) Box and whisker plots showing median and interquartile range of participants' reaction times on correctly answered trials for the *cued* and *uncued* conditions.

Procedure

The procedure was the same as in Experiment 1 except that at the start of testing, participants were assigned to either the gaze or arrow version of the task. Thus, participants only received instructions and test trials relating to one type of cue. Participant allocation was assigned such that the two groups were filled as close to equal as possible. If, at the time of starting the experiment, fewer participants had been assigned to one group, then the participant was assigned to the other group. If the same number of participants had been assigned to each group, then participants were assigned to one of the two groups with a probability of .5.

Analysis

We calculated d' for each participant as described in Experiment 1. Further, we followed the same procedure for excluding participants as in Experiment 1 (exclusion if d' score was not within 2.5 median absolute deviations of the pooled median). This led to 4 exclusions. A 2 (cue type: gaze vs. arrow) x 2 (consistency: cued vs. uncued) ANOVA was used to analyse d' scores. In addition, for each cue type, we conducted a paired t-test to compare participants' d' in the *cued* and *uncued* conditions.

Participants' median response times were calculated as described in Experiment 1. Again, we used the same exclusion criteria as in Experiment 1 (exclusion if median response time was not within 2.5 median absolute deviations of the pooled median). This led to 5 exclusions. A 2 (cue type: gaze vs. arrow) x 2 (consistency: cued vs. uncued) ANOVA was used to analyse reaction times.

After exclusion of participants based on availability of data files, d' scores, and reaction times, the final sample size for all analyses was n = 157.

Results

Accuracy - d'

For both types of cue, participants were better able to detect whether they had seen the letter when the letters had been cued than when they had not been cued (arrow - cued: M =1.71, SD = 0.79; arrow - uncued: M = 1.49, SD = 0.66; gaze - cued: M = 1.93, SD = 0.75, gaze - uncued: M = 1.62, SD = 0.66). This was observed as a statistically significant difference between the conditions for each of the cue types separately (arrow: $t(78) = 4.08$, $p < .001$, $d = 0.30$; gaze: $t(77) = 4.56$, $p < .001$, $d = 0.44$) and as a statistically significant main effect of consistency in a two-way ANOVA ($F(1, 155) = 37.405$, $p < .001$, $\eta_p^2 = 0.194$). The ANOVA revealed no statistically significant main effect of cue type ($F(1, 155) = 2.522$,

p = .31, η_p^2 = 0.016) and no statistically significant interaction between cue type and consistency (F(1, 155) = 1.061, p = .305, η_p^2 = 0.007).

Response times

The two-way ANOVA revealed no statistically significant main effect of cue type (F(1, 155) = 0.427, p = .515, η_p^2 = 0.003) and no statistically significant main effect of consistency (F(1, 155) = 0.659, p = .418, η_p^2 =0.004) on participants' reaction times. There was also no statistically significant interaction effect between cue type and consistency on participants' response times (F(1, 155) = 0.996, p = .32, η_p^2 =0.006).

Discussion

The results of Experiment 2 showed that, regardless of cue type, participants were more accurate at judging whether they had previously seen a letter when – at the time it was presented – it had been cued than when it had not been cued. The improved recall of cued letters observed in the group in which the cue was a social stimulus (gaze) thus replicated the findings from Experiment 1. Because this effect was also observed in the group presented with a non-social cue (arrow) and there was no statistically significant difference regarding this effect between the two cue types, our results suggest that the observed effect on recall is not specific to social stimuli such as gaze cues. Like in Experiment 1, we found no significant difference in the time it took participants to respond, regardless of cue type and consistency, strengthening the suggestion that the improved accuracy for cued items cannot be explained by a speed-accuracy trade-off.

General Discussion

Across two experiments, we demonstrated that orienting cues increase the accuracy of participants' recall for letters presented at the cued location compared to uncued letters in a working memory task. In Experiment 1, we demonstrated this effect for gaze cues and in Experiment 2, we replicated the effect for gaze cues and demonstrated that the effect also occurs for arrow cues. Notably, we found that there was no statistically significant difference in the effect between gaze and arrow cues. Thus, the results of the two experiments indicate that recall for verbal content in working memory can be improved when the content is presented at a cued location regardless of whether the cue is considered social (gaze) or non-social (arrows). A cue-driven change in spatial attention may provide the most likely and parsimonious explanation for why verbal items that are cued are remembered better than uncued items. When spatial attention is drawn away from the to-be-remembered items (i.e., uncued items), participants need to re-orient towards the location of the to-be-remembered items, such that the length of time these items are attended to (and in which they can be encoded) is less than for cued items for which no re-orientation is needed (Alister *et al.*, 2024).

The findings of Experiment 2 contrast with the results of the most closely related studies of attentional cueing on working memory (Gregory and Jackson, 2017, 2019): while the results of Experiment 2 regarding the impact of *gaze cues* act as a conceptual replication of these previous studies, the results regarding the impact of *arrow cues* clearly differ from the results of these previous studies because there, arrow cues produced no improvement in recall. Although the specific effect of gaze cues on recall has also been reported by other studies, Gregory *et al.* (2022) found that both social (head movement) and non-social (movement of a stick) cues improved participants' ability to recollect information about 3D objects. Consequently, we need to consider what could explain why some studies find that social but not non-social cues influence recall while other studies find an effect on recall also for non-social cues (namely Gregory *et al.*, 2022, and our Experiment 2).

Gregory *et al.* (2022) proposed the increased salience of the moving non-social stimulus as a potential explanation of why they found a cueing effect on recall also with a non-social orienting cue. Relatedly, in Experiment 2 of the current study, in order to be able to make a generalised claim regarding arrows (and not a single arrow) and provide the equivalent number of different arrows to the number of different faces in the gaze cue group, we presented participants in the arrow group with six different arrow exemplars. A consequence of this was that the arrows in the current study may have been more salient to participants than in previous studies, where a single arrow has been used. Critically, these previous studies used multiple exemplars of faces for the social orienting cue but only a single exemplar for the non-social orienting cue (Gregory & Jackson, 2017, 2019; Ishikawa & Yoshioka, 2025; Nie *et al.*, 2018; Zhang *et al.*, 2023; an exception is Dodd *et al.*, 2012 who used a single schematic face). The use of multiple exemplars may reduce habituation to a repeatedly presented stimulus (Thompson, 2009). In the case of faces, repetition of the same face is known to reduce typical responses but continuous presentation of different faces does not (Gauthier *et al.*, 2000). Thus, the difference in the number of arrow exemplars presented in previous studies may have reduced the salience of the arrow cues in a way that the salience of multiple gaze cues did not. Consequently, we cannot rule out that an effect also for non-social cues would be found in studies on recall of non-verbal content in working memory tasks when both social and non-social cues have similar levels of salience.

In addition to highlighting the question about the salience of the orienting cue, our results open up further research avenues and theoretical considerations for cueing effects on memory. In regard to cueing effects on recall in working memory tasks, future work may need to systematically investigate the possibility of an interaction between the type of orienting cue (social vs. non-social) and the nature of the to-be-remembered items (verbal vs. non-verbal). Theoretical implications of such an interaction should consider that spatial attention – to the extent that it is assumed to be similar for both social and non-social orienting cues – cannot provide the full explanation of the effect of cues on recall, because spatial attention would be the same both for verbal and non-verbal to-be-remembered-items. Thus, the divergence of patterns across cues would indicate that the way that verbal and non-verbal content is stored within working memory plays a crucial role in whether a cue will improve recall. In line with this idea that the way that verbal content is stored in working memory matters, a recent review of verbal interference paradigms highlights that covert language tends to play a role in memory when the to-be-remembered items have a readily available label (Nedergaard *et al.*, 2023). Finally, in regard to cueing effects on long-term memory, it remains to be investigated why for verbal content, both gaze cues and arrow cues are able to produce a cueing effect on recall in a working memory task, while this effect is reported to only carried forward to long-term memory for gaze cues specifically (Dodd *et al.*, 2012).

Conclusion

The current study sought to extend previous findings that have demonstrated an impact of social cues on memory. In the case of long-term memory, it has previously been found that a social cue but not a non-social cue (arrows) improves accuracy for recall of both verbal items (words) and non-verbal items (colour). In the case of working-memory, it has been found that a social cue improved accuracy for recollecting non-verbal items. The results of Experiments 1 and 2 indicate that both gaze and arrows modulate recall of verbal items in a working memory task. For these current results, spatial attention appears to be sufficient in explaining why orienting cues modulate recall in a working memory task for verbal content.

Ethics and consent

The study was approved by the Ethics Committee for Research at the Faculty of Humanities and Social Sciences, University of Rijeka [640-01/20-01/71].

All participants gave informed written consent to participate by filling in an online (electronic) consent form.

Data availability statement

The raw data from certain trials of the experiment contain personal identifiable information and cannot be made publicly available due to ethical considerations. However, the following data has been made available and contains all information necessary to replicate our analysis, results and data visualisations.

Zenodo: Data From “Gaze cues and arrow cues modulate accuracy of recall of verbal items in a working memory task”, https://doi.org/10.5281/zenodo.18294236 (Legg *et al.*, 2026a).

This project contains the following data:

- “gaze-working-memory-data.csv” which contains the trial by trial data for each participant from Experiment 1. Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0)

- “gaze-arrow-wm-data.csv” which contains the trial by trial for each participant from Experiment 2. Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0)

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0)

Software availability statement

Software used in the experiment is available from:

- Source code available from: https://github.com/elegg/gaze-cueing-wm-verbal-experiment

- Archived software: https://doi.org/10.5281/zenodo.18294236

- License: MIT License

Software used for analysis and visualisations is available from:

- Source code available from: https://github.com/elegg/gaze-cueing-memory-verbal-analysis
- Archived software available from: https://doi.org/10.5281/zenodo.18294571
- License: MIT License

Extended data

Zenodo: Extended Data From "Gaze improves working memory for verbal items", https://doi.org/10.5281/zenodo.18294406 (Legg *et al.*, 2026b).

This project contains the following data:

- Extended Data - Gaze-WM.docx (a word document containing: 1. an example consent form questionnaire, 2. an example of the instructions – text and image - presented to participants in Experiment 1, 3. an example of the text presented to the participant in the debrief section of the experiment, 4. an example of the instructions presented to participants in the arrow group of Experiment 2 and, 5. an example of the instructions presented to participants in the gaze group of Experiment 2).

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0)

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Version 2

Reviewer Report 14 March 2026

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✔ **Samantha Gregory**
University of Salford, Salford, England, UK

The authors have addressed my comments, and I have found the results of study 2 to be enlightening. The idea around the multiple arrows being the reason for the result in study 2 is an interesting one. This definitely adds salience, as does the transition from box to arrow, so I agree with this salience interpretation. I also appreciated the replication of study 1s gaze result in study 2.

I recommend that the manuscript be accepted.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Social gaze cuing, attention, working memory

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 05 March 2026

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✔ **Jari Hietanen**
Tampere University, Tampere, Finland

I congratulate the authors for carrying out a new experiment. As we see, the results were rather

revealing. I have only two comments.

The first is very minor. In Introduction, fourth paragraph, second sentence: "For recall of items stored in long-term memory, apart from Dodd *et al.* (2012), only one study investigated the effects of cueing". >> "..the effects of gaze cuing".

In General Discussion, the authors discuss about the possible reasons for conflicting results regarding the effects of arrow cuing (in paragraph starting "Gregory *et al.* (2022) proposed the increased ...". The authors suggest that, perhaps, one reason for their finding a cueing effect also for arrows was related to the number of different version of their arrow cues. This might be so. But, in my mind, another possibility is related to the visual appearance of their neutral and directional symbolic cues. The change from a square (neutral) to an arrow (directional) is visually very salient. Perhaps more salient than in the previous studies not reporting an effect for arrow cues. So this could be a reason for the present findings also, and the authors might want to bring up this possibility too in their Discussion. This is just a suggestion.

In sum, I am happy with the present version of the manuscript and have no further comments.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cognitive psychology/attention orienting by gaze cuing

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 04 March 2026

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?

Krzysztof Cipora
Copernicus Center for Interdisciplinary Studies, Jagiellonian University in Krakow, Krakow, Poland

I think the authors have done a decent job revising the manuscript and most of my concerns are properly addressed. I think adding the second experiment was a great choice. Although the second experiment changes the conclusions quite dramatically, it is very informative.

It has now become clear why the idea of facial cuing arose in the first place, when specificities of the effect above and beyond effects of arrow cues are explained. This might be helpful to several readers.

However, there are still a couple of points I would like the authors to address.

1. Power analysis for Experiment 1. Where did the assumed effect size of d = 0.50 come from? In

psychology it is rather a large effect, hence a word of justification would be useful. For instance, Brysbaert (refer to reference 1) as the best guess for an effect size in psychology proposes d = 0.40 and provides extensive justification for that. It is fine to be interested in larger effects only, but some explanation would help the reader understand this choice.

2. Figures 2 and 4. I know it may be a matter of taste, but you might consider presenting the datapoints along with the boxplots. It is a matter of displaying 34 dots per condition so the figure should not be too overcrowded and shows the exact distribution of the data.

3. Effect of faces, effect of arrows and whether they affect spatial attention or working memory. In Discussion of Experiment 1 you write: "However, in light of the debate about whether such an improvement of recall may be based on spatial attention or is directly related to changes in working memory itself and in light of previous studies highlighting that the effect for non-verbal items may be specific to social, gaze cues, (Dodd et al., 2012; Gregory & Jackson, 2017, 2019; Ishikawa & Yoshioka, 2025) it was necessary to test to what extent the effect observed in Experiment 1 was specific to the gaze cue." I am not sure whether I can follow the argument here. To my reading you are claiming that presence of the effect for faces but not for arrows implies that working memory is engaged, while presence of both effects implies attentional effects. I am asking myself why such dissociation of effects of facial cues and arrows would indicate the role of working memory. Invalid facial cues might well be preventing the encoding of the information, so the working memory might not have obtained the sufficiently accurate material in the first place. For this argument to hold you would need to demonstrate that the material was perceived similarly in both conditions and the difference originates from the effects on working memory specifically. If I do not get the point, you might consider that some of your future readers do not get it either, and consider explaining it in a little bit more detail.
You acknowledge a possibility that the effect takes place in attention rather than working memory in the first paragraph of the general discussion. Nevertheless, I suggest reading the paper carefully to check for consistency in this. As for now, for instance potentially problematic claims can be found in the conclusion of the abstract.

4. Power analysis for Experiment 2. Which effect do you specifically mean? The interaction showing no effect for arrows and an effect of faces? Be more specific.

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Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cognitive psychology, numerical cognition with some expertise in attention and working memory.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Version 1

Reviewer Report 08 January 2026

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Jeanette A. Chacón-Candia
University of Granada, Granada, Spain

This study aimed to investigate whether socially relevant cues modulate working memory for verbalizable information, in a similar way to what has been previously reported for colour stimuli (Gregory & Jackson, 2017). In an online experiment, participants were first presented with a central schematic face looking straight ahead, which subsequently shifted its gaze to the left or right along the horizontal axis. After 500 ms, a grid containing four letters appeared either to the left or right of the central cue. Following a retention interval indicated by a fixation cross, a single probe letter was presented. Participants were required to indicate whether the probe letter had been part of the previously presented letter grid.

Using this paradigm, the authors examined whether working memory was enhanced when the letter grid appeared at the location cued by gaze, or whether gaze-target congruency did not influence participants' ability to remember the letters.

The authors found that participants were more accurate in remembering the letters when the grid appeared at the gazed-at location than when it appeared on the opposite side. Based on these results, they conclude that joint attention can enhance working memory for verbalizable stimuli, such as letters.

Before providing my comments on the manuscript, I would like to note that I consider the investigation of social attention and its connection with other cognitive functions, such as working memory, to be an interesting and valuable area of research. It is encouraging to see how other authors are engaging in this line of work and contributing to the expansion of the literature on these interesting topic.

General Comments and Suggestions

- A relevant point that I believe could strengthen the manuscript concerns the relationship between the present findings and previous work by Gregory and Jackson (2017). The authors repeatedly state that their paradigm is highly comparable to that study and explicitly build on its theoretical framework. However, an important methodological difference should be acknowledged.

In Gregory and Jackson (2017), a direct comparison was made between socially relevant cues (eye-gaze) and non-social cues (arrows and low-level motion cues). Their central conclusion (that eye-

gaze selectively modulates working memory) was explicitly based on this contrast, leading the authors to argue that the effect was driven by the social relevance of gaze. In the present study, by contrast, only socially relevant cues (eye-gaze) are included. As a result, the paradigm does not allow for a direct test of whether the observed effects are specific to social cues or could also be elicited by non-social directional cues.

Despite this limitation, the authors draw conclusions that closely mirror those of Gregory and Jackson (2017), attributing the observed working memory benefits for verbalizable stimuli to social mechanisms such as joint attention. Without including a non-social control condition, however, these claims appear less strongly supported. Explicitly discussing this methodological difference, and tempering the theoretical conclusions, accordingly, would improve the clarity and strength of the manuscript.

Building on this point, it may be relevant for the authors to consider recent meta-analytic evidence questioning the social specificity of the classic gaze-cueing paradigm. Specifically, Chacón-Candia et al. (2023) showed that, at a quantitative level, the classic gaze-cueing task does not produce effects that reliably differ from those elicited by non-social cues such as arrows. This evidence suggests that the attentional orienting effects observed in standard gaze-cueing paradigms may reflect domain-general mechanisms rather than uniquely social processes.

In light of this, taking into account this literature, and maybe extending the current design to include an appropriate non-social control cue (e.g., arrows), or at least discussing this limitation explicitly, would substantially strengthen the manuscript. In particular, a qualitative comparison between social and non-social cues within the working memory task would allow the authors to more convincingly support claims regarding the role of joint attention or social relevance in modulating working memory performance.

- Following the previous point, it may be worth expanding the theoretical background to include additional recent studies examining the relationship between social attentional orienting and working memory. Although these studies do not focus exclusively on verbal working memory or employ identical experimental paradigms, they are nevertheless highly relevant to the aims of the present work, as they address how socially relevant cues influence attention and working memory processes.
For example, studies such as Foglino & Wykowska (2025), Nie et al. (2018), and Zhang et al. (2023) provide important evidence showing how social attention can modulate working memory performance under different task conditions. I consider that including this literature would help better situate the present findings within the broader field and strengthen the theoretical framework of the study.

Minor comments / clarifications

- Out of curiosity, it would be helpful to report the age range of the participants. Given that the mean age is 38 years, this seems relatively high, maybe providing the full range would help to better characterize the sample.

- The manuscript mentions that two participants were excluded based on the criterion of 2.5 mean absolute deviations. However, it is not entirely clear how many participants were included in the final sample after exclusions. We suggest clarifying this information explicitly in the Participants

section.

- It is not reported in the manuscript whether the hypotheses were pre-registered prior to data collection. If the study was not pre-registered, we would simply encourage the authors to consider this practice in future work, as it can enhance transparency and reproducibility.

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Is the work clearly and accurately presented and does it engage with the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

Are all the source data and materials underlying the results available?
Yes

Are the conclusions drawn adequately supported by the results?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Social Attention, Social Cognition

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 19 Jan 2026

Edward Legg

Dear Dr. Chacón Candia,
Many thanks for your thorough and helpful comments on the original version of our manuscript. We have changed the manuscript according to your comments, all of which also align with the comments by the other reviewers. This refers to two main aspects, namely the inclusion of a second experiment that tests the effects of both social cues (gaze cue) and non-social cues (arrow cue) on recall of verbal items in working memory, and the expansion of the theoretical discussions in this research field.
Below we provide point-by-point responses to your comments on the original version of our manuscript – for this we have pasted your comments in italics and provide our replies in plain font.

This study aimed to investigate whether socially relevant cues modulate working memory for verbalizable information, in a similar way to what has been previously reported for colour stimuli (Gregory & Jackson, 2017). In an online experiment, participants were first presented with a central schematic face looking straight ahead, which subsequently shifted its gaze to the left or right along the horizontal axis. After 500 ms, a grid containing four letters appeared either to the left or right of the central cue. Following a retention interval indicated by a fixation cross, a single probe letter was presented. Participants were required to indicate whether the probe letter had been part of the previously presented letter grid. Using this paradigm, the authors examined whether working memory was enhanced when the letter grid appeared at the location cued by gaze, or whether gaze-target congruency did not influence participants' ability to remember the letters. The authors found that participants were more accurate in remembering the letters when the grid appeared at the gazed-at location than when it appeared on the opposite side. Based on these results, they conclude that joint attention can enhance working memory for verbalizable stimuli, such as letters. Before providing my comments on the manuscript, I would like to note that I consider the investigation of social attention and its connection with other cognitive functions, such as working memory, to be an interesting and valuable area of research. It is encouraging to see how other authors are engaging in this line of work and contributing to the expansion of the literature on these interesting topic. General Comments and Suggestions
- A relevant point that I believe could strengthen the manuscript concerns the relationship between the present findings and previous work by Gregory and Jackson (2017). The authors repeatedly state that their paradigm is highly comparable to that study and explicitly build on its theoretical framework. However, an important methodological difference should be acknowledged. In Gregory and Jackson (2017), a direct comparison was made between socially relevant cues (eye-gaze) and non-social cues (arrows and low-level motion cues). Their central conclusion (that eye-gaze selectively modulates working memory) was explicitly based on this contrast, leading the authors to argue that the effect was driven by the social relevance of gaze. In the present study, by contrast, only socially relevant cues (eye-gaze) are included. As a result, the paradigm does not allow for a direct test of whether the observed effects are specific to social cues or could also be elicited by non-social directional cues. Despite this limitation, the authors draw conclusions that closely mirror those of Gregory and Jackson (2017), attributing the observed working memory benefits for verbalizable stimuli to social mechanisms such as joint attention. Without including a non-social control condition, however, these claims appear less strongly supported. Explicitly discussing this methodological difference, and tempering the theoretical conclusions, accordingly, would improve the clarity and strength of the manuscript.

Response: Thank you for these comments. We have opted to conduct a second experiment, in which we directly compared gaze cues and arrow cues. The results of this second experiment showed cueing effects on recall by both gaze cues (thus replicating our original findings) and arrow cues. We discuss these findings in the revised Discussion section, which we have now extended to also discuss methodological differences to the Gregory and Jackson (2017) but also other previous studies, and what conclusions can be drawn based on these comparisons across studies.

Building on this point, it may be relevant for the authors to consider recent meta-analytic evidence questioning the social specificity of the classic gaze-cueing paradigm. Specifically, Chacón-Candia et al. (2023) showed that, at a quantitative level, the classic gaze-cueing task does not produce effects that reliably differ from those elicited by non-social cues such as arrows. This evidence suggests that the attentional orienting effects observed in standard gaze-cueing paradigms may reflect domain-general mechanisms rather than uniquely social processes.

Response: Thank you for making us aware of this meta-analysis. It is particularly relevant given that our Experiment 2 finds a similar effect in both the gaze and arrow group. We have now included this meta-analysis when we relate the findings from standard detection tasks to those investigating cueing on recall in memory tasks.

In light of this, taking into account this literature, and maybe extending the current design to include an appropriate non-social control cue (e.g., arrows), or at least discussing this limitation explicitly, would substantially strengthen the manuscript. In particular, a qualitative comparison between social and non-social cues within the working memory task would allow the authors to more convincingly support claims regarding the role of joint attention or social relevance in modulating working memory performance.
Response: Thank you for the suggestions. We felt it would be most appropriate to run a second experiment with a non-social control. The results of this second experiment showed cueing effects on recall by both gaze cues (thus replicating our original findings) and arrow cues, which are discussed further in the revised Discussion section, which has now also been expanded.

- Following the previous point, it may be worth expanding the theoretical background to include additional recent studies examining the relationship between social attentional orienting and working memory. Although these studies do not focus exclusively on verbal working memory or employ identical experimental paradigms, they are nevertheless highly relevant to the aims of the present work, as they address how socially relevant cues influence attention and working memory processes. For example, studies such as Foglino & Wykowska (2025), Nie et al. (2018), and Zhang et al. (2023) provide important evidence showing how social attention can modulate working memory performance under different task conditions. I consider that including this literature would help better situate the present findings within the broader field and strengthen the theoretical framework of the study.
Response: Thank you for highlighting these studies. Originally, we were constrained by a word limit on brief reports, however we have now expanded both our Introduction and Discussion, and we have included these three studies too.
Minor comments / clarifications

- Out of curiosity, it would be helpful to report the age range of the participants. Given that the mean age is 38 years, this seems relatively high, maybe providing the full range would help to better characterize the sample.
Response: We have now provided information about the age range along with the mean and standard deviation that we reported previously.

- The manuscript mentions that two participants were excluded based on the criterion of 2.5 mean absolute deviations. However, it is not entirely clear how many participants were included in the final sample after exclusions. We suggest clarifying this information explicitly in the Participants section.
Response: We have now added information about final sample sizes used in the analysis for both our experiments.

- It is not reported in the manuscript whether the hypotheses were pre-registered prior to data collection. If the study was not pre-registered, we would simply encourage the authors to consider this practice in future work, as it can enhance transparency and reproducibility.
Response: Thank you for the suggestion, and we agree on the usefulness of pre-registrations for transparency of research. We had not pre-registered the original study, which was the outcome of a student project (not that students projects cannot or should not be pre-registered, indeed we teach students about preregistrations), which is why we also did not think of pre-registering the second experiment simply because we did not think about it at the time. At the time we ran the second experiment we had not yet received your review (it was clear from the previous reviews that running an experiment with a non-social control was the best course of action). We will take this as a good reminder to incorporate pre-registrations into our workflow.

Competing Interests: No competing interests were disclosed.

Reviewer Report 29 December 2025

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Krzysztof Cipora
Copernicus Center for Interdisciplinary Studies, Jagiellonian University in Krakow, Krakow, Poland

In the paper the authors show how cuing with a directed gaze affects working memory measured with accuracy of probe recognition depending on whether the stimuli set was presented on the cued or non-cued side. The authors report better accuracy for cued than non-cued stimuli, while there is no difference in terms of reaction times.

The paper reads very well and clearly communicates what the authors have done (also followed by shared materials), what results they obtained and how they interpret the results. Thus I can see a merit in its publication at some point. At the same time, I would like to raise rather critical points when it comes to interpretation of the results both in terms of joint attention and in terms of crucial role of working memory.

Joint attention aspect: In studies demonstrating cuing paradigm (more or less along the lines of M. Posner model of attention), the basic stimulus used to guide participants' attention (in a so-called endogenous paradigm) have been arrows. They facilitate detection of a stimulus presented laterally on the cued side etc. See e.g., a rather classic paper by Raz & Buhle 2006 (https://doi.org/10.1038/nrn1903). See also a recent review on the cuing with eye gaze: https://doi.org/10.1037/bul0000353

To be able to show that the effect is due to social cues in particular (and joint attention) one would need to either (a) dissociate this effect from effect caused by non-social stimuli (e.g., arrows), (b) provide a compelling theoretical argument that the effect of cuing in related to joint attention event without the social aspect of the cue. The latter to my understanding is not so obvious - even without social aspect there is an adaptive advantage of attention functioning this way, and Posner's model provides quite a lot of such arguments.

Working memory aspect: if we assume that cuing mechanism takes place, it implies that spatial attention is directed towards a specific location and tuned to perceive the stimuli appearing in that location. In case of incongruent trial, the attention is directed elsewhere, it needs to be re-allocated to the place where the stimulus is actually presented. Only following that process the information about the stimulus is gathered. Given the stimulus presentation time is rather limited (150ms), the re-orienting of attention might be taking some extra time and resources, leaving less time to properly encode the stimulus. In short: the effects do not necessarily originate from the functioning of working memory.

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2. McKay K, Grainger S, Coundouris S, Skorich D, et al.: Visual attentional orienting by eye gaze: A meta-analytic review of the gaze-cueing effect.*Psychological Bulletin*. 2021; **147** (12): 1269-1289 Publisher Full Text

Is the work clearly and accurately presented and does it engage with the current literature?

Partly

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

Are all the source data and materials underlying the results available?

Yes

Are the conclusions drawn adequately supported by the results?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cognitive psychology, numerical cognition with some expertise in attention and working memory.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 19 Jan 2026

Edward Legg

Dear Prof. Cipora,
Thank you for the thoughtful and detailed comments to the original version to our manuscript. In line with your and the other reviewers' comments, we opted to conduct a second experiment in which we tested two new groups of participants: one with gaze cues as the orienting cue, and one with arrow cues as the orienting cue. The results show that recall of verbal items was modulated by gaze cues (thus replicating the findings of our original experiment – now experiment 1) but also by arrow cues.
In line with your suggestions to expand the discussion of conceptual questions and possible mechanisms, we have now expanded both the introduction and discussion sections. In the latter, we interpret the observed findings in line with orienting cues having shifted participants' spatial attention.
Below we provide point-by-point responses to your comments on the original version of our manuscript – for this we have pasted your comments in italics and provide our replies in plain font.
In the paper the authors show how cuing with a directed gaze affects working memory measured with accuracy of probe recognition depending on whether the stimuli set was presented on the cued or non-cued side. The authors report better accuracy for cued than non-cued stimuli, while there is no difference in terms of reaction times. The paper reads very well and clearly communicates what the authors have done (also followed by shared materials), what results they obtained and how they interpret the results. Thus I can see a merit in its publication at some point. At the same time, I would like to raise rather critical points when it comes to interpretation of the results both in terms of joint attention and in terms of crucial role of working memory.
Joint attention aspect: In studies demonstrating cuing paradigm (more or less along the lines of M. Posner model of attention), the basic stimulus used to guide participants' attention (in a so-called endogenous paradigm) have been arrows. They facilitate detection of a stimulus presented laterally on the cued side etc. See e.g., a rather classic paper by Raz & Buhle 2006 (https://doi.org/10.1038/nrn1903). See also a recent review on the cuing with eye gaze: https://doi.org/10.1037/bul0000353 To be able to show that the effect is due to social cues in

particular (and joint attention) one would need to either (a) dissociate this effect from effect caused by non-social stimuli (e.g., arrows), (b) provide a compelling theoretical argument that the effect of cuing in related to joint attention event without the social aspect of the cue. The latter to my understanding is not so obvious - even without social aspect there is an adaptive advantage of attention functioning this way, and Posner's model provides quite a lot of such arguments.
Response: Thank you for these comments. We agree that a non-social control is a critical step toward showing that a cueing effect is specific to social stimuli. We have now conducted a second experiment which we report in the revised version of the manuscript. The results of this second experiment replicated the effect of gaze cues on recall for verbal items but also showed an equivalent effect of arrow cues on recall.
Working memory aspect: if we assume that cuing mechanism takes place, it implies that spatial attention is directed towards a specific location and tuned to perceive the stimuli appearing in that location. In case of incongruent trial, the attention is directed elsewhere, it needs to be re-allocated to the place where the stimulus is actually presented. Only following that process the information about the stimulus is gathered. Given the stimulus presentation time is rather limited (150ms), the re-orienting of attention might be taking some extra time and resources, leaving less time to properly encode the stimulus. In short: the effects do not necessarily originate from the functioning of working memory.
Response: Thank you for raising this point. We agree and this is particularly pertinent in light of our second experiment because in the absence of a difference between the gaze and arrow groups, it is possible that the cueing effects are explained by a shift in spatial attention at encoding. We discuss this in detail in the Discussion section of the revised manuscript.

Competing Interests: No competing interests were disclosed.

Reviewer Report 27 December 2025

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Samantha Gregory
University of Salford, Salford, England, UK

The manuscript presents a single study investigating whether gaze cues affect working memory for verbalizable items. The findings show an effect of gaze on memory for these items.
The study is justified and the findings as they are presented are clear and well presented.
However, I have a few concerns.
While the basis of the study being Dodd et al 2012, and Gregory and Jackson 2017 was clear, there was a limited literature base drawn upon, and while this is a brief report some consideration of more recent findings in the area would be appropriate.
It is also notable that there was no control comparison conducted, in previous gaze cuing work

mentioned, such as Gregory and Jackson, Dodd et al, and Bayliss et al 2006, an arrow cue was used as a non-social control stimuli. This comparison is required to be able to claim a social cuing effect. I believe this gap should at least be considered in the manuscript, even if not directly tested.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

Are all the source data and materials underlying the results available?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Social gaze cuing, attention, working memory

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 19 Jan 2026

Edward Legg

Dear Dr. Gregory,
Thank you for your comments to the original version to our manuscript, which helped us in the revision process. Based on your comments – all of which also align with the other reviewers' comments – we have changed two main things in the revised manuscript: first, we have expanded the overview of the research field and the discussions within both in the Introduction and Discussion sections, and second, we have conducted and now report a second experiment, in which we tested the effect on recall of both gaze cues and arrow cues. This experiment revealed that both gaze and arrow cues improved participants' performance in the working memory task, such that in the discussion we now include a possible and most parsimonious interpretation based on shifts in spatial attention. Below we provide point-by-point responses to your comments on the original version of our manuscript – for this we have pasted your comments in italics and provide our replies in

plain font.

The manuscript presents a single study investigating whether gaze cues affect working memory for verbalizable items. The findings show an effect of gaze on memory for these items. The study is justified and the findings as they are presented are clear and well presented. However, I have a few concerns. While the basis of the study being Dodd et al 2012, and Gregory and Jackson 2017 was clear, there was a limited literature base drawn upon, and while this is a brief report some consideration of more recent findings in the area would be appropriate.
We thank you for the suggestion to expand the Introduction. We were initially constrained by the word limit of the brief report, but we have now expanded the Introduction section of the revised manuscript, such that a more thorough overview of the literature and the debates within it are provided to the reader.

It is also notable that there was no control comparison conducted, in previous gaze cuing work mentioned, such as Gregory and Jackson, Dodd et al, and Bayliss et al 2006, an arrow cue was used as a non-social control stimuli. This comparison is required to be able to claim a social cuing effect. I believe this gap should at least be considered in the manuscript, even if not directly tested.
We have now conducted a second experiment which we report in the revised version of the manuscript, in which we replicated the effect of gaze cues on recall for verbal items but also found an equivalent effect of arrow cues on recall. In relating these results to previous literature, we have now also expanded the Discussion section.

Competing Interests: No competing interests were disclosed.

Reviewer Report 25 November 2025

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Jari Hietanen
Tampere University, Tampere, Finland

The manuscript describes a single study investigating the effect of gaze cuing on working memory, specifically for retention of verbal information (a matrix of 4 letters). The results showed that the participants were more accurate in judging whether a target letter (presented 1000 ms after the presentation of the matrix) had been among letters in the matrix when the matrix appeared at the gaze-at location than when it appeared at the opposite location. The authors interpreted the results to show that “joint attention can improve working memory for verbalizable content such as letters”.

As a basis for their study, the authors refer to two previous studies which investigated the effects

of gaze cuing on long-term retention of verbal stimuli (Dodd et al., 2012) and the effects of gaze cuing on short-term (working memory) retention of non-verbal visual information (colors) (Gregory & Jackson, 2017). The authors motivate their study by arguing that they aim to investigate whether gaze cuing (or joint attention as they call it) improves also verbal working memory performance.

The aim of the study is justified. However, if the authors aim to show that joint attention improves verbal working memory, they should be able to show that the reported findings are not just reflecting general attentional effects. In studies by both Dodd et al. (2012) and by Gregory & Jackson (2017) this was achieved by showing that attention cuing by symbolic cues (arrows) did not result in better memory performance for cued vs. uncued simuli. I am somewhat surprised that the authors of the present manuscript do not describe this aspect of those two previous studies at all, nor they discuss the potential issue related to attentional vs. memory effects behind their findings in their discussion either. By the way, there is also a more recent study by Ishikawa and Yoshioka (2025) in which they also used the same approach (i.e. comparing gaze cuing vs arrow cuing).

Thus, I am afraid but the present study cannot provide convincing evidence that joint attention improves verbal working memory performance.

Otherwise, the experiment appeared to be carefully conducted and the results were appropriately analyzed.

As a minor issue, in Methods, the authors could mention that, on each trial, the letters in the matrix were randomly selected among the used consonants. I take that this was the case. Also, I suppose that the target letter was one of those presented in the matrix on half of the trials, and that this manipulation was orthogonal to that of the cuing (i.e. cued vs uncued).

Reference

Ishikawa, M., Yoshioka, A. Gaze cues facilitate incidental learning in children aged 7–10 years, but arrow cues do not. *Psychon Bull Rev* **32**, 1712–1721 (2025). https://doi.org/10.3758/s13423-025-02657-x

Is the work clearly and accurately presented and does it engage with the current literature?

Partly

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

Are all the source data and materials underlying the results available?

Yes

Are the conclusions drawn adequately supported by the results?

No

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cognitive psychology/attention orienting by gaze cuing

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 19 Jan 2026

Edward Legg

Dear Prof. Hietanen, Thank you for the thoughtful comments to the original version to our manuscript. In light of your and the other reviewers' comments, we have opted to conduct a second experiment. Our intention had been to provide data and a short report regarding the first step in testing whether orienting cues affect recall in a working memory task for verbal content, without necessarily going further into what may underlie this effect. However, in light of your and the other reviewers' comments, all of which we agree with, we have opted to conduct a second experiment. In this second experiment, we tested two new groups of participants, one for whom the orienting cue was a gaze cue (direct replication of Experiment 1., i.e., the study reported in the original version of our manuscript) and one for whom the orienting cue was an arrow cue. Here, we found that both gaze and arrow cues improved participants' performance in the working memory task. Consequently, we have expanded our discussion to include an interpretation based on shifts in spatial attention (which provides the most likely and parsimonious explanation for our pattern of results), but where we also briefly discuss avenues for future research that are opened up by these results. Below we provide point-by-point responses to your comments on the original version of our manuscript – for this we have pasted your comments in italics and provide our replies in plain font.

The manuscript describes a single study investigating the effect of gaze cuing on working memory, specifically for retention of verbal information (a matrix of 4 letters). The results showed that the participants were more accurate in judging whether a target letter (presented 1000 ms after the presentation of the matrix) had been among letters in the matrix when the matrix appeared at the gaze-at location than when it appeared at the opposite location. The authors interpreted the results to show that "joint attention can improve working memory for verbalizable content such as letters". As a basis for their study, the authors refer to two previous studies which investigated the effects of gaze cuing on long-term retention of verbal stimuli (Dodd et al., 2012) and the effects of gaze cuing on short-term (working memory) retention of non-verbal visual information (colors) (Gregory & Jackson, 2017). The authors motivate their study by arguing that they aim to investigate whether gaze cuing (or joint attention as they call it) improves also verbal working memory performance. The aim of the study is justified. However, if the authors aim to show that joint attention improves verbal working memory, they should be able to show that the reported findings are not just reflecting general attentional effects. In studies by both Dodd et al. (2012) and by Gregory & Jackson (2017) this was achieved by showing that attention cuing by

symbolic cues (arrows) did not result in better memory performance for cued vs. uncued simuli. I am somewhat surprised that the authors of the present manuscript do not describe this aspect of those two previous studies at all, nor they discuss the potential issue related to attentional vs. memory effects behind their findings in their discussion either. By the way, there is also a more recent study by Ishikawa and Yoshioka (2025) in which they also used the same approach (i.e. comparing gaze cuing vs arrow cuing).

Thank you for the comment – we have now conducted a second experiment which we report in the revised version of the manuscript, and which is described in more detail also in our general reply to the reviewers' comments. The results of this second experiment – whereby we replicate the effect of gaze cues on recall for verbal items but also found an equivalent effect of arrow cues on recall – are now also discussed in terms of the most likely explanation through general attentional effects. We are also grateful for the information about the recent Ishikawa and Yoshioko (2025) study, which we had missed, and have now included it in the Introduction of the revised manuscript.

Thus, I am afraid but the present study cannot provide convincing evidence that joint attention improves verbal working memory performance. Otherwise, the experiment appeared to be carefully conducted and the results were appropriately analyzed. As a minor issue, in Methods, the authors could mention that, on each trial, the letters in the matrix were randomly selected among the used consonants. I take that this was the case. Also, I suppose that the target letter was one of those presented in the matrix on half of the trials, and that this manipulation was orthogonal to that of the cuing (i.e. cued vs uncued).

Thank you for alerting us that we missed to provide this information in the Methods of the original manuscript - we have now added information about the randomisation. The reviewer is correct that the target letter had been present in the array of consonants on half of trials and we have now described this in the Methods section of the revised manuscript.

Competing Interests: No competing interests were disclosed.