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# Shifting views on the symbolic cueing effect: Cueing attention through recent prior experience

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Several studies have demonstrated that centrally presented, non-predictive, directional symbols (arrows, directional words, eye gaze) can influence response times to detect the onset of a target item presented in a peripheral location. Although symbolic cueing effects have been reliably demonstrated, the underlying mechanisms that produce these effects are not well understood. In two experiments we test the idea that perceptual integration between cue-target pairs mediates symbolic cueing effects. Our findings suggest symbolic cueing effects may not necessarily reflect the orienting power of highly over-learned directional symbols. Rather, symbolic cueing effects are also mediated by relatively recent experiences with coherent cue-target objects during the experimental session. We elaborate on the implications of our findings for conventional explanations of symbolic cueing effects.

In this paper we investigate two important assumptions underlying recent explanations of a novel finding in the attentional cueing literature, the symbolic cueing effect for non-predictive, central cues. The symbolic cueing task is a variant of the Posner visual cueing procedure (Posner, 1980). Participants are asked to detect the onset of a target that can appear in one of two locations. The symbolic cueing effect is defined by faster responses to targets appearing in a validly cued location (e.g., a dot appearing on the pointed side of an arrow cue) than to targets appearing in

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an invalidly cued location (e.g., a dot appearing on the open side of an arrow).

Early research using the symbolic cueing method suggested cueing effects could occur only when cues offered predictive information about the likely location of a following target (Jonides, 1981). However, a host of recent studies has shown that central symbolic cues that are non-predictive of target location can indeed produce reliable cueing effects. These symbolic cueing effects are typically small (5-10 ms), but have been reliably observed in studies using a variety of symbolic cues, including eye gaze (Friesen & Kingstone, 1998; Hietanen, 1999; Ristic, Friesen, & Kingstone, 2002), arrows (Tipples, 2002), directional words (Hommel, Pratt, Colzato, & Godijn, 2001), and numbers (Fischer, Castel, Dodd, & Pratt, 2003).

Although there has been some controversy surrounding particular explanations of the symbolic cueing effect (Tipples, 2002), there is general agreement about two processes that contribute to such effects. The first process is an evaluation process that allows for the rapid extraction of the directional meaning of a cue. The second process is an orienting process that directs attentional resources to an implied target location. Together, the evaluation and orienting processes work to allocate attentional resources to locations in space that are signaled by the symbolic cue. In turn, the symbolic cueing effect occurs because the presence of attentional resources facilitates perception of validly cued targets relative to invalidly cued targets.

Much of the controversy surrounding explanations of the symbolic cueing effect has focused on whether the cue-evaluation process is mediated by general or specific mechanisms. For example, Friesen and Kingstone (1998) argued that symbolic cueing effects for eye gaze cues are mediated by a special, eye-gaze detector module (Baron-Cohen, 1995). In support of this idea, Kingstone, Tipper, Ristic, & Ngan (2004; see also Ristic & Kingstone, 2005) demonstrated that symbolic cueing effects using an ambiguous car/eye gaze cue depended on instructional manipulations to perceive the ambiguous cue as an eye gaze cue. Alternatively, other researchers have pointed out that symbolic cueing effects can occur with symbolic cues that are not biologically relevant, including arrows (Tipples, 2002) and directional words (Hommel et al., 2001), which are presumably not mediated by mechanisms specialized to process eye gaze information. Instead, it has been suggested that some symbolic cueing effects may be mediated by general-level processing mechanisms.

The debate over the general or specific nature of mechanisms involved in producing the symbolic cueing effect has not been resolved, and the possibility remains that the alternatives are not mutually exclusive. On the one hand, symbolic cueing effects using biologically relevant cues could be governed by a highly specialized module evolved to rapidly process directional attributes of biologically relevant stimuli. On the other hand, symbolic cueing effects using over-learned cues could occur because a lifetime of experience with particular symbols allows directional meaning to be automatically extracted by a general processing mechanism. Both views suggest, for different reasons, that the symbolic cueing effect provides novel insight into processes responsible for directing attentional resources.

The present research is not aimed at the distinction between specific and general processing mechanisms, but rather at tacit assumptions inherent to both the general and specific processing mechanism accounts of symbolic cueing effects. A review of the current literature suggests symbolic cueing effects are mediated by over-learned cues to direction information. This tacit assumption implies that directional symbols gain their directional cueing power through long-term real-world experience, rather than short-term experience within the experimental context.

A more pervasive assumption is that symbolic cueing effects necessarily reflect the covert allocation of attentional resources. This assumption is supported by the fact that symbolic cueing effects can be observed with non-predictive cues and short cue-target SOAs (e.g., 100 ms). Following this logic, target detection is faster for valid than invalidly cued targets because attentional resources are assigned to the validly cued target location prior to target onset. An implication of this view is that target detection should be speeded for all targets appearing in attended locations.

In our opinion, the extent to which the experimental context constrains the expression of symbolic cueing effects has not been adequately addressed. Yet, such a test may provide novel insight to the underlying cause of symbolic cueing effects. To this end, and to foreshadow the results, we demonstrate across Experiments 1a, 1b, and 2, that symbolic cueing effects can be reversed, or eliminated by changing the nature of the target used to elicit detection responses.

The idea to test these two tacit assumptions stems from a novel alternative account of symbolic cueing effects, which emphasizes the integration of cue and target into coherent perceptual objects (for a related discussion of cue-target integration processes in exogenous spatial cueing studies see Lupiañez, Decaix, Sieroff, Milliken & Bartolomeo, 2004; Lupiañez, Milliken, Solano, Weaver, & Tipper, 2001). We describe this alternative account in more detail later in the article, and at this point focus on a novel cueing method designed to take advantage of object coherence of cue and target. In particular, as in prior studies of symbolic cueing effects, participants completed a task that required the detection of a target stimulus following presentation of a non-predictive, central symbolic cue (see Figure 1). The novel aspect of our design concerned the choice of cue and target stimuli (see Figure 2).

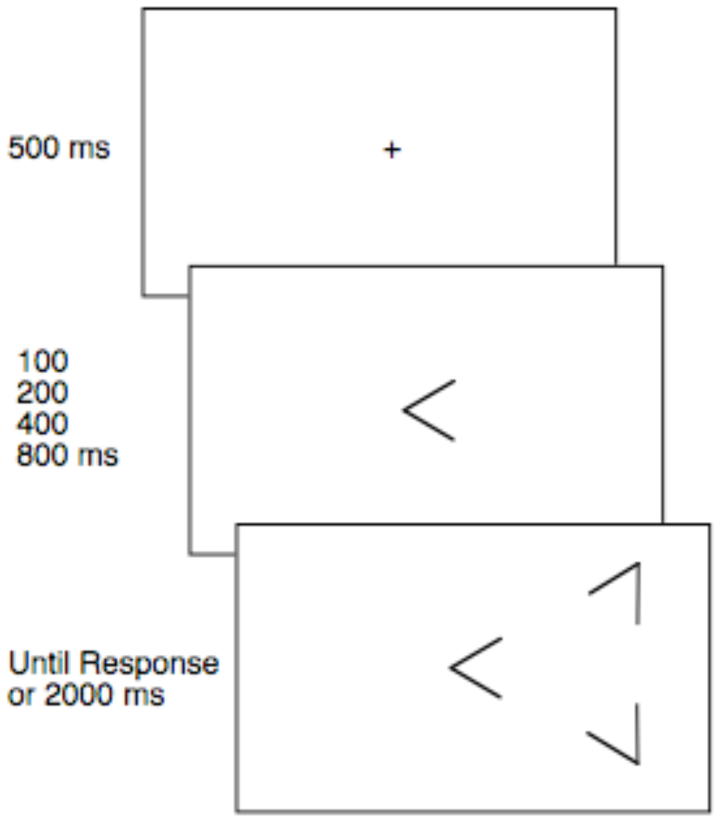


**Figure 1. Each trial began with the presentation of a fixation cross. After 500 milliseconds, the fixation cross was replaced with a cue that was displayed for one of 4 intervals (100, 200, 400, 800 ms). Following the SOA interval, a target was presented to the right or left of cue. Both the target and the cue remained on the screen until a response was made, or until 2000 msec elapsed.**

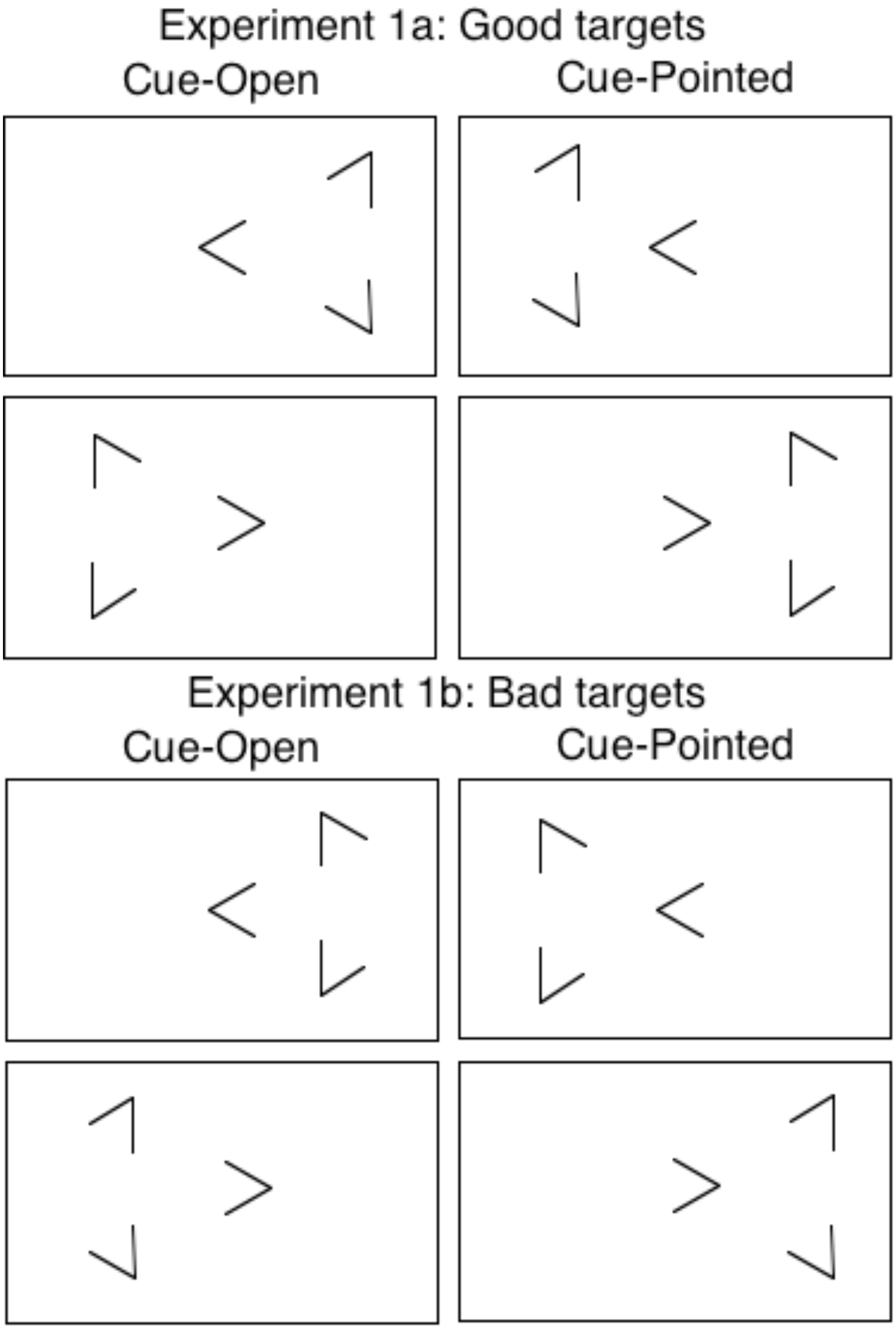


**Figure 2. Depicts the cue-target pairs used in Experiments 1a and 1b, and 2. Experiment 1a always employed good target types that appeared equally frequently in valid and invalid locations. Experiment 1b always employed bad target types that appeared equally frequently in valid and invalid locations. Experiment 2 was a mixed design in which all trial types used in Experiments 1a and 1b were combined and presented equally frequently.**

We constructed cue and target stimuli that could be paired in various ways to form coherent or incoherent cue-target objects. There were two centrally presented arrow cues roughly resembling a greater-than symbol (>), or a less-than symbol (<). There were two target stimuli, each consisting of two symbols arranged vertically to form two-thirds of a notional triangle (see Figure 1). Each target stimulus could appear on the left or the right of each cue. The factorial combination of these stimulus conditions produced eight distinct cue-target pairs. We defined the eight distinct cue-target pairs in terms of two factors: cue side, and target type. The cue side factor had two levels, cue-open and cue-pointed, referring to the side of space relative to a cue in which a target appeared. The target type factor had two levels: good and bad. Good targets were those targets that could potentially be paired with a cue to form a coherent cue-target object, whereas bad targets were those targets that never formed a coherent cue-target object. Critically, two of the eight distinct cue-target pairs (i.e., the cue-open, good-target pairs) formed a coherent object in the form of a notional triangle. This aspect of the design was the primary means of investigating the possibility that target detection would be influenced by integration processes involving cue-target pairs. We expected target detection performance to be speeded on trials when the cue-target pairs formed a coherent object.

## EXPERIMENTS 1A AND 1B

In Experiments 1a and 1b we investigated the extent to which symbolic cueing effects depend on recent experience with coherent cue-target objects. In Experiment 1a, experimental trials were limited to good targets. We expected target detection performance to be faster on cue-open/good trials, in which the cue-target pair formed a coherent cue-target object, than on cue-pointed/good trials, in which the cue-target pair formed an incoherent object. In Experiment 1b, experimental trials were limited to bad targets. We expected no differences in target detection performance between cue-open/bad and cue-pointed/bad trials because neither cue-target pair formed a coherent object. Importantly, in both Experiments 1a and 1b, cues were not predictive of target location or target type. Participants were not given specific instructions regarding the cue, but were instructed to detect the onset of each target appearing in the left or right location by pressing a key as quickly and accurately as possible.

## METHODS

**Participants**. The participants were 40 undergraduate students enrolled in psychology courses at McMaster University who volunteered for course credit.

**Materials and Procedure.** We followed a standard visual cueing task procedure involving the presentation of a centrally appearing, non-predictive cue, followed by a target pattern appearing in one of two locations, left or right of fixation (see Figure 1). The cue subtended .95° of visual angle in height and width. Each target was composed of two vertically aligned 'triangle corners' (see Figure 1) subtending 4.3° of visual angle in height. Targets were presented to the left or right of fixation, approximately 3.57° of visual angle from the centre of the cue to the centre of the target. The cues and targets appeared in white against a black background. There were three factors in our design: cue side (open vs. pointed), target type (good vs. bad), and SOA (100 ms, 200 ms, 400 ms, 800 ms). The SOA manipulation was included primarily as an exploratory variable.

In Experiment 1a, the experimental conditions were limited to cue-open and cue-pointed trials involving good target types. In Experiment 1b, the experimental conditions were limited to cue-open and cue-pointed trials involving bad target types (see Figure 1). Participants in both experiments completed 13 blocks of 40 trials, for a total of 520 trials. For each block of trials, every cue/target pair was presented equally frequently across all four SOA conditions. Finally, 20% of the trials in each block were catch trials, in which a cue appeared that was not followed by a target.

The experiment was conducted on a PC, with a 15" CRT screen, using MEL experimental software (Schneider, 1988). Participants were seated approximately 57 cm from the computer monitor. At the beginning of each trial, participants were presented with a fixation cross displayed in white against a black background for 500 ms. Next, a cue was presented for 100, 200, 400 or 800 ms, followed immediately by the target display. Targets were presented either to the left or right of fixation. Both the target and cue remained on the screen until a keypress response to the target onset was made, or until 2000 ms elapsed.

## RESULTS

Before performing an analysis of participants' reaction times, error trials were identified and removed. Anticipation errors were defined as those trials in which response times were less than 100 ms. Misses were defined as those trials in which response times were greater than 1000 ms. False alarms were defined as catch trials in which participants responded in less than 1000 ms. The percentage of errors in each condition for Experiments 1a and 1b are reported in Table 1. An analysis of participants' misses for Experiments 1a and 1b is reported at the end of this section. For each participant in Experiments 1a and 1b, the correct response times in each condition were submitted to an outlier elimination procedure (Van Selst & Jolicoeur, 1994). Mean RTs were then computed using the remaining observations, and are reported in Table 2. An alpha criterion of .05 was adopted for all statistical tests.

### Experiment 1a

Mean RTs were submitted to a 2x4 repeated measures ANOVA that included cue side (open vs. pointed), and SOA (100, 200, 400, 800) as within-participant factors. The main effect of cue side was significant [F (1, 19) = 7.85, MSE = 249.68]. Detection responses were faster for cue-open trials (321 ms) than cue-pointed trials (328 ms). Of less interest was the significant main effect of SOA [F(3, 57) = 26.53, MSE = 244.64]. The general trend for the main effect of SOA across all experiments appeared to be that RTs were slower in the 100ms and 800 ms conditions than the 200ms and 400ms conditions. The cue validity by SOA interaction was not significant [F(3,57) < 1][1].

### Experiment 1b

Mean RTs were submitted to a 2x4 repeated measures ANOVA that included cue side (open vs. pointed), and SOA (100, 200, 400, 800) as within-participant factors. Critically, the main effect of cue side was not significant. Detection responses on cue-open trials (350 ms) were not

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[1] A small programming error resulted in targets to the left of fixation being presented slightly further from the cue than targets to the right of fixation. This difference was not so obvious that it triggered concern during conduct of the study, but it was measurable (about .5 cm difference). We are confident that this methodological imperfection does not compromise our conclusions, as the side to which targets was presented was orthogonal to the cue validity manipulation of interest, and an analysis that included target location as a factor indeed revealed that it did not interact with cue validity.

different from detection responses on cue-pointed trials (350 ms). Of less importance was the significant main effect of SOA [F (3, 57) = 7.33, MSE = 510.00], which followed the same pattern as in Experiment 1a. The cue validity by SOA interaction was not significant.

**Table 1. Percentage of errors in Experiments 1a, 1b, and 2 as a function of cue-side, target-type, and SOA.**

| SOA | | 100 ms | | 200 ms | | 400 ms | | 800 ms | |
|---|---|---|---|---|---|---|---|---|---|
| Cue Side | | Open | Pointed | Open | Pointed | Open | Pointed | Open | Pointed |
| Experiment 1a | | | | | | | | | |
| Good | Anticipation | 0.4 | 0.2 | 1.0 | 1.0 | 2.0 | 2.0 | 1.0 | 1.0 |
| | Miss | 0.2 | 0.2 | 1.0 | 0.3 | 1.0 | 1.0 | 0.4 | 0.4 |
| | False Alarm | 4.0 | | | | | | | |
| Experiment 1b | | | | | | | | | |
| Bad | Anticipation | 0.4 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.5 |
| | Miss | 1.0 | 1.0 | 1.0 | 0.4 | 1.0 | 1.0 | 0.4 | 1.0 |
| | False Alarm | 4.0 | | | | | | | |
| Experiment 2 | | | | | | | | | |
| Good | Anticipation | 0.4 | 1.0 | 0 | 1.0 | 2.0 | 2.0 | 1.0 | 0.4 |
| | Miss | 0.2 | 0.2 | 1.0 | 0.4 | 0.4 | 0.2 | 0 | 1.0 |
| Bad | Anticipation | 1.0 | 0.2 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | Miss | 0.2 | 0.4 | 0.2 | 0 | 0.2 | 1.0 | 1.0 | 0 |
| | False Alarm | 4.0 | | | | | | | |

### Error analysis

For each participant in Experiments 1a and 1b, the mean percentage of misses was computed for each condition. These means were submitted to separate 2x4 repeated measures ANOVAs that included cue side (open vs. pointed) and SOA (100, 200, 400, 800) as within-participant factors. There were no significant effects in the analysis of misses in Experiment 1a. For the analysis of misses in Experiment 1b, there was a significant main effect of SOA. This effect owes to the fact that misses were extremely infrequent in the longest SOA condition.

**Table 2. Mean target detection response latencies in Experiments 1a (Good targets) and 1b (Bad targets), with standard errors (in parentheses), as a function of cue-side and SOA.**

| SOA | 100ms | | | 200 ms | | | 400 ms | | | 800 ms | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cue Side | O | P | P-O | O | P | P-O | O | P | P-O | O | P | P-O |
| Experiment 1a | | | | | | | | | | | | |
| Good | 335 | 341 | 6 | 312 | 321 | 9 | 307 | 315 | 8 | 329 | 335 | 6 |
| SE | | | (2.8) | | | (2.0) | | | (4.9) | | | (4.0) |
| Experiment 1b | | | | | | | | | | | | |
| Bad | 362 | 362 | 0 | 344 | 342 | -2 | 342 | 340 | -2 | 353 | 355 | 3 |
| SE | | | (3.5) | | | (5.1) | | | (5.7) | | | (4.0) |

O = Cue-open, P = Cue-pointed, P-O = cue-side effect, SE = standard error

## DISCUSSION

The results from Experiments 1a and 1b confirmed our predictions. In Experiment 1a, target detection performance for good targets was faster for targets appearing on the cue-open side than for targets appearing on the cue-pointed side. In Experiment 1b, target detection performance for bad targets was not influenced by the cue-side manipulation. The results of Experiment 1a and 1b raise a number of questions regarding the conventional interpretation of symbolic cueing effects.

Experiments 1a and 1b demonstrate that factors other than the direction of the symbolic cue play an important role in producing symbolic cueing effects (see also, Kingstone, Tipper, Ristic, and Ngan, 2004). It is worth noting that the cues in Experiments 1a and 1b could easily be interpreted as arrows commonly used to elicit symbolic cueing effects in other target detection tasks. Arrow cues are well known to speed target detection for targets presented on the pointed-side relative to the open-side of the arrow cue. In keeping with these results, one might predict that target detection performance in Experiments 1a and 1b should be faster for all target types appearing on the pointed side of the cue. In contrast, Experiment 1a demonstrated a “reversed” symbolic cueing effect, and Experiment 1b eliminated the symbolic cueing effect altogether. The important conclusion across these experiments is that the nature of the perceptual match between cue-target pairs can strongly mediate the symbolic cueing effect reported here.

It is worth considering whether the "reversed" symbolic cueing effect observed in Experiment 1a is indeed mediated by processes involved in symbolic control over attentional orienting. For example, it is possible that speeded detection for cue-open/good targets reflects a benefit to target detection conveyed by a gestalt-like perceptual integration processes. On this view, fluent integration of coherent cue-target pairs may lead to faster detection responses for coherent cue-target objects than to incoherent cue-target objects. Perceptual integration processes of this nature may well proceed independently of processes involved in symbolic control over attentional orienting.

Experiment 2 was conducted to determine whether the "reversed" symbolic cueing effect was entirely driven by gestalt-like perceptual integration processes. According to the perceptual integration view, the nature of the target stimulus is critically important for determining whether cue-target integration proceeds fluently. Specifically, the perceptual integration view predicts that symbolic cueing effects should be observed for good targets, but not observed for bad targets. This prediction stems from the assumption that fluent integration will occur for cue-open/good targets forming coherent cue-target objects, leading to faster detection responses for targets in those conditions. On the other hand, fluent integration should never occur for the cue-open/bad, or cue-pointed/bad targets, as these cue-target pairs never form coherent cue-target objects.

## EXPERIMENT 2

Experiment 2 was exactly the same as Experiments 1a and 1b, except all of the possible stimulus combinations used in Experiments 1a and 1b were mixed together and presented randomly to participants. This design allowed us to determine whether perceptual integration processes were entirely responsible for the "reversed" symbolic cueing effect observed in Experiment 1a. The critical issue was to determine whether symbolic cueing effects would be observed for good targets, and not bad targets. It is important to note that in this mixed design, both good and bad target types could appear in the cue-open and cue-pointed locations. As a result, the cue-side manipulation can be measured separately for good target types that sometimes form coherent cue-target objects, and bad target types that never form coherent cue-target objects.

## METHOD

**Participants**. The participants were 20 undergraduate students enrolled in psychology courses at McMaster University who volunteered for course credit.

**Materials and Procedure.** Experiment 2 was run using the same apparatus and procedure used in Experiments 1a and 1b. The only difference was that for Experiment 2 all 8 possible cue-target pairs were included in the design. That is, cue-side (open vs. pointed) and target type (good vs. bad) were completely crossed. Every cue-target pair was presented equally frequently. All other aspects of the design were held constant.

## RESULTS

Before performing an analysis of participants' reaction times, error trials were identified and removed using the same criterion used in Experiment 1. For each participant, the correct response times in each condition were submitted to an outlier elimination procedure (Van Selst & Jolicoeur, 1994). Mean RTs were then computed using the remaining observations. These means were submitted to a 2x2x4 repeated measures ANOVA that included cue side (open vs. pointed), target type (good vs. bad), and SOA (100, 200, 400, 800) as within-participant factors.

The main effect of cue side was significant [$F (1, 19) = 9.31$, $MSE = 668.36$]. Detection responses were faster for cue-open trials (331 ms) than cue-pointed trials (339 ms). Interestingly, the critical cue-side by target type interaction was not significant, $p < .27$. This null-result suggests that perceptual integration processes are not solely responsible for the cueing effects reported here. Were there any trend at all toward such an interaction, we might expect it to be most robust at shorter SOAs, where symbolic cuing effects in detection tasks tend to be observed most robustly (Friesen & Kingston, 1998). To look at this issue more carefully, we dropped the 800 ms SOA data from the previous analysis, and re-analyzed the data using only the 100, 200, & 400 ms SOA conditions. The critical cue-side by target type interaction was again not significant, $p< .56$. Furthermore, we conducted separate 2-tailed t-tests on the overall cueing effect (cue-pointed – cue-open) for good and bad targets. The cueing effect for good targets (10 ms) was significant, [$t(19)=3.71$]. As well, the cueing effect for bad targets (8 ms) was significant, [$t(19)=2.21$].

Of less importance was a significant main effect of SOA. [F (3, 57) = 11.01, M S E = 668.36]. There was no interaction between SOA and validity, and no three-way interaction between SOA, validity, and target type.

**Error analysis**

Both the anticipation errors and false alarms reflect errors made before a target appeared. As a result, these errors are uninterpretable and were not submitted to further analysis. For each participant, the mean percentage of misses was computed for each condition. These means were submitted to a 2x2x4 repeated measures ANOVA that included cue-side (open vs. pointed), target type (good vs. bad), and SOA (100, 200, 400, 800) as within-participant factors. There were no significant main effects. The three-way interaction between cue-side, target type, and SOA was significant [F(3,57) = 4.3, MSE=8.47^-5]. However, very few errors were made overall, and the pattern of error rates that gave rise to the interaction was not easily interpretable, nor did it contradict the RT results described above.

### DISCUSSION

The purpose of Experiment 2 was to determine whether the cueing effects reported in Experiment 1a were entirely mediated by perceptual integration processes. In Experiment 2, target detection performance was speeded for both good and bad targets appearing on the cue-open side relative to the cue-pointed side. This pattern of data suggests the cueing effects observed in Experiment 2 are not entirely driven by a perceptual integration process that facilitates target detection uniquely for coherent cue-target pairs.

## GENERAL DISCUSSION

Symbolic cueing effects are commonly explained by a cue-evaluation process that automatically extracts directional meaning from symbols, and an orienting process that covertly shifts attentional resources to signaled target locations. We investigated two untested assumptions underlying this view of symbolic cueing effects, and established boundary conditions for observing symbolic cueing effects in a target detection task. The first goal was to determine whether symbolic cueing effects necessarily measure the attentional orienting power of highly overlearned directional symbols. The second goal was to determine whether symbolic cueing effects are necessarily mediated by attentional orienting processes. We manipulated the perceptual match between cue-target pairs by varying the form of the to-be-detected target. The central finding across Experiments 1a and 1b was that symbolic cueing effects were observed (1a), or eliminated (1b), by changing the form of the to-be-detected target. Experiment 2 established that the cueing effects reported here could not be entirely explained by perceptual integration processes. Taken together, the pattern of results suggest a need to extend current explanations of symbolic cueing effects.

**Table 3. Mean target detection response latencies for Experiment 2, with standard errors (in parentheses), as a function of cue-side, target-type, and SOA.**

| SOA | 100ms | | | 200 ms | | | 400 ms | | | 800 ms | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cue Side | O | P | P-O | O | P | P-O | O | P | P-O | O | P | P-O |
| Good | 339 | 349 | 10 | 322 | 335 | 13 | 326 | 332 | 6 | 340 | 346 | 6 |
| SE | | | (4.0) | | | (4.1) | | | (5.1) | | | (4.4) |
| Bad | 340 | 348 | 8 | 326 | 328 | 2 | 315 | 329 | 14 | 343 | 342 | -1 |
| SE | | | (4.5) | | | (4.2) | | | (5.9) | | | (5.2) |

O = Cue-open, P = Cue-pointed, P-O = cue-side effect, SE = standard error

### Long term vs. short term experience

Much debate has focused on the extent to which symbolic cueing effects reflect general or specific orienting processes. A common assumption underlying both perspectives is that directional symbols acquire their orienting power over the long-term, either by repeated experiences in the world (e.g., arrows), or by functionally specific adaptations occurring across evolutionary time-scales (e.g., eye-gaze). For both views, symbolic cueing tasks provide a tool to measure the orienting power of a symbolic cue that has acquired directional cueing power over the long-term. Alternatively, symbolic cueing effects could also be mediated by relatively short-term experiences inherent to the experimental contexts employed in most symbolic cueing tasks.

The results of Experiments 1a and 1b bear directly on the possibility that symbolic cues acquire directional cueing power over the course of the experimental session. Cues were always non-predictive greater-than, or less-than arrow symbols. According to long-term experience, directionality should be signaled by the pointed-side of the arrow; and, targets presented on the pointed-side should be detected faster than targets presented on the open-side. In contrast to these expectations, in Experiment 1a good targets demonstrated a "reverse" symbolic cueing effect. That is, good targets were detected faster for cue-open than cue-pointed target locations. In Experiment 1b, bad targets were not detected faster for cue-open than cue-pointed target locations. The important conclusion from these experiments is that symbolic cueing effects can be mediated by short-term constraints inherent to the experimental context. At the same time, we do not deny the possibility that long-term factors play some role in mediating previously reported symbolic cueing effects, and we suggest that future research should clarify the extent to which symbolic cueing effects are mediated by short or long-term experience. In the remaining portion of the general discussion we elaborate on candidate processes that could account for the apparent flexibility of symbolic cueing effects across different experimental contexts.

**Perceptual integration hypothesis**

The cueing effect reported in Experiment 1a could be mediated by gestalt-like perceptual integration processes that facilitate target detection performance for coherent cue-target objects. A process of this nature would completely explain the pattern of results across Experiments 1a and 1b, and would not require further assumptions about cue-evaluation, or covert orienting of attention. Instead, target detection would be influenced at the time of target onset by integration processes working to group the cue and target into an object.

To unpack the implications of the perceptual integration hypothesis forwarded here, it is worth remembering the highly austere task requirements imposed in the target detection task described in the current research. Namely, participants were instructed to press a button as quickly as possible in response to a flash of light. The likelihood that perceptual integration processes can play a role in mediating performance for such basic perceptual processing may seem remote, and in contradiction with conventional bottom-up views of perceptual processing. Indeed, the role of perceptual integration in target detection would suggest that features of the visual display as a simple as flashes of light are not processed independently of form. Instead, the perceptual integration hypothesis assumes that holistic aspects of the object may be perceived before the processing of constituent features is completed, and as a result may be available to influence performance in target detection tasks.

In sum, the prospect of perceptual integration processes mediating symbolic cueing effects is interesting because such a demonstration would extend knowledge of symbolic cueing effects, and challenge conventional feed-forward views of perceptual processing. Although the present results do not clearly identify a role for perceptual integration processes in mediating the cueing effects reported here, grouping processes have been reported to influence identification of individual features in other domains (e.g., the word-superiority effect; Reicher, 1969; see also Hochstein & Ahissar, 2002; and Grossberg, 1995; for discussion of related phenomena). Indeed, gestalt grouping processes have been previously shown to influence target detection in speeded-identification tasks (Prinzmetal & Banks, 1977). For these reasons, we are optimistic that a fruitful avenue for future research will be to further clarify the role of perceptual integration processes both in symbolic cueing tasks, and in more general target detection contexts.

### Object-based expectation hypothesis

A strong version of the perceptual integration hypothesis predicts that facilitation of target detection should occur only for coherent cue-target objects. In contrast, we found no evidence in Experiment 2 that cueing effects depended entirely on coherent cue-target objects. Instead, equivalent cueing effects for both good and bad target types were observed. We propose that these results provide novel insight into the processes mediating symbolic cueing effects reported here and elsewhere.

The intriguing pattern of results is that cueing effects for bad targets were eliminated in Experiment 1b, but were observed in Experiment 2. A crucial difference between these experimental contexts was asymmetries in the experience of coherent cue-target objects. Coherent cue-target objects were never experienced in Experiment 1b, but were sometimes experienced in Experiment 2. Apparently, recent experience with coherent cue-target objects in the experimental context can change the pattern of cueing effects for bad targets that never form coherent cue-target objects. One implication of this result is that aspects of the processing associated with detecting coherent cue-target objects generalize to the detection of incoherent cue-target objects. To explain this pattern of generalization we forward the object-based expectation hypothesis.

According to the object-based expectation view, the presentation of a symbolic cue triggers the retrieval of coherent memory episodes that are associated with the cue. The retrieved episodes then set up an expectation for a target to appear in a location that could contain a coherent target. On this basis, attentional resources are allocated to one of the potential target locations. The presence of attentional resources would then be expected to facilitate target detection for any target appearing at that location.

The object-based expectation hypothesis accepts that a cue-evaluation process rapidly extracts directional meaning during processing of the cue. However, the cue-evaluation operating in the present set of experiments is apparently not tapping into the long-term directional meaning of a cue. Instead, cue-driven expectations about potential target locations are generated on the basis of recent experience with coherent cue-target objects. We take this demonstration to be the most important contribution of the current research, as it implies a re-evaluation of the processes thought to underlie symbolic cueing effects. In particular, symbolic cueing effects using directional arrow cues, or eye-gaze cues, may also be mediated by recent experiences that occur during the experimental session. For example, validly cued targets in the form of a dot appearing to the right of a right pointing arrow, or a dot appearing to the right of a right looking eye-gaze cue, may be perceived as more coherent than invalidly cued targets. From this perspective, symbolic cueing effects may be driven by relatively general expectations about target location, derived not from some inherent over-learned meaning of the cue, but rather mediated by recent experience with coherent cue-target relationships.

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