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Which Way Is Which? Examining Global/Local Processing With Symbolic Cues

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Abstract

A new method combining spatial-cueing and compound-stimulus paradigms draws on involuntary attentional orienting elicited by a spatially uninformative central arrow cue to investigate global/local processing under incidental processing conditions, wherein global/local levels were uninformative (do not aid performance) and task-irrelevant (need not be processed to perform the task). The task was peripheral target detection. Cues were compound arrows, which were either consistent (global/local arrows oriented in same direction) or inconsistent (global/local arrows oriented in opposite directions). Global/local processing was measured by spatial-cueing effects (response time [RT] difference between target locations validly cued by an arrow and targets at different locations), with the test of global/local advantage represented by the effect of cue-level for inconsistent cues (RT difference between global-valid and local-valid cues). Cue-target interval (stimulus-onset-asynchrony [SOA]) was manipulated to test whether global/local advantage varied with relative stimulus availability. Experiment 1 observed a Cue-Level × SOA interaction such that an early, large global cueing effect was followed by a later, smaller local cueing effect, indicative of a global-to-local shift in advantage. This occurred despite knowledge that global/local arrows were uninformative and task-irrelevant and could therefore be ignored, thus displaying key properties of an involuntary process. Experiment 2 added neutral cues (arrow at one level, rectangle at the other) and determined that the reversal was not due to inhibition of the globally cued location or to attenuation of global information but rather to the

presence of conflicting spatial information. Experiments 3 and 4 ruled out alternative accounts for these results. These data indicate global precedence in attended but incidentally processed objects.

Keywords: global/local, symbolic cuing, global precedence, selective attention, spatial orienting

Visual scenes (scenes, objects, faces) can be conceptualized as containing global and local information, where global information corresponds to overall form, and local information corresponds to finer-grain detail (Neisser, 1967). To examine how information across levels contributes to scene understanding, Navon (1977) presented a compound stimulus—a large global letter composed of smaller local letters—and instructed participants to respond to one level while ignoring the other. Navon found that the global level was responded to faster (global advantage) and was more difficult to ignore (global interference). To explain this finding, a global precedence hypothesis was proposed, whereby a disposition to register form grants processing priority to global information, resulting in early and temporally stable availability of this information. Thus, early availability explained the global advantage and temporal stability explained global interference.

Global precedence is therefore a hypothesis about processing disposition. It provides a theoretical account of global advantage/ interference but is not entailed by it, as highlighted by evidence that advantage and interference do not co-vary systematically (Amirkhiabani & Lovegrove, 1999; LaGasse, 1993; Lamb & Robertson, 1989; Navon & Norman, 1983). That is, global precedence describes the course of visual processing, whereas global advantage and interference are simply phenomena that may or may not be observed as visual processing unfolds. Though advantage and interference may be related, they are independent and thus may arise for a variety of reasons. As such, global precedence can accommodate the observation of advantage or interference, but neither is required for its existence. To determine whether a disposition exists, each level must be equated in terms of likelihood of processing (Navon, 2003), which requires not only the option to process either level but also the option to process neither level. To examine this, one would ideally need to incorporate a compound stimulus that is task-irrelevant. In all previous studies of global/local processing, however, participants have been required to process a compound stimulus in a goal-directed or stimulus-driven manner via task instructions and stimulus parameters that emphasize

global or local characteristics. As such, a crucial test of global precedence is missing: Does global precedence characterize global/local processing in the absence of a direct demand for global or local processing? To examine this issue, the present study combines Navon's (1977) compound stimulus paradigm with Posner's (1980) spatial-cueing paradigm to capitalize on recent evidence that central presentation of overlearned spatial symbols influences the distribution of spatial attention, even when these symbols are task-irrelevant. To our knowledge, this is the first time these paradigms have been combined.

In the traditional spatial-cueing paradigm, participants respond to a target appearing at a peripheral location previously indicated by a spatial cue (valid condition) or at a different location (invalid condition). Cueing effects are measured as the difference in response time (RT) between valid and invalid cues, with facilitation evidenced by faster RTs to cued locations. Traditionally, cueing effects have been dichotomized as either exogenous or endogenous on the basis of their magnitude and time course. Exogenous (involuntary) cueing effects are characterized by large, early, and transient facilitation followed by a period of inhibition (slower responses at cued vs. uncued locations) whereas endogenous (voluntary) cueing effects are smaller, later, temporally stable, and unaccompanied by inhibition (see Funes, Lupiáñez, & Milliken, 2005, for a review). Over the last decade, however, numerous reports indicate that behaviorally relevant symbolic stimuli such as directional arrows can influence attentional control in ways that are distinct from the traditional exogenous-endogenous taxonomy (Gibson & Kingstone, 2006; Hommel & Akyürek, 2009; Hommel, Pratt, Colzato, & Godijn, 2001; Pratt & Hommel, 2003; Ristic & Kingstone, 2006, 2012). In particular, symbolic cues elicit early facilitation, similar to exogenous cues, and prolonged facilitation unaccompanied by inhibition, similar to endogenous cues. Critically, symbolic cueing effects occur even when the cue is spatially uninformative and completely irrelevant to the primary target detection task (Frischen, Bayliss, & Tipper, 2007), thereby displaying key properties of involuntary processes (Hasher & Zacks, 1979).

Given that attention is involuntarily oriented in the direction consistent with the meaning of an arrow, the present study sought to measure global/local processing in terms of spatial-cueing effects elicited by presentation of a compound arrow cue. Accordingly, when levels of a cue are inconsistent (directed at opposite locations), a global advantage would be revealed by a global cueing effect (faster RTs to

targets at global-valid vs. local-valid locations). To examine whether availability of global information changes over time, stimulus-onset-asynchrony (SOA—time interval between compound-stimulus onset and target presentation onset) was varied (Navon, 1991).

Experiment 1

The purpose of Experiment 1 was to test global precedence under incidental processing conditions, with processing of global/ local levels being uninformative (does not aid task performance) and task-irrelevant (need not be processed to perform the task). If a global advantage is attributable to earlier availability of global information, then inconsistent cues should elicit a global cueing effect. Furthermore, if the availability of global information is stable over time, then the magnitude of the global cueing effect should be stable across SOA.

Method

Participants

Fifty-two undergraduates from the University of Nebraska–Lincoln participated in exchange for course credit. All participants had normal or corrected-to-normal vision and were naïve to the purpose of the experiment. Three participants completed fewer than half of all trials and were excluded from analysis.

Stimuli

Cues were structured such that 26 local arrows (each subtending .625° × .50° visual angle) yielded a single global arrow (7.5° × 5.0°). Local arrows were outlined in black and presented on a white background. Testing took place on a Pentium IV computer with a 17-in. (43.18-cm) monitor in a room equipped with soft lighting and sound attenuation.

Design and procedure

There were 240 trials. A central fixation point began each trial and was replaced by the cue after 500 ms, which remained onscreen until a response. A variable SOA (250, 500, 750 ms) preceded the onset of the target (a black circle subtending 1° visual angle). The intertrial interval was 1,500 ms. Cue direction and target location were presented with equal probability leftward or rightward and to the left or

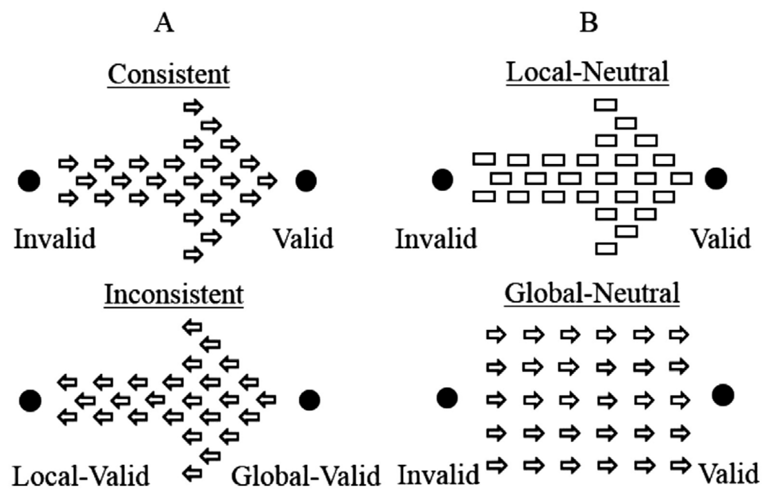

Figure 1. Compound arrow cues. (**A**) Consistent and inconsistent cue conditions. (**B**) Local-neutral and global-neutral cue conditions.

right of fixation, respectively. Participants were seated ~48 cm from the monitor and were instructed to press the spacebar as quickly as possible when the target appeared while maintaining central fixation throughout. Participants were informed that central arrows were irrelevant to their task and did not predict target location. Compound arrow cues are shown in Figure 1A, the combinations of which may be classified by three factors: consistency (consistent, inconsistent), validity (valid, invalid), and cue-level (global, local). Consistent cues (global and local arrows oriented in the same direction) were either valid (both levels oriented toward the target) or invalid (both levels oriented away from the target). Inconsistent cues, in contrast, were always valid given that either the global or local level was always oriented toward the target. As such, this was a nested design with validity nested within consistent cues and cue-level (whether the global or local level was valid) nested within inconsistent cues. Furthermore, as the ratio of valid to invalid trials was consequently 3:1, the design was also unbalanced. To account for this fact, individual RTs were analyzed with the consistency factor specified as a multivariate outcome.

Results and Discussion

RTs less than 100 ms or greater than 2.5 *SD*s above condition means were removed (4.2%). Condition mean RTs are shown in Figure 2A.

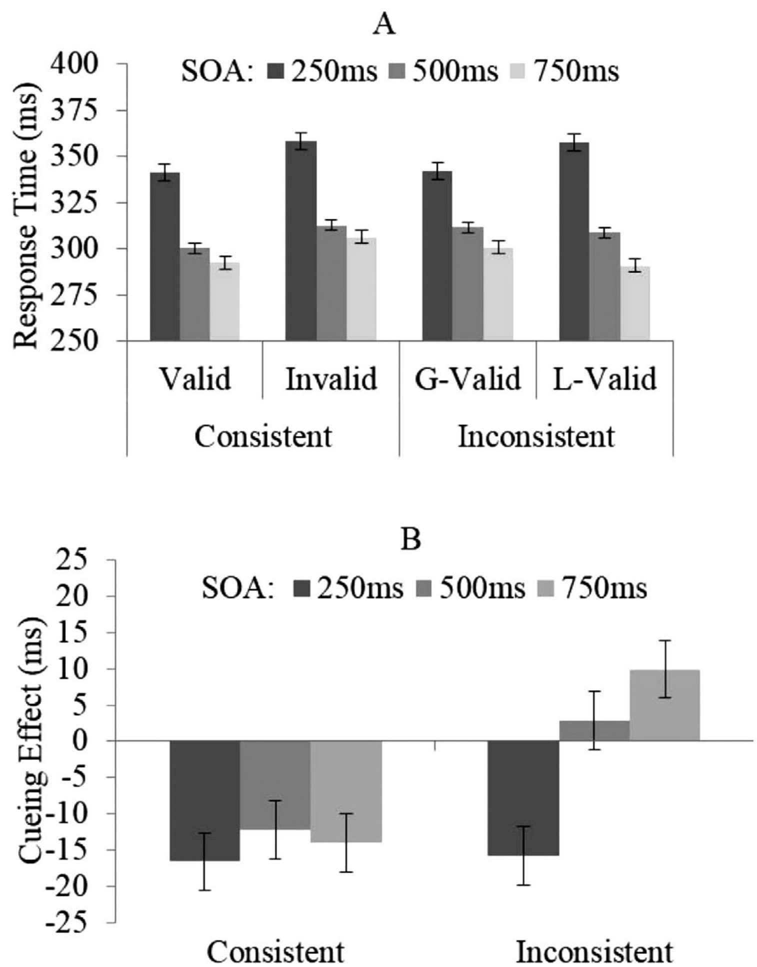

Figure 2. Experiment 1 data. (**A**) Mean response time for each Cue × Validity-State as a function of stimulus-onset-asynchrony (SOA). G-Valid × global-valid; L-Valid × local-valid. (**B**) Mean cueing effects for consistent (valid–invalid) and inconsistent (G-valid–L-valid) cues as a function of SOA. Error bars represent ×1 standard error of the mean.

Overall, there was a significant main effect of SOA, $F(2, 94) \times 330.51$, $p < .001$, reflecting faster RTs with increasing SOA. The main effect of consistency was not significant ($F < 1$), nor was its interaction with SOA, $F(2, 94) = 2.49$, $p = .12$. Importantly, cueing effects were observed with both consistent and inconsistent cues, which are shown in Figure 2B.

For consistent cues, the effect of validity was significant, $F(1, 47) = 50.13$, $p < .001$, such that RTs were faster for valid ($M = 312$) versus invalid ($M = 326$) cues. The interaction of validity and SOA was

not significant ($F < 1$), indicating that the cueing effect was stable across SOA. For inconsistent cues, the effect of cue-level was not significant ($F < 1$), but the interaction with SOA was, $F(2, 94) = 14.36$, $p < .001$. At SOA = 250 ms, there was a significant global cueing effect such that RTs were faster for global-valid ($M = 342$) versus local-valid ($M = 358$) cues, $t(48) = 4.50$, $p < .001$. At SOA = 500 ms, the effect of cue-level was not significant, $t(48) = -0.80$, $p = .42$. At SOA = 750 ms, there was a significant local cueing effect, such that RTs were faster for local-valid ($M = 291$) versus global-valid ($M = 301$) cues, $t(48) = -2.79$, $p = .005$.

The presence of a global advantage despite the fact that the cue was uninformative and task-irrelevant suggests that the global advantage (a) was obligatory and (b) generalizes to conditions in which objects are incidentally processed, which is consistent with global precedence. Interestingly, a local advantage was observed at the latest SOA. As there was little reason to favor one level over the other, let alone to favor both levels in a temporally prescribed order, this suggests that the global-to-local shift in advantage was obligatory. On the one hand, the effect of SOA may suggest that the availability of global information attenuated over time, thereby producing a null effect at intermediate SOAs and permitting the local level to dominate at later SOAs, which contrasts with global precedence in that the availability of global information should not attenuate and thus should always elicit a global cueing effect. On the other hand, Hommel and Akyurek (2009) found that spatial symbols with incompatible meaning produced conflict between symbolic and voluntary attentional control modes, resulting in competition. Assuming focus shifts induced by irrelevant arrows are more likely to be undone in the presence of competition and that this process takes time, this would explain the null effect at intermediate SOAs. This would be consistent with global precedence as selection of local information would have occurred only after global information had been processed. It is worth noting, however, that the pattern of results for inconsistent cues mirrors that which is typically observed with exogenous cues (early facilitation followed by later inhibition), making it unclear whether the later local advantage was attributable to inhibition of the globally cued location or to a shift in processing advantage. Neutral cues should delineate among these possibilities.

Experiment 2

Experiment 2 replicates and extends Experiment 1 by including two neutral conditions in which directional meaning was represented at only one level. In the global-neutral condition, the global level was a rectangle, and the local level consisted of arrows. In the local-neutral condition, the global level was an arrow, and the local level consisted of rectangles. If attenuation of global information over time gave rise to the local advantage in Experiment 1, then the magnitude of the local-neutral cueing effect should decrease with SOA. If the global-to-local shift in advantage was due to inhibition of the globally cued location, then the local-neutral cueing effect should show an early global cueing effect and late local cueing effect. If conflicting spatial information between levels gave rise to the local advantage, then the magnitude of the local-neutral cueing effect should be stable across SOA given that the conflicting level does not contain spatial information.

Method

Participants

Forty-four undergraduates from the University of Nebraska–Lincoln participated in exchange for course credit. All participants had normal or corrected-to-normal vision and were naïve to the purpose of the experiment.

Stimuli

Global-neutral cues were 30 local arrows arranged to form a global rectangle, whereas local-neutral cues were 26 local rectangles arranged to form a global arrow. Consistent and inconsistent cues were the same as in Experiment 1, as was the size of global and local elements.

Design and procedure

These were identical to Experiment 1, with two exceptions. First, there were 480 trials. Second, there were two blocks of trials, with consistent and inconsistent cues in one block and neutral cues in the other. Blocking was used to ensure that perception of neutral cues was not biased by the consistent/inconsistent cues between trials. Each block was performed twice (120 trials/block), with block order counterbalanced across participants. Neutral cues could be any of the

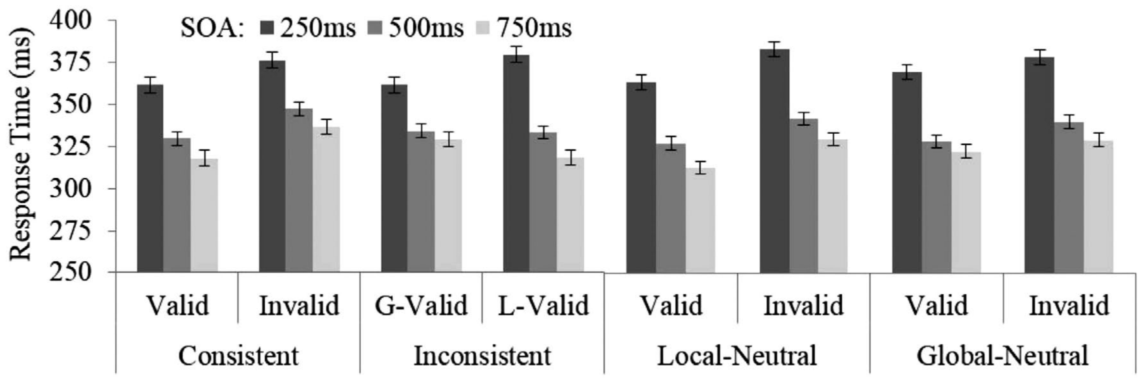

Figure 3. Experiment 2 mean response time for each Cue × Validity-State as a function of stimulus-onset-asynchrony (SOA). Error bars represent ±1 standard error of the mean. G-Valid = global-valid; L-Valid = local-valid.

four patterns presented in Figure 1B, the combinations of which may be classified by the factors validity (valid, invalid) and neutral-level (global-neutral, local-neutral).

Results and Discussion

RTs less than 100 ms or greater than 2.5 *SD*s above condition means were removed (2.4%). Condition mean RTs are shown in Figure 3. Overall, there was a significant main effect of SOA, $F(2, 84) = 313.29$, $p < .001$, reflecting faster RTs with increasing SOA. Neither the main effect of consistency nor its interaction with SOA was significant (*F*s < 1). Importantly, there were significant cueing effects for each cue type, which are shown in Figure 4.

For consistent cues, the effect of validity was significant, $F(1, 42) = 48.31$, $p < .001$, such that RTs were faster for valid ($M = 336$) versus invalid ($M = 354$) cues. The interaction of validity and SOA was not significant ($F < 1$), indicating that the cueing effect was stable across SOA. For neutral cues, the effect of validity was significant, $F(1, 42) = 35.52$, $p < .001$, such that RTs were faster for valid ($M = 337$) versus invalid ($M = 350$) cues, on average. There was also a significant Validity × Neutral-Level interaction, $F(1, 42) = 5.06$, $p = .02$, indicating that the cueing effect was larger for local-neutral (17 ms) versus global-neutral cues (9 ms). The SOA × Validity × Neutral-Level interaction was not significant ($F < 1$), indicating that these effects were stable across SOA.

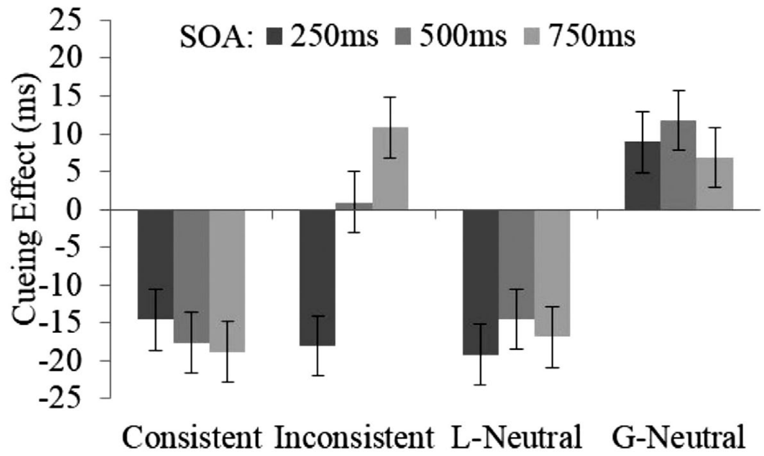

Figure 4. Experiment 2 mean cueing effects for consistent (valid–invalid), inconsistent (global-valid–local-valid), local-neutral (valid–invalid), and global-neutral (invalid–valid) cues as a function of stimulus-onset-asynchrony (SOA). Note that the global-neutral cueing effect was remapped. This was done simply to reflect that this cueing effect was attributable to the local level. Error bars represent ±1 standard error of the mean. L-Neutral = local-neutral; G-Neutral = global-neutral.

For inconsistent cues, the effect of cue-level was not significant ($F < 1$), but the interaction with SOA was, $F(2, 84) = 13.40$, $p < .001$. At SOA = 250 ms, there was a significant global cueing effect (18 ms) such that RTs were faster for global-valid ($M = 361$) versus local-valid ($M = 379$) cues, $t(43) = 4.27$, $p < .001$. At SOA = 500 ms, the effect of cue-level was not significant, $t(43) = -0.23$, $p = .82$. At SOA = 750 ms, there was a significant local cueing effect (10 ms) such that RTs were faster for local-valid ($M = 319$) versus global-valid ($M = 329$) cues, $t(43) = -2.37$, $p = .02$.

Experiment 2 replicated the global-to-local shift in dominance as function of SOA observed in Experiment 1 and determined that this shift was not attributable to attenuation of global information over time or to inhibition of globally cued locations, as evidenced by a temporally stable cueing effect for local-neutral cues.

Experiments 3 and 4

Experiment 2 suggests that the early global advantage was due to global precedence and that the global-to-local shift in dominance was attributable to conflicting spatial information between levels. There

are at least two alternative interpretations, however, that need to be ruled out. In Experiments 1–2, the global arrow was closer to the location it indicated than were many of the local arrows. One possibility, therefore, is that the global advantage observed at short SOAs was due not to global precedence but to spatial proximity, that is, the proximity of the global arrow boundaries to the target may have led to a sensory bias in favor of global information. Relatedly, given that the detection task required attention to oriented outside of the global arrow boundaries, it is possible that task demands and spatial proximity together encourage or prime global processing in an indirect manner. Experiment 3 examined this possibility by manipulating target eccentricity such that targets appeared either inside or outside the boundaries of the global arrow. If the global advantage was due to spatial proximity, then a local advantage would be expected for targets appearing inside the boundaries of the global arrow, and a global advantage would be expected for targets appearing outside.

A second possibility is that global and local levels differed in their validity power. Given that the baseline power of global-neutral cues was half that of local-neutral cues, it is possible that this difference reflects the cue's basic potential rather than its locality. For example, the arrow cues used Experiments 1–2 were relatively small and contained many local elements. Patterns composed of many relatively small elements (*many-element patterns*) may be perceived as overall form associated with texture such that local elements lose their function as individual parts of the form, whereas patterns composed of few relatively large elements (*few-element patterns*) may be perceived as overall form and figural parts (Kimchi, 1992; Pomerantz, 1983). It is possible, therefore, that the use of many-element cues rendered the global level more salient, resulting in a priority for global information (Kimchi, 1990; Kimchi & Palmer, 1982). Although the low cueing power of local arrows cannot explain the global-to-local shift in dominance, it could account for the early global advantage. To examine this possibility, Experiment 4 made the local level more salient with the use of few-element cues. Accordingly, if the early global advantage can be attributed to differential salience between global and local levels, then making the local level more salient should lead to an early local advantage.

It is worth noting that the magnitude difference between global-neutral and local-neutral cueing effects is not necessarily incompatible

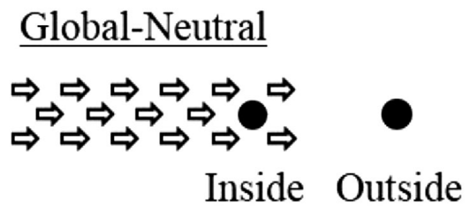

Figure 5. Global-neutral cue used in Experiment 3. This figure also shows possible target locations for the inside and outside proximity conditions.

with global precedence. For one, previous work has demonstrated that global rectangles interfere more with local forms than local rectangles interfere with global form (Navon, 1991, Experiment 5), meaning that the difference in baseline could be due to stronger global versus local interference, which would be consistent global precedence. For another, the neutral forms of the global and local levels were not perceptually equivalent (though both forms were rectangles with an area equivalent the arrow at the corresponding level, the neutral form of the global level was clearly more square), so a difference in baseline should not be too surprising. For this reason, Experiments 3–4 modified the global-neutral cue to be more rectangular at the global level (see Figure 5).

Experiment 3

Method

These were identical to Experiment 2 except that (a) on 50% of trials the target appeared inside the boundaries of the global arrow (see Figure 5), and (b) a different global-neutral cue was used. Global-neutral cues were 17 local arrows (each subtending 1.25° × 1.0° visual angle) arranged to form a single global rectangle (7.5° × 3.0°). Participants (N = 35) completed 576 trials.

Results and Discussion

RTs less than 100 ms or greater than 2.5 *SD*s above condition means were removed (2.5%). Cueing effects for each cue type as a function of SOA are shown in Figure 6. Overall, there was a main effect of SOA,

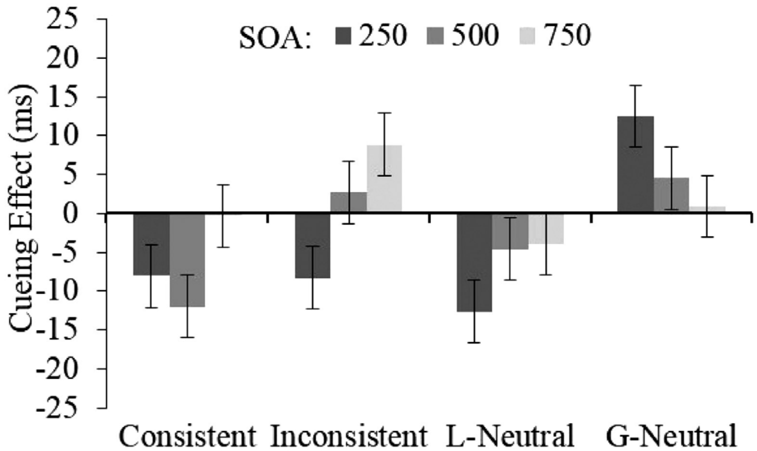

Figure 6. Experiment 3 mean cueing effects, averaging over the proximity factor, for consistent (valid–invalid), inconsistent (global-valid–local-valid), local-neutral (valid–invalid), and global-neutral (invalid–valid) cues as a function of stimulus-onset-asynchrony (SOA). Note that the global-neutral cueing effect was remapped. This was done to reflect that this cueing effect was attributable to the local level. Error bars represent ±1 standard error of the mean. L-Neutral = local-neutral; G-Neutral = global-neutral.

$F(2, 68) = 597.31$, $p < .001$, reflecting faster RTs with increasing SOA. The main effect of proximity (i.e., whether the target appeared inside or outside of the cue) was not significant ($F < 1$), though there was an SOA × Proximity interaction, $F(2, 68) = 6.81$, $p = .009$, such that the effect of SOA was larger for outside versus inside targets. Neither the main effect of consistency nor its interaction with SOA was significant (Fs < 1). Likewise, neither the Proximity × Consistency nor Proximity × Consistency × SOA interaction was significant (Fs < 1).

Importantly, if spatial proximity can account for the results of Experiments 1–2, then a local advantage should be observed for targets appearing inside the boundaries of the global arrow, and a global advantage should be observed for targets appearing outside. In contrast, and consistent with Experiments 1–2, the SOA × Cue-Level interaction was significant for inconsistent cues, $F(2, 68) = 6.92$, $p = .009$, the pattern of which replicated the global-cueing effect at SOA = 250 ms, $t(34) = 2.24$, $p = .025$, and the local-cueing effect at SOA = 750 ms, $t(34) = -2.45$, $p = .014$; the effect of cue-level was not significant at SOA = 500 ms, $t(34) = -0.75$, $p = .45$. There were also effects of validity for consistent cues, $F(1, 34) = 8.94$, $p = .005$, and for neutral

cues, $F(1, 34) = 14.36$, $p < .001$, reflecting significant cueing effects for these cues. Critically, proximity did not interact with cue-level for inconsistent cues or with validity for consistent cues (*F*s < 1). Thus, spatial proximity did not significantly alter the global-to-local sequence.

Only responses to neutral cues were influenced by proximity. First, there was a significant Proximity × Level × SOA interaction, $F(2, 68) = 5.23$, $p = .02$, such that the Level × SOA interaction (i.e., effect of level—faster RTs for global-neutral vs. local-neutral cues—decreased with increasing SOA) was significant only for outside targets. As the three-way interaction was driven by the null effect of Level × SOA for inside cues, it reflects an inconsequential effect of proximity that does not alter the interpretation of the critical finding. Second, there was a significant Proximity × Validity × SOA interaction, $F(2, 68) = 4.23$, $p = .04$, indicating that the Validity × SOA interaction (i.e., smaller cueing effect with increasing SOA) was larger for inside versus outside targets. Looking at Figure 7, which shows the pattern of cueing effects for inside and outside targets, it is clear that driving this interaction was the much larger cueing effect for inside targets at SOA = 250 ms relative to the cueing effect for outside targets. Although this might reflect a spatial proximity effect for global-neutral cues given that its local-cueing effect was larger for inside versus outside targets, the fact that local-neutral cues still led to a global-cueing effect for inside targets and that this global-cueing effect was similarly much larger for inside versus outside targets (as well as the fact that these global- and local-cueing effects were the same magnitude) provides strong evidence that the global advantage in the present experiments was not due to spatial proximity.

Interestingly, for consistent cues, there was a nearly significant Validity × SOA interaction, $F(2, 68) = 2.98$, $p = .08$, such that the effect of validity was smaller at SOA = 750 ms relative to the 250-ms, $t(34) = 1.48$, $p = .13$, and 500-ms SOAs, $t(34) = 2.14$, $p = .03$. Similarly, for neutral cues, there also was a significant Validity × SOA interaction, $F(2, 68) = 7.67$, $p = .006$, such that the effect of validity was smaller at the 750-ms, $t(34) = 2.87$, $p = .004$, and 500-ms SOAs, $t(34) = -1.93$, $p = .05$, relative to the 250-ms SOA. Thus, for consistent and neutral cues, cueing effects appear to dissipate at large SOAs. It is unclear what might have caused this. We examined intertrial effects of proximity, cue type, SOA, and target location as a possible explanation, but in each case consistent and neutral cueing effects at SOA = 750 ms were either absent or severely diminished. As such, the

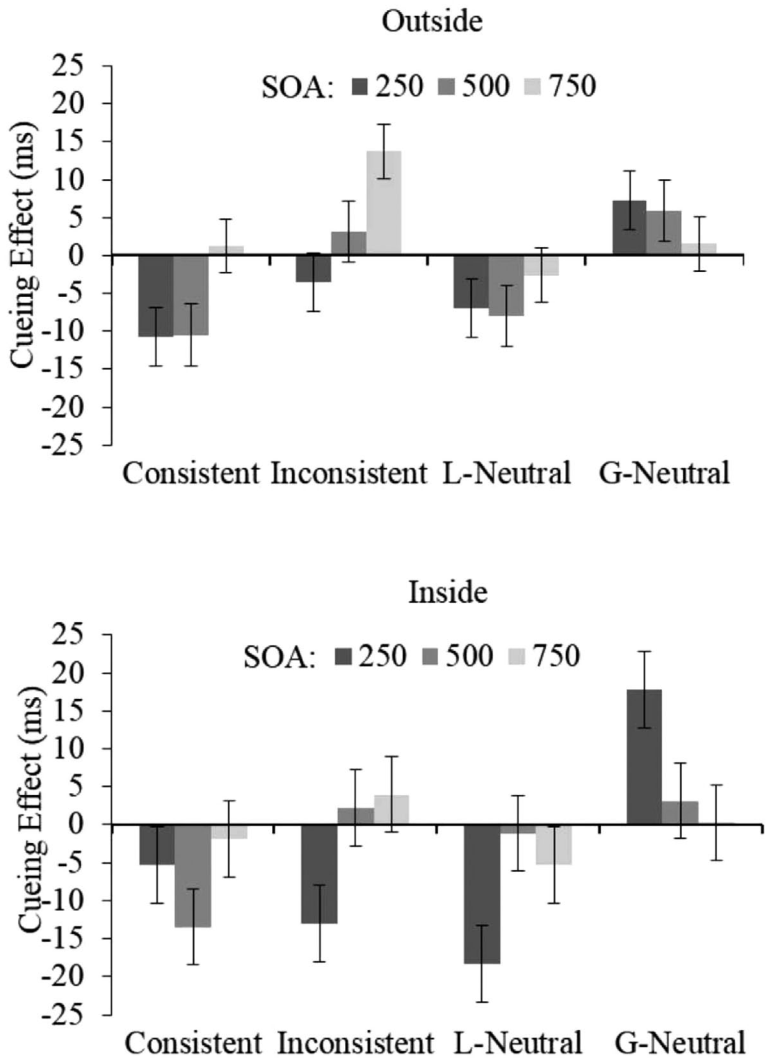

Figure 7. Experiment 3 mean cueing effects for consistent (valid–invalid), inconsistent (global-valid–local-valid), local-neutral (valid–invalid), and global-neutral (invalid–valid) cues as a function of stimulus-onset-asynchrony (SOA), plotted separately for targets appearing outside (left panel) and inside (right panel) the boundaries of the global arrow cue. Note that the global-neutral cueing effect was remapped. This was done to reflect that this cueing effect was attributable to the local level. Error bars represent ±1 standard error of the mean. L-Neutral = local-neutral; G-Neutral = global-neutral.

introduction of spatial uncertainty from the proximity manipulation is likely at play. For example, Kimchi and Merhav (1991) found mutual interference between global and local levels (i.e., no advantage) under spatial uncertainty. Assuming this was the case here, the present

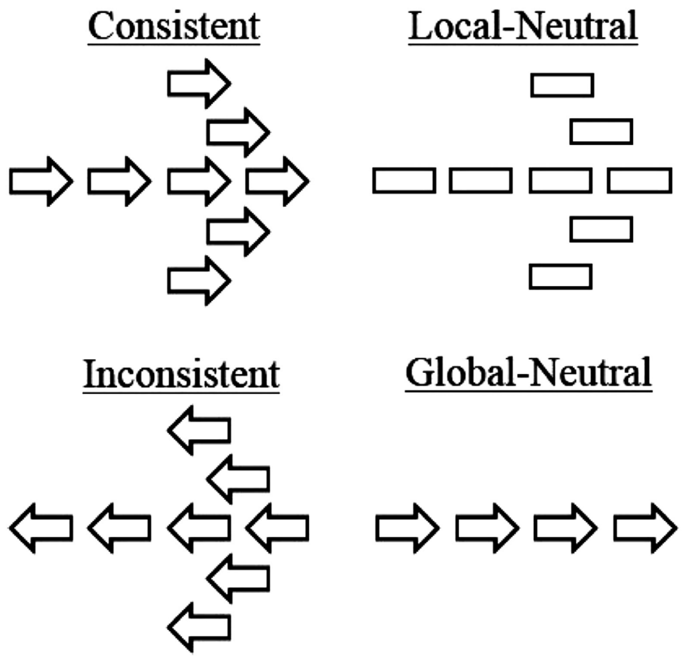

Figure 8. Experiment 4 “few-element” cue stimuli.

results suggest that such mutual interference takes time to develop (given that an advantage was always observed at SOA = 250 ms) and may interact with eccentricity (given that an advantage was observed with neutral cues at SOA = 500 ms for outside but not inside targets).

Experiment 4

Method

These were identical to Experiment 2 except for cue stimuli (see Figure 8). Consistent, inconsistent, and local-neutral cues were eight local arrows/rectangles (each subtending 1.25° × 1.0° visual angle) arranged to form a single global arrow (7.5° × 5.0°). Global-neutral cues were four local arrows (each subtending 1.25° × 1.0° visual angle) arranged to form a single global rectangle (7.5° × 1.0°). Participants (*N* = 24) completed 480 trials.

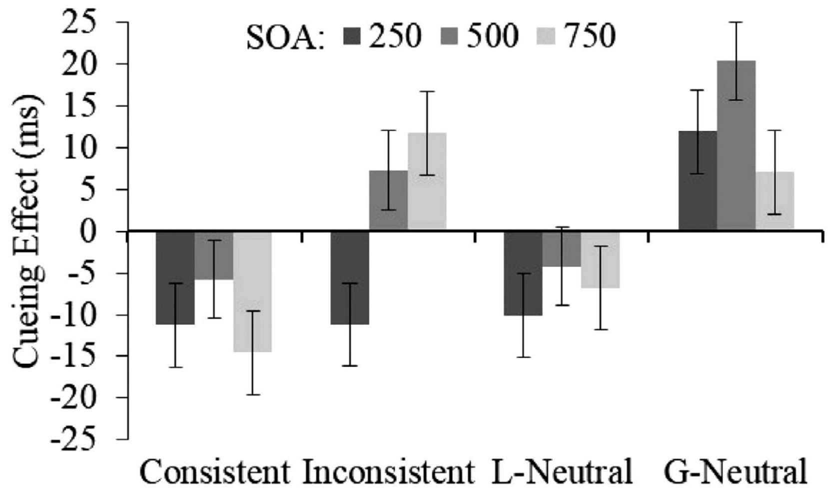

Figure 9. Experiment 4 mean cueing effects for consistent (valid–invalid), inconsistent (global-valid–local-valid), local-neutral (valid– invalid), and global-neutral (invalid–valid) cues as a function of stimulus-onset- asynchrony (SOA). Note that the global-neutral cueing effect was remapped. This was done to reflect that this cueing effect was attributable to the local level. Error bars represent ±1 standard error of the mean. L-Neutral = local-neutral; G-Neutral = global-neutral.

Results and Discussion

RTs less than 100 ms or greater than 2.5 *SD*s above condition means were removed (2.1%). Cueing effects for each cue type as a function of SOA are shown in Figure 9. Overall, there was a main effect of SOA, $F(2, 46) = 111.09$, $p < .001$, reflecting faster RTs with increasing SOA. Neither the main effect of consistency nor its interaction with SOA was significant (*F*s < 1).

For inconsistent cues, the effect of cue-level was not significant ($F \times 1$), but its interaction with SOA was, $F(2, 46) = 4.75$, $p = .03$. Consistent with Experiments 1–3, there was a global-cueing effect at SOA = 250 ms, $t(23) = 1.85$, $p = .07$, and a local-cueing effect at SOA = 750 ms, $t(23) = -1.97$, $p = .05$; the effect of cue-level was not significant at SOA = 500 ms, $t(23) = -1.21$, $p = .23$. Thus, few-element cues did not lead to an early local-cueing effect. For consistent cues, the effect of validity was significant, $F(1, 23) = 9.0$, $p < .01$, such that RTs were faster for valid ($M = 317$) versus invalid ($M = 328$) cues. The interaction of validity and SOA was not significant ($F < 1$), indicating that the cueing effect was stable across SOA. For neutral cues, the effect of

validity was significant, $F(1, 23) = 21.99$, $p < .001$, such that RTs were faster for valid ($M = 317$) versus invalid ($M = 327$) cues. The Validity × Neutral-Level interaction was not significant, $F(1, 23) = 1.96$, $p = .16$, nor was its interaction with SOA ($F < 1$), indicating that the cueing effect was the same size for local-neutral and global-neutral cues and was stable across SOA. Thus, consistent with Experiment 3, global and local arrows did not differ in their baseline validity power, suggesting the difference observed in Experiment 2 was attributable either to global-to-local interference or to the shape of the global level rather than differential baseline validity power. It is also worth noting that consistent and neutral cueing effects were stable across SOA, which replicates Experiments 1–2 and points to spatial uncertainty as the source of their dissipation in Experiment 3.

General Discussion

The present study tested global precedence under conditions where processing of global/local levels was incidental and, therefore, optimally suited for the testing of a hypothesized processing disposition. Participants performed a peripheral target detection task in the presence of a central non-predictive task-irrelevant compound arrow cue. Given evidence that these cues elicit involuntary spatial-cueing effects, global/local processing was measured by spatial-cueing effects. Supporting the notion that global information is available early and receives priority, a global-cueing effect was observed at the earliest SOA despite cue processing being unnecessary. This suggests either that attention to the global level was obligatory or that the locus of the global advantage lies within processes preceding selective attention (e.g., perceptual organization; Neisser, 1967). In either case, the source of the global advantage seems perceptual, consistent with Navon's (1977) proposal. This conclusion is strengthened by the fact that the global advantage was observed within the spatial-cueing paradigm, wherein responses (simple target detection) do not depend on post-perceptual processing stages to nearly the same extent as typical global/local tasks (e.g., identification, discrimination, categorization). Interestingly, and somewhat unexpectedly, a local-cueing effect was observed at the latest SOA. The observation of a global advantage temporally preceding a local advantage under stimulus and task

conditions that provided little if any basis for favoring one level over the other, let alone for favoring both levels in a temporally prescribed order, suggests that the global-to-local processing sequence may be obligatory. Importantly, this shift was not due to attenuation of global information as the magnitude of the cueing effect for the neutral condition in which only the global level was an arrow remained constant across SOA. It would seem then that the early prioritization of global information leads to large, rapid cuing effects that eventually give way to later processing at other levels—though the conflict between cue levels influences response at these later times (Hommel & Akyurek, 2009). In support of this interpretation, and as predicted by global precedence, the global advantage was twice the size of the local advantage. Taken together, the present data find support for global precedence in attended but incidentally processed objects.

Though the present study was designed to examine global/local processing under incidental processing conditions, the interaction of SOA with cue-level also has the potential to advance understanding of spatial-cueing effects more generally. Exogenous and endogenous cues, which differ in magnitude and time course, are traditionally thought to reflect distinct subtypes of attention, with symbolic cues representing a hybrid of these subtypes. The present results demonstrate the importance of cue-level in the magnitude and time course of a cue's effect on attention. Specifically, cues at a global level had larger and earlier effects on attention, meaning differences among cues may reflect differences in representational level rather than, or in addition to, different types of attention.

Finally, it is important to note that the present use of an incidental processing paradigm is important in that it closely reflects the manner in which a great deal of information is processed in the real world. Though attention, perception, and action can be strongly influenced by goals and intentions, processing of stimuli routinely occurs in a passive manner given the overwhelming number of inputs available at any given time. The present results suggest that under such conditions the perceptual system is more prepared to process global versus local information. This reasoning dovetails with Navon's (1977, 2003) conceptualization of global precedence as a processing disposition. Accordingly, a disposition constitutes just one vector in a complex space in which vectors are not necessarily orthogonal, meaning a disposition could easily be counteracted by any number of modulating

factors in real-world situations. It should not be surprising, therefore, that task and stimulus parameters are capable of modulating and reversing asymmetries in processing dominance (e.g., Schyns & Oliva, 1994; Oliva & Schyns, 1997). In this light, the test of any disposition would necessarily require proper control and possibly special conditions. The present study suggests that incidental processing is one such condition.

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