A short-lived face alert during inhibition of return

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Abstract In the present study, we explored the role of faces in oculomotor inhibition of return (IOR) using a tightly controlled spatial cuing paradigm. We measured saccadic response latency to targets following peripheral cues that were either faces or objects of lesser sociobiological salience. A recurring influence from cue content was observed across numerous methodological variations. Faces versus other object cues briefly reduced saccade latencies toward subsequently presented targets, independently of attentional allocation and IOR. The results suggest a short-lived priming effect or social facilitation effect from the mere presence of a face. In the present study, we further showed that saccadic responses were unaffected by face versus nonface objects in double-cue presentations. Our findings indicate that peripheral face cues do not influence attentional orienting processes involved in IOR any differently from other objects in a tightly controlled oculomotor IOR paradigm.

Keywords Eye movements and visual attention · Cognitive and attentional control · Inhibition of return · Face perception

Attention allows for the selective processing of one source of information over other simultaneously available sources. Stolz (1996) demonstrated that the spatial orienting of ex-

ogenous visual attention can be influenced by content at peripheral locations. Using Posner's (1980) spatial cuing paradigm, the semantic relation of peripherally presented cue words to a context word was shown to influence the disengagement of attention. Subsequent research has also shown that emotional valence of cues can influence attentional disengagement (e.g., Fox, Russo, Bowles, & Dutton, 2001; Okon-Singer, Tzelgov, & Henik, 2007). Faces represent a stimulus set that receives preferential attention. In the present study, we explored the role of faces in oculomotor inhibition of return (IOR)—a phenomenon reflecting the bias of attentional orienting away from recently inspected locations.

Human faces are considered to be both socially and biologically relevant stimuli. Evidence from single-cell recordings (e.g., Perrett, Hietanen, Oram, & Benson, 1992) and neuroimaging (e.g., Clark et al., 1996; Kanwisher, McDermott, & Chun, 1997; Sergent & Signoret, 1992) indicates the highly specialized nature in which faces are processed (Haxby, Hoffman, & Gobbini, 2000). Further attesting to their status as a special stimulus, evidence of attentional priority for faces has been observed across a range of behavioral paradigms, including visual search (e.g., Ro, Friggel, & Lavie, 2007), spatial cuing (e.g., Bindemann, Burton, Langton, Schweinberger, & Doherty, 2007; Theeuwes & Van der Stigchel, 2006), flicker (Ro, Russell, & Lavie, 2001; Weaver & Lauwereyns, 2011), go/no-go (e.g., Bindemann, Burton, Hooge, Jenkins, & de Haan, 2005), and inattention blindness paradigms (e.g., Devue, Laloyaux, Feyers, Theeuwes, & Brédart, 2009; Mack & Rock, 1998).

Recently, IOR has emerged as a useful phenomenon to explore influence of peripheral cue content on exogenous control of covert attention (e.g., Fox, Russo, & Dutton, 2002; Stoyanova, Pratt, & Anderson, 2007; Taylor &

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Therrien, 2005; Theeuwes & Van der Stigchel, 2006). First discovered and investigated by Posner and Cohen (1984; see Klein, 2000, for a review), IOR refers to the finding that, after attention has been exogenously cued and then withdrawn from a location, attention is biased against returning to the region, indicated by inhibited processing of stimuli at (or near) the previously *attended* location relative to previously *unattended* locations. This follows an initial period of facilitative processing enjoyed while attention resides at the cued location. It is upon the subsequent withdrawal of attention that IOR is thought to develop (or at least become evident). The phenomenon is considered to promote efficient foraging behavior by biasing attention away from returning to locations that have already received recent attentional processing, thus encouraging the processing of novel locations (Klein, 1988; Klein & MacInnes, 1999; Tipper, Weaver, & Watson, 1996).

In the spatial cuing paradigm, IOR can be induced by extending the stimulus onset asynchrony (SOA) between the cue and target onset. Fox et al. (2002) used IOR to explore the impact of emotional valence of peripheral cues on disengagement processes, finding a reduced IOR effect following angry (vs. neutral and happy) face cues for high trait-anxious participants. The authors argued that this effect reflected longer holding of attention on the basis of the logic that IOR does not begin to develop until attention has disengaged from the cued location, so a delayed disengagement from the cued location will be reflected by reduced IOR magnitude over the same time scale.

An intriguing question concerns whether, given the sociobiological importance and prioritized attentional status enjoyed by faces (vs. sociobiologically neutral objects), their processing at a peripheral location ought to differentially influence IOR—that is, the manner in which attention is subsequently inhibited from returning to the sampled location. Taylor and Therrien (2005) compared the magnitude of IOR (as expressed by manual motor responses) in response to neutral or scrambled face cues in a spatial cuing paradigm, but found no evidence that cue content influenced IOR. Stoyanova et al. (2007) similarly found no difference in IOR magnitude in response to fearful, neutral, or scrambled face cues. However, Theeuwes and Van der Stigchel (2006) simultaneously presented two cues (a face and a sociobiologically neutral cue) on opposing sides of fixation and discovered a small but significant effect showing slower saccadic responses toward locations previously containing a face. This finding was interpreted as reflecting an IOR effect for the face location, indicating that faces preferentially captured attention in a fairly exogenous manner. Note that capture was inferred from the presence of IOR, with the authors' logic based on the tenet that IOR occurs only after attention has been *reflexively* oriented towards the cued location (Posner & Cohen, 1984). Their findings suggest

that faces may be more likely to elicit IOR because of their ability to receive initial attentional priority over other objects.

In the present study, we focused on examining the role of faces in a tightly controlled oculomotor IOR paradigm. We proposed to expand on previous research (Stoyanova et al., 2007; Taylor & Therrien, 2005) through convergent operations, by measuring saccadic responses and using shorter SOAs, while employing strict eye-control procedures in a spatial cuing paradigm.

Saccadic responses rely on neural mechanisms of motor control that are vastly different than those involved in manual movement, and they tend to produce crisp reaction time (RT) distributions with mean values that are typically several hundreds of milliseconds faster than those obtained with manual responses. Accordingly, eye movements might be considered to represent a more sensitive and dynamic measure of attentional allocation than manual motor responses.

In addition to using a longer SOA than that used in previous research (500–1000 ms; Stoyanova et al., 2007; Taylor & Therrien, 2005; Theeuwes & Van der Stigchel, 2006), we also included a shorter SOA of 200 ms in line with evidence that doing this provides saccadic IOR effects of a greater magnitude (Klein, 2000; Li & Lin, 2002). We propose that a greater IOR effect might be more sensitive to cue content, such that an influence not evident at SOAs of 500 ms (as used by Stoyanova et al., 2007) may become evident at SOAs of 200 ms.

Experiment 1

In **Experiment 1**, we compared the magnitude of oculomotor IOR in response to task-irrelevant cues that were either human faces or objects of less sociobiological significance (the latter henceforth referred to as “neutral cues”). Participants were asked to ignore the cues and make a simple saccadic localization response to a subsequent target presented in either the cued or uncued location. In addition to presenting single cues, two-cue (competition) trials were included to provide a subset of trials in which the physical transients on either side of fixation effectively canceled each other out. As a result, these latter trials acted as a control condition in which, unlike in single-cue trials, strong physical transient information would not be available to reflexively capture attention. These competition trials also served as an opportunity to replicate and extend Theeuwes and Van der Stigchel's (2006) findings.

Both SOAs were expected to produce IOR effects, reflected by longer RTs in cued versus uncued trials, but with a larger effect predicted at the short SOA. On the basis of expectations of a later disengagement of attention from the cued location, we anticipated finding a reduced IOR

effect for face cues than for neutral cues in the single-cue trials (Fox et al., 2002). Furthermore, we hypothesized that an influence from faces would be larger at the short SOA, because of the increased sensitivity afforded by the larger IOR effect. The two-cue competition cuing condition was predicted to produce RTs that fell between those in single-cued and uncued trials.

Method

Participants Twenty-nine Victoria University of Wellington (VUW) students participated in exchange for course credit. All participants were naive to the purpose of the experiment and had normal or corrected-to-normal vision. Participation was voluntary, and informed consent was given. After preliminary data analyses, one participant was excluded because of excessive errors (over 30% of trials removed, see trial rejection criteria below). The remaining 28 participants (16 female, 23 right-handed) had a mean age of 19.21 years.

Apparatus, stimuli, and procedure The experiment was programmed using SR Research Experiment Builder (2007) (version 1.4.128RC) and was displayed on a 21-in. monitor. Participants were seated at a viewing distance of approximately 57 cm. The EyeLink® 1000 (SR Research Ltd.) was used to measure eye movements. Cue stimuli were taken from Ro et al.'s (2001) study and consisted of six grayscale photographs within each of four category types: faces, appliances, musical instruments, and clothing (the latter three making up the broader neutral cue category; see Fig. 1a).

The trial sequence is presented in Fig. 1b. Participants initiated trials by fixating a central black dot ($0.5^\circ \times 0.5^\circ$) on a white background for 500 ms. One or two cues (each subtending $2.9^\circ \times 2.9^\circ$) were then presented for 100 ms at 9.7° to either the left, right, or both sides of fixation. Following a variable cue–target SOA of 200 ms or 700 ms, the fixation point was removed and a saccade target (either an & or % symbol written in black 36-point Arial font, vertically subtending 1.4°) appeared to the left or the right at the same eccentricity as the cue stimuli. Participants were asked to ignore the cues and to maintain fixation until the target appeared, at which point they made a speeded saccade toward the target. If fixation was broken before the target appeared, a visual reminder was displayed and the trial restarted. After 12 practice trials, six experimental blocks of 40 trials were completed, providing 240 analyzable trials. Trials were self-paced.

Design The dependent variable was saccadic RT following target presentation. Within-participants factors included two SOAs (200 and 700 ms) $\times$ three cuing conditions (cued, uncued and competition) $\times$ two cue values (face and neutral). Both SOA lengths were equally likely. A single cue

Fig. 1 **a** Stimuli used as cues, separated into categories of clothing, faces, appliances, and musical instruments. **b** Task sequence. Participants fixated the central point for 500 ms, after which either one or two objects were presented for 100 ms to the left, right, or both sides of fixation. Following a variable delay (100 or 600 ms), a target symbol appeared either to the left or right. Participants executed a speeded saccade to the target

was presented on 80% of trials, of which 25% were faces and 75% were neutral objects. In the single-cue trials,

targets appeared in cued and uncued locations with equal probability. The competition cuing condition contributed the remaining 20% of trials. It involved the simultaneous presentation of a face and a neutral cue on either side of fixation, with either cue being equally likely to appear at the upcoming target location. The cue value in the competition trials refers to which of the two (face or neutral) cues preceded the target.

Neither cue location nor value was predictive of the target location. The trial order was pseudorandom, with the constraint of no more than four successive presentations of the same SOA, cuing condition, specific cue category, or cue and target location. Two trial orders (one reversed) were counterbalanced across participants.

Results

Saccadic RT was measured as the time taken to initiate the first saccade following target presentation, defined by a shift in eye position greater than 2° , and of a velocity surpassing $30^\circ/\text{s}$. Fixation initiation and maintenance was measured as a constant fixation anywhere within 3.7° of the central fixation point.

Trials were rejected if fixation was not maintained until the target presentation or if a saccade was anticipative (initiated within 100 ms of target onset), late (after three standard deviations above mean saccade latency), or contained an eyeblink. Of the remaining 28 participants, 8.13% of trials were excluded from primary analyses. Figure 2 presents the mean RTs and standard errors for saccade responses as a function of cue value and cuing condition, separately for the 200- and 700-ms SOA conditions. An alpha level of .05 was used for all inferential statistical tests.

Single cuing condition For the single cue conditions, a three-way repeated measures ANOVA was conducted on mean saccade RTs using within-participants factors of SOA (200 vs. 700 ms), cuing condition (cued vs. uncued), and cue value (face vs. neutral). A significant main effect of SOA, $F(1, 27) = 137.64$, $p < .001$, indicated that RTs were, on average, 85 ms faster in the 700-ms (vs. 200-ms) SOA condition. An interaction between SOA and cuing condition was also apparent, $F(1, 27) = 17.54$, $p < .001$. Accordingly, 2×2 repeated measures ANOVAs were conducted for each SOA, using cuing condition and cue value as within-participants factors (reported in separate paragraphs below).

SOA of 200 ms Analyses for the 200-ms SOA yielded a main effect of cue value, $F(1, 27) = 17.93$, $p < .001$, whereby saccades were initiated faster following face cues ($M = 277$ ms) than neutral cues ($M = 288$ ms). A significant main effect of cuing condition was also found, $F(1, 27) = 41.91$, $p < .001$, in which RTs were significantly faster to

Fig. 2 Experiment 1: Mean saccade reaction times (in milliseconds) and standard errors for face and neutral cue trials as a function of cuing condition and SOA (in milliseconds). Each SOA condition is presented in a separate panel. In the competition cuing condition, the label (“face” or “neutral”) pertains to the cue at the location where the target would appear

uncued (265 ms) versus cued (305 ms) targets, indicating an IOR effect. No interaction was observed between cue value and cuing condition ($F < 0.6$).

SOA of 700 ms Analyses for the 700-ms SOA condition showed a significant main effect of cuing condition on saccadic RTs, $F(1, 27) = 24.03$, $p < .001$. Again, an IOR effect was indicated by faster saccades made toward uncued (191 ms) rather than toward cued (210 ms) targets. There was no significant main effect of cue value, nor an interaction between cue value and cuing condition (remaining F values < 0.1).

Competition cuing condition For the competition cuing condition, RTs were submitted to a two-way repeated measures ANOVA, using SOA (200 vs. 700 ms) and cue value (face vs. neutral) as within-participants factors. A significant main effect of SOA was revealed, $F(1, 27) = 144.69$, $p < .001$, in which RTs were, on average, 96 ms faster in the

700-ms (vs. 200-ms) SOA condition. No significant main effect of cue value, nor an interaction between cue value and SOA, was evident (remaining F values < 0.3).

Discussion

Results showed an IOR effect for the single-cue trials, which was larger at SOAs of 200 ms (41 ms) versus 700 ms (19 ms). Cue value influenced RTs, in that responses to targets following face cues (vs. neutral objects) were faster, but only at the shorter SOA. Interestingly, this face advantage did not interact with the IOR effect, indicating that it was not due to later attentional disengagement. Saccadic RTs were not significantly different between face versus neutral cues when in competition, suggesting that faces also did not preferentially capture attention.

An additional experiment was conducted with new participants to rule out the possibility that the degree to which cued RTs were slower than uncued RTs in the single-cue 200-ms SOA condition reflected masked perception of the target stimulus when presented in the same spatial display location as the preceding cue. The eccentricity of the target stimuli was reduced to 7.9° , making their presentation more central than the cue locations and thus removing any cue–target spatial overlap (this spatial presentation of the stimuli was henceforth used in all subsequent experiments). Comparable results to those in [Experiment 1](#) were observed. The IOR effect was again larger in the 200-ms SOA condition, suggesting that the IOR effect observed in [Experiment 1](#) was not because of forward masking in cued trials. No difference was again observed between RTs for face versus neutral cued trials in competition, nor was any interaction observed between cue value and single cuing conditions. The main effect of cue value in single-cue trials approached significance only for the shorter SOA condition, $F(1, 29) = 3.65$, $p = .066$.

In yet another experiment, we aimed to assess whether an influence from face cues on attentional orienting processes, and thus IOR, might be observed in the current paradigm with less emphasis on fixation maintenance. Previous studies have suggested that the quality of fixation maintenance is inversely correlated with distractibility (Paus, 1991) and frontal lobe dysfunction (Smyrnis et al., 2004). In line with these proposals, we reasoned that participants might be more susceptible to influences from cues when the immediate feedback on fixation maintenance prior to the target appearance is removed (i.e., the trial no longer aborted in case of fixation break). The fixation point remained. Without ongoing feedback informing participants of failures to maintain central fixation, the attentional engagement at central fixation—both overtly and covertly—would be reduced, thus increasing the likelihood that cue content would be processed. We did not provide immediate feedback on fixation in any of our subsequent experiments. Comparable

IOR effects were again observed. No interaction was found between single cuing conditions and cue value at either SOA, despite a main effect of cue value independent of IOR at 200-ms SOAs once again becoming evident. Although an interaction was significant between cue value and SOA for the competition cuing condition, planned contrasts showed that simple differences between face- and neutral-cued RTs were not significant at either SOA.

Thus, across all three experiments, face cues showed no indication of having an impact on oculomotor IOR differently from neutral cues, even at 200-ms SOAs, contrary to expectations. These results indicate that faces did not preferentially capture or hold attention over sociobiologically neutral object cues, a result that—although consistent with some previous research (e.g., Stoyanova et al., 2007; Taylor & Therrien, 2005)—is inconsistent with other findings (Bindemann et al., 2007; Theeuwes & Van der Stigchel, 2006; Weaver & Lauwereyns, 2011). Particularly interesting in the present findings was the lack of evidence for an influence of cue content on hold processes of exogenous orienting (Fox et al., 2001; Fox et al., 2002; Stolz, 1996). It could be that attention was rendered less susceptible to cue content by the inclusion of competition (vs. only single-cue) trials in the current paradigm, leading participants to employ different target detection strategies.

Experiment 2

In the previous experiment (and in the two follow-up experiments), participants could expect to be presented on any given trial with either an irrelevant single cue on one side of fixation or with two cues (i.e., one in each hemifield). However, previous research did not mix single- and double-cue trials (Fox et al., 2001; Fox et al., 2002; Stolz, 1996; Theeuwes & Van der Stigchel, 2006). This might have resulted in the development of different target detection strategies that could account for the differences from our findings. [Experiment 2](#) involved only single cue presentations to test the validity of this interpretation.

Method

Participants Thirty-nine new VUW students participated. Data from three participants were excluded following preliminary data analyses ($>30\%$ error trials). The remaining 36 participants (28 female, 33 right-handed) had a mean age of 19.25 years.

Stimuli and apparatus The same stimuli and apparatus as in the two previous follow-up experiments were used.

Procedure The procedure differed from previous experiments in that only single cues were presented on trials.

Participants consequently completed just 10 practice trials and 192 analyzable trials, separated into four blocks of 40 and one of 32 trials.

Design Except for having only two cuing conditions (cued and uncued), the experimental design was identical to that of the previous experiments.

Results

From the data of the 36 participants that were submitted to further analyses, a total of 12.20% error trials were excluded. Mean RTs and standard errors for each SOA in [Experiment 2](#) as a function of cue value and cuing condition are presented in [Fig. 3](#).

Single cuing condition The three-way ANOVA again indicated a main effect of SOA, $F(1, 35) = 237.32$, $p < .001$, in which participants responded 67 ms faster following the long (vs. short) cue–target SOA. Additional two-way ANOVAs were conducted for each SOA (reported separately below) as a consequence of finding an interaction between SOA and cuing condition, $F(1, 35) = 23.59$, $p < .001$.

SOA of 200 ms Analyses revealed a main effect of cue value, $F(1, 35) = 8.56$, $p < .01$. Participants' responses to targets following face cues ($M = 246$ ms) were faster than those following neutral cues ($M = 253$ ms). An IOR effect was observed, indicated by a main effect of cuing condition, $F(1, 35) = 80.12$, $p < .001$, in which uncued RTs (230 ms) were faster than cued RTs (273 ms). There was no interaction between the cue value and cuing condition ($F < 2.0$).

SOA of 700 ms No main effect of cue value was apparent at the 700-ms SOA condition ($F < 0.6$). There was, however, a main effect of cuing condition, $F(1, 35) = 80.89$, $p < .001$, indicating an IOR effect, in which uncued targets (173 ms) produced faster RTs than cued targets (196 ms). An interaction between cue value and cuing condition was also apparent, $F(1, 35) = 11.43$, $p < .01$. A planned paired-samples t test showed that the IOR effect for face cues (31 ms) was greater than that for neutral cues (20 ms), $t(35) = 3.38$, $p < .01$.

Discussion

An IOR effect was again observed, approximately twice as large at 200-ms SOAs. Despite processing of cue content being even more likely and under more similar circumstances to previous research, no consequent impact on attentional hold processes was observed, as would be characterized by reduced IOR in face- as compared with neutral-cue conditions. The main cue value effect independent of IOR

Fig. 3 [Experiment 2](#): Mean saccade reaction times (in milliseconds) and standard errors for face and neutral cue trials as a function of cuing condition and SOA (in milliseconds). Each SOA condition is presented in a separate panel

at 200-ms SOAs was again evident and, although an influence of cue content was observed at 700-ms SOAs, it was characterized by a *greater* IOR effect for faces than neutral cues (opposite of predictions).

The recurrent finding of a main effect of cue value that was apparent only in the 200-ms SOA condition and was independent of the single-cuing condition was intriguing and merited further investigation. In [Experiment 3](#), we examined whether this effect, both in its independence from cuing and occurrence only at shorter SOAs, represents a robust phenomenon or a mere artifact of intermixing different SOA lengths within trial blocks.

Experiment 3

In contrast with our variable SOA, Fox et al. (2001), Fox et al. (2002), and Stolz (1996) employed a constant cue–target SOA within each experiment. Could this simple methodological difference account for our divergent results regarding the finding of an influence from cue content on the disengagement of attention?

Intermixing SOA conditions within trial blocks makes the timing of the target appearance following the cue uncertain. This might have produced our main effect of cue value observed only at 200-ms SOAs and independent of cuing. Under such conditions, participants might be taking advantage of the 700-ms SOA condition's being more temporally predictive of target onset (i.e., after 200 ms has elapsed from cue onset, the target could then only be presented at 700 ms; see Gabay & Henik, 2008). Consequently, attentional resources might be prioritizing the processing of temporal rather than spatial information, such that any influence of cue content on attention would more likely be moderated by manipulations of temporal expectancy of the target rather than its spatial relationship with the preceding cue.

In Experiment 3, we investigated whether the recurrent main effect of cue value reflects a robust new phenomenon or whether—once temporal uncertainty is removed, making each SOA condition equally predictive of target onset—we would now find a comparable influence of cue content that was evident across both SOAs and that interacted with cuing condition, thus indicating an impact on IOR. The SOA conditions were separated so that a target could always be expected at a fixed SOA on a particular block of trials.

Method

Participants Thirty-seven new VUW students participated in Experiment 3. Following preliminary analyses, seven participants were excluded (>30% error trials). The remaining 30 participants (24 female, 26 right-handed) had a mean age of 20.97 years.

Stimuli and apparatus The same stimuli and apparatus were used as for Experiment 2.

Procedure The only procedural difference from Experiment 2 was that the 192 experimental trials were now separated into four blocks of 48 trials.

Design The primary methodological difference from previous experiments was that the two SOA conditions were no longer intermixed within the same trial block. The different SOAs were separated into blocks so that the first two blocks of the experiment were at one SOA and the second two at the alternative SOA. The order of the two SOAs (and two

trial blocks within each SOA) was then counterbalanced across participants.

Results

From the 30 participants included in further analyses, a total of 12.55% of trials were excluded. Figure 4 shows the mean RTs and standard errors for each SOA as a function of cue value and cuing condition.

Single cuing condition A main effect of SOA was significant in the three-way ANOVA, $F(1, 29) = 46.31$, $p < .001$, whereby the 700-ms (relative to the 200-ms) SOA condition

Fig. 4 Experiment 3: Mean saccade reaction times (in milliseconds) and standard errors for face and neutral cue trials as a function of cuing condition and SOA (in milliseconds). Same format as in Fig. 3

experienced a 29-ms RT benefit. A significant $SOA \times$ Cuing Condition interaction, $F(1, 29) = 22.69$, $p < .001$, prompted two two-way ANOVAs to be conducted for each SOA.

SOA of 200 ms A significant main effect of cue value was found, $F(1, 29) = 6.04$, $p < .05$, in which RTs to face cues ($M = 206$ ms) were faster than those to neutral cues ($M = 212$ ms). A significant main effect of cuing was also evident, $F(1, 29) = 102.68$, $p < .001$, showing an IOR effect from faster RTs to uncued (191 ms) versus cued targets (229 ms). No significant interaction between cue value and cuing condition was observed ($F < 2.1$).

SOA of 700 ms There was no evidence of a main effect of cue value in the 700-ms SOA trials ($F < 0.8$). An IOR effect was observed, reflected by a significant main effect of cuing, $F(1, 29) = 31.78$, $p < .001$, in which RTs following uncued targets (173 ms) were faster than those following cued targets (191 ms). There was no interaction between cue value and cuing condition ($F < 0.6$).

Discussion

We found IOR effects comparable to our previous experiments but, more importantly, the same cue value effect at 200-ms SOA trials as in Experiments 1 and 2 was evident. This effect was again independent of cuing and was absent at the 700-ms SOA. These results indicate a robust influence of cue content on RTs, still observed following numerous methodological variations.

Experiment 4

Experiment 4 was designed to rule out an alternative interpretation that the present findings regarding the cue value effect observed at short SOAs and independent of cuing might be attributed to the low-level characteristics, rather than to the semantic processing, of face (vs. neutral) cues. **Experiment 4** was essentially a replication of **Experiment 2** (i.e., with the two SOA conditions intermixed rather than blocked), although with all cue objects inverted. By inverting the cue stimuli, low-level features can be controlled while higher level processing of cue content becomes more impaired (particularly for faces, see Yin, 1969). If the independent main effect of cue value observed at 200-ms SOAs in the previous experiments was indeed due to cue content, then we would expect to see the effect disappear when all cue objects were inverted. Alternatively, if this effect was driven by physical characteristics of the cue stimuli, then this effect would be unaffected by whether cues were inverted.

Method

Participants Forty-two new VUW students participated in **Experiment 4**. After preliminary data analyses, eight participants were excluded because of excessive trial errors ($>30\%$) and two others were excluded because of computer malfunction/calibration error. The remaining 32 participants (17 female, 31 right-handed) had a mean age of 19.91 years.

Stimuli The same stimuli were used as in Experiments 2 and 3. However, cue stimuli were now displayed inverted.

Procedure The same procedures as those for **Experiment 2** were used, except the 192 experimental trials were separated into four blocks of 48 trials (as in **Experiment 3**).

Apparatus and design The same apparatus and design were used as in **Experiment 2** (i.e., the two SOA conditions were intermixed within the same trial block).

Results

Following preliminary analyses, 14.18% of trials were excluded from the 32 participants whose data were subsequently analysed. Mean RTs and standard errors are presented in Fig. 5 as a function of cue value and cuing condition for each SOA.

Single cuing condition The three-way repeated measures ANOVA revealed a main effect of SOA, $F(1, 31) = 283.03$, $p < .001$, in which responses were, on average, 60 ms faster in the 700-ms (vs. 200-ms) SOA condition. An SOA and cuing condition interaction was significant, $F(1, 31) = 16.35$, $p < .001$, prompting further 2×2 ANOVAs to be carried out, again reported in separate paragraphs for each SOA, below.

SOA of 200 ms A significant main effect of cuing, $F(1, 31) = 112.24$, $p < .001$, revealed an IOR effect characterized by faster RTs on uncued ($M = 227$ ms) versus cued ($M = 263$ ms) trials. There was no main effect of cue value, or an interaction between cue value and cuing condition (remaining F values < 2.5).

SOA of 700 ms Analyses showed a main effect of cuing condition for the 700-ms condition, $F(1, 31) = 41.91$, $p < .001$. As for the 200-ms SOA condition, uncued RTs (176 ms) were faster than cued RTs (194 ms), indicating an IOR effect. Again, no main effect of cue value, or an interaction between cuing condition and cue value, was observed (remaining F values < 0.6).

Fig. 5 Experiment 4: Mean saccade reaction times (in milliseconds) and standard errors for face and neutral cue trials as a function of cuing condition and SOA (in milliseconds). Same format as in Fig. 3

Discussion

The results showed that, when all cue objects were inverted, the main effect of cue value independent of IOR at 200-ms SOAs was no longer observed. The basic findings were otherwise replicated. The low-level physical characteristics of the cue stimuli were the same as in Experiment 2, indicating that the lack of a similar face effect observed in the present experiment was because of impaired semantic processing of the cues resulting from their inverted display. This finding was consistent with that of Ro et al. (2001) who, using the same stimuli as in the present study, failed to replicate an attentional priority found for face stimuli once all objects were inverted. The present results suggest that

cue content rather than low-level features contributed to the recurring finding in Experiments 1 to 3 of an RT advantage following face (vs. neutral) cues at 200-ms SOAs, apparently independent of attentional orienting processes.

General Discussion

Taking together our findings across all four experiments, we observed robust effects of IOR which, for single cues, was approximately twice as large at SOAs of 200 ms. Based on the inference that orienting must have occurred if IOR was observed (e.g., Theeuwes & Van der Stigchel, 2006; but see Posner & Cohen, 1984), these effects confirm that covert attentional orienting processes were employed in response to the single-cue presentation. Attention was first exogenously captured by the abrupt onset of the cue and, after withdrawing, took longer to subsequently return to a cued versus uncued location. Effects of cue value tended to occur only at short SOAs and independently of attentional orienting measures (i.e., IOR). This means that although there was evidence that peripheral cue content was processed, no evidence suggested that their subsequent impact on RTs was achieved via influence on attentional orienting mechanisms. Faces briefly facilitated saccadic responses to targets regardless of whether attention had previously sampled the same location in response to the preceding cue, but only when cue stimuli were presented upright. This finding indicates that face cues, either alone or in competition, were not superior in their ability to capture or hold attention.

Our findings extend those of Stoyanova et al. (2007) and Taylor and Therrien's (2005) by showing that, even when using shorter SOAs, which produced larger IOR, and employing more implicit oculomotor measures of attention, face cues did not have an impact on IOR any differently from other objects, despite their sociobiological significance.

It is surprising that such durable effects of cue content, independent of attentional orienting, would be found in a spatial attention task. The finding contrasts with previous research (Fox et al., 2001; Fox et al., 2002; Okon-Singer et al., 2007; Stolz, 1996) showing an influence of cue content on exogenous covert attentional mechanisms. Such conflicting results might be reconciled by considering that past research measured manual motor responses, whereas we examined oculomotor responses, which have a very different underlying neural basis. Another crucial difference was that instead of manipulating the semantic relatedness (Stolz, 1996) or emotional valence (Fox et al., 2001; Fox et al., 2002; Okon-Singer et al., 2007) of cues, we manipulated their sociobiological salience to measure impact of cue content on attention. However, the present findings extend those of recent research (Weaver, Phillips, & Lauwereyns,

2010), which found that cue content primed a task-influencing manual response independently of attentional orienting processes (albeit under conditions of high information overlap between cue and task set) by showing that cue content can similarly have an impact on oculomotor responses.

In the present study, the mere abrupt presence of an upright face in the periphery was sufficient to briefly facilitate saccadic responding to targets, irrespective of where attentional resources were spatially allocated or of observer intentions. It is conceivable that such a preconscious automatic (Bargh, 1992) phenomenon might prove useful in everyday visual environments, in which it is not always possible or convenient to orient the fovea for purposes of finely detailed perceptual analyses. In these circumstances, it might be more effective to bypass the visual attentional system in favor of priming or facilitating more immediate action. This could represent an efficient strategy in situations when it is more appropriate to sacrifice benefits from further processing for timely reacting. Such an influence from a face cue may suggest a short-lived form of social facilitation (Allport, 1920/1967; Triplett, 1898). Because we may learn that it is necessary to be prepared to react to the unpredictable demands produced by social contexts (i.e., drive theory, Zajonc, 1965, 1980), the sudden appearance of a face (even a passive observer, Dashiell, 1935) may induce a higher level of alertness and readiness to respond to subsequent events (such as a saccade target). This concept shares similarities to the notion of a “threat-detector” route for facial processing, for which it has been argued that finely detailed representations may be traded off for faster perception of basic arousal or emotion information (and thus action) in response to potentially threatening faces (Morris, de Gelder, Weiskrantz, & Dolan, 2001; Öhman, 2002).

Follow-up studies to further substantiate and investigate the present findings might include more systematic investigations of the time course over which the influence from face cues might operate. This could be achieved by using a wider range of SOAs, including those designed to induce facilitation effects (e.g., 50 ms and 100 ms). The stage at which the face has to appear to influence saccadic responses might also be determined by attempting to replicate the present results using face and neutral stimuli as targets, preceded by simpler (e.g., luminance) cues.

It is interesting that across three experiments (Experiment 1 and the two follow-up experiments), we failed to observe Theeuwes and Van der Stigchel’s (2006) recent finding of slower saccades directed to the location previously containing the face versus neutral cue, when both cues were presented simultaneously. It is likely that our differing results were a reflection of using an exogenous event (i.e., the abrupt peripheral onset of the target) rather than an endogenous event (i.e., a central pointer, used in Theeuwes & Van

der Stigchel, 2006) to signal the saccadic response, suggesting that their finding may not extend to saccades that are exogenously generated.

In summary, in the present study, we showed that although faces failed to have an impact on IOR in a tightly controlled oculomotor paradigm, they did induce a brief alertness-type effect, facilitating the saccadic responding to subsequent targets, independently of attentional allocation.

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