Task-dependent exogenous cuing effects depend on cue modality

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Abstract

Task-dependent exogenous cuing effects on reaction time in detection and discrimination tasks have been ascribed to delayed withdrawal of attention in discrimination tasks. Alternatively, these differences may be due to cue-induced response inhibition in detection tasks. Unimodal and crossmodal versions of the Posner paradigm were examined with short cue–target intervals. Targets above or below fixation required either detection or discrimination responses. Cuing effects were determined for the target-elicited P1 component and for the lateralized readiness potential (LRP). Task-dependent cuing effects on reaction time were found in the unimodal but not in the crossmodal version, but not for the P1 component. The LRP data indicated that inhibition of return in the unimodal detection task had a premotoric locus. These findings suggest that inhibition in the unimodal detection task resulted from speeded motor inhibition triggered by the visual cue.

Descriptors: Exogenous orienting, Unimodal, Crossmodal, IOR, Motor inhibition

A well-known observation in the field of spatial attention concerns the influence of irrelevant unpredictive onsets on performance to subsequent targets when they require simple button presses or choice responses (e.g., Posner & Cohen, 1984). When irrelevant onsets (e.g., exogenous cues) are followed after a short time interval (about 300 ms) by targets, responses are commonly faster when targets occur near cued locations than when they occur at uncued locations. In combination with the observation of an enhanced contralateral P1 ERP component[1] for cued as compared to uncued targets (e.g., see Hopfinger & Mangun, 1998), it seems reasonable to postulate that exogenous orienting effects induced by irrelevant onsets facilitate performance to stimuli presented shortly afterward by affecting the processing of these stimuli at an early perceptual level. Empirical findings from several recent studies, however, suggest that this picture is more complex.

Facilitation of perceptual processing appears to depend on a number of stimulation and task variables. First, display characteristics, such as the employment of boxes indicating possible target positions, the use of intermediate fixation cues (Lupiáñez, Milán, Tornay, Madrid, & Tudela, 1997; Pratt, Kingstone, & Khoe, 1997), the use of sustained rather than transient cues (Collie, Maruff, Yucel, Danckert, & Curry, 2000; Wascher & Tipper, 2004), and sensory interactions between cues and targets (Tassinari & Berlucchi, 1993), all these factors (see also Klein & Taylor, 1994; Taylor & Klein, 1998) have been found to influence the size and direction of the exogenous orienting effect on reaction time (RT). Second, for discrimination tasks where the so-called stimulus onset asynchrony (SOA; i.e., the time interval between cue and target onset) is short (< 500 ms), typically facilitation effects are reported on RT, whereas in simple detection tasks a reverse effect is often found (e.g., see Klein, 2000; Lupiáñez et al., 1997; Lupiáñez, Miliken, Solano, Weaver, & Tipper, 2001; Van der Lubbe, Vogel, & Postma, 2005; see also Tanaka & Shimojo, 1996, 2000). In the present study, we specifically focused on the influence of the type of task on the exogenous cuing effect. To this end, our task displays were kept as simple as possible; no explicit position markers and no intermediate fixation cues were employed (see Van der Lubbe et al., 2005). Furthermore, only short SOAs (< 400 ms) were examined because task-dependent exogenous cuing effects especially for these SOAs are in need of an explanation.[2] Finally, we wanted to

[1]The P1 component originates from extrastriate visual areas V3/V3a,V4, and the fusiform gyrus (Di Russo, Martínez, Sereno, Pitzalis, & Hillyard, 2001; for a survey, see Hopfinger, Luck, & Hillyard, 2004).

[2]This task-dependent effect implies that an explanation for inhibition of return in terms of sensory interactions for short SOAs (see Tassinari & Berlucchi, 1993) is not satisfying.

know whether these task-dependent effects are in some way affected by the modality of the cue, which could provide important additional information about the underlying mechanisms (see later). Therefore, we examined task-dependent exogenous cuing effects both with visual and with auditory exogenous cues.

In a previous study on task-dependent exogenous orienting effects (Van der Lubbe et al., 2005), we observed major performance differences between effects of visual exogenous cues in a visual detection and discrimination task across a wide range of cue–target intervals, with SOAs varying from 144, 188, 236, and 588 to 940 ms. For the three shortest SOAs, responses were always faster (34 ms) for cued than for uncued targets in the discrimination task (in the following denoted as a positive cuing effect), whereas a reversed effect, a negative cuing effect (-27 ms), commonly denoted as inhibition of return (IOR), was found in the detection task. For the SOAs of 588 and 940 ms, IOR was clearly present in the detection task (-45 ms), but not for the discrimination task (14 ms). The early IOR in our detection task is somewhat in contrast with the overall data pattern such as reported in the meta-analysis by Samuel and Kat (2003), as they showed a crossover from facilitation to IOR at an SOA of 250 ms. Several data points in their graphics, however, indicate that our findings with short SOAs are not unique (e.g., see Tassinari & Berlucchi, 1993).

To account for these major task differences, we considered two hypotheses: the delayed attention withdrawal hypothesis and the speeded motor inhibition hypothesis. First, according to the delayed attention withdrawal hypothesis, attention may dwell much longer on exogenously cued locations in discrimination tasks because stimuli have to be identified, implying that attention plays a crucial role for perceptual identification (see Klein, 2000; Lupiáñez et al., 2001). In contrast, in detection tasks attention is less relevant and may therefore already be withdrawn from the cued location when the target is presented. Thus, the adjective "delayed" of this hypothesis applies to a delay in the redirection of attention from cued to other uncued locations in discrimination tasks relative to simple detection tasks. Alternatively, according to the speeded motor inhibition hypothesis, inhibition arises in a spatial motor map that is involved in the control of manual responses (i.e., pressing the response buttons; e.g., see Harvey, 1980). Due to the fact that the response in a detection task is highly prepared (e.g., see Ilan & Miller, 1999; Low & Miller, 1999), the abrupt stimulus onset or offset might already be sufficient to trigger this response. A first possible consequence is that participants may have to inhibit the response from execution and this inhibition may be, hence, bound to the location of the cue. A secondary effect, due to this location-specific inhibition, is that responses to subsequent targets presented at or near cued locations may be delayed because the inhibition induced by the prior cue must be overcome before the actual response can be made.[3]

Behavioral support for the idea that IOR may reflect attention withdrawal comes from studies employing perceptual measures such as d' and accuracy (Handy, Jha, & Mangun, 1999; Klein & Dick, 2002). Several ERP studies additionally confirmed that IOR was accompanied by a P1 reduction for cued as compared to uncued targets (McDonald, Ward, & Kiehl, 1999, Exp. 1; Prime & Ward, 2004; Van der Lubbe et al., 2005; Wascher & Tipper, 2004, Exp. 2; for a meta analysis, see Klein, 2004), suggesting that attention was no longer allocated to the cued position, but other studies failed to reveal such a relation (Eimer, 1994; Hopfinger & Mangun, 1998, 2001). Most relevant to our concern, Wascher and Tipper (2004, Exp. 1) and McDonald et al. (1999; Exp. 2) reported a P1 reduction for cued targets in case of short SOAs, which, however, was not accompanied by IOR, suggesting that the relation between P1 effects and behavior is not self-evident. In the study of McDonald et al., no attempt was made to remove the overlapping ERP response to the prior cue, whereas in the study of Wascher and Tipper, a correction was performed by subtracting the ERP obtained in catch trials. However, this subtraction method may be less appropriate than application of the so-called adjacent response filter (ADJAR) developed by Woldorff (1993), as carried out in the studies of Hopfinger and Mangun (1998, 2001). As a consequence, the observed P1 reduction for cued targets in case of short SOAs remains somewhat obscure.

Another relevant electrophysiological measure is the lateralized readiness potential (LRP; De Jong, Wierda, Mulder, & Mulder, 1988; Gratton, Coles, Sirevaag, Eriksen, & Donchin, 1988). The onset of the stimulus-locked LRP (s-LRP), which reflects the start of hand-related motor activation relative to target onset, was found to be later for cued than for uncued targets together with IOR. Prime and Ward (2004) observed this pattern in a discrimination task with long SOAs with an intervening reorienting event, and Van der Lubbe et al. (2005) found this pattern in a simple detection task with SOAs ranging from 144 to 940 ms. Prime and Ward additionally noticed that the onset of the response(r)-locked LRP, which indexes the duration of motor processes until the response, was not different for cued and uncued targets. The latter data suggest that the locus of IOR is premotoric, and can easily be explained by the delayed attention withdrawal hypothesis. However, the speeded motor inhibition hypothesis may also account for these results when inhibition is considered to occur at a more central processing level. In the discrimination task of Van der Lubbe et al. no earlier s-LRP for cued relative to uncued targets was obtained in case of a positive cuing effect on RT. The latter aspect could indicate that the positive cuing effect in the discrimination task and the IOR in the detection task affect different processes, which seems not in line with a single-process explanation in terms of a delayed withdrawal of attention (see also Samuel & Kat, 2003; Wascher & Tipper, 2004). Nevertheless, the absence of an s-LRP-onset effect in the discrimination task may be due to insufficient sensitivity of the LRP.

A crucial test for the delayed attention withdrawal hypothesis in the current study with short SOAs would concern task-dependent cuing effects on the amplitude (and possibly latency; see Fu, Fan, Chen, & Zhuo, 2001) of the extrastriate P1 component. To enable application of the earlier mentioned ADJAR method of Woldorff (1993) in our study, we varied SOA between cue and target in several small steps between 210 and 390 ms. Thus, a first question to be addressed here is whether task-dependent cuing effects on RT are accompanied by comparable effects on the P1 component, which would provide more support for the general validity of the delayed attention withdrawal hypothesis, and may

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[3]This explanation resembles aspects of the oculomotor suppression account of IOR (Klein & Taylor, 1994; Tassinari, Biscaldi, Marzi, & Berlucchi, 1989; Taylor & Klein, 1998). The speeded motor inhibition hypothesis, however, emphasizes inhibition of manual responses and not of eye movements. In fact, the tendency to direct the eyes toward the cued location is likely to be stronger in discrimination tasks than in detection tasks, as reduced visibility of targets is more detrimental in those tasks. As a consequence, this hypothesis might actually predict more inhibition in discrimination than in detection tasks.

additionally be corroborated by our LRP findings. However, the observation of corresponding task effects regarding the start of the s-LRP and RT but not with regard to the amplitude and/or latency of the P1 component would be in line with the predictions of the speeded motor inhibition hypothesis (see Table 1).

Importantly, as we will argue in the following, the predictions of the delayed attention withdrawal hypothesis and the speeded motor inhibition hypothesis differ with regard to task-dependent exogenous cuing effects when different cue modalities are employed. Concerning exogenous orienting, one might simply propose that task-dependent effects should be the same, as both visual and auditory cues invoke the same attentional mechanism. Many authors argue that crossmodal exogenous orienting effects with auditory cues and visual targets (e.g., see McDonald & Ward, 2000; McDonald, Teder-Sälejärvi, Di Russo, & Hillyard, 2003; McDonald, Teder-Sälejärvi, & Hillyard, 2000; Schmitt, Postma, & De Haan, 2000, 2001; Spence & Driver, 1997; Van der Lubbe & Postma, 2005) are quite comparable to unimodal exogenous orienting effects (Eimer & Driver, 2001; Farah, Wong, Monheit, & Morrow, 1989; Santangelo, Van der Lubbe, Belardinelli, & Postma, 2006; Spence, Lloyd, McGlone, Nicholls, & Driver, 2000; but see Schmitt et al., 2000, 2001), and it has been suggested that both effects arise from modulation within the superior colliculus (e.g., see Stein & Meredith, 1993). Indeed, IOR with long SOAs has been shown to take place along all possible pairings between vision, touch, and audition (Spence et al. 2000), which supports the involvement of a single supramodal orienting mechanism. However, some discrepancies have been observed. For example, unimodal studies reported an enhancement of the P1 component (i.e., increased positivity) for cued as compared to uncued targets at about 120 ms after target onset (Hopfinger & Mangun, 1998), whereas crossmodal studies with auditory exogenous cues found increased negativity (Nd), from 200 to 400 ms after stimulus onset (McDonald & Ward, 2000) but also earlier, from 120 to 260 ms (McDonald et al., 2003). These ERP differences, however, need not imply that the supramodal view is incorrect. For example, differences in temporal activation patterns of visual and auditory cues and the difficulty of comparing intensities between cue modalities may be responsible for this discrepancy. In addition, a recent study by McDonald, Teder-Sälejärvi, Di Russo, and Hillyard (2005) showed that reflexive shifts of attention to sudden sounds in temporal order judgment tasks also affected the P1 component, which accords with the supramodal view. Thus, if one adopts a supramodal orienting mechanism and combines this with the delayed attention withdrawal hypothesis, comparable results in our detection and discrimination tasks should be found in unimodal and crossmodal settings (see Table 1).

More complicated become matters when cues indeed affect response tendencies, in line with the speeded motor inhibition hypothesis. It has been argued that motor inhibition will only be triggered by the cue when participants have to prevent a response to this cue (e.g., see Spence et al., 2000; this also provides an explanation for the discrepant findings of Schmitt et al., 2000, 2001). In that case, a crucial aspect concerns the similarity between cues and targets (see also Lupiáñez & Weaver, 1998; Pratt, Hillis, & Gold, 2001). Namely, when cues and targets are highly dissimilar, the triggering of response tendencies becomes unlikely. As a consequence, when auditory cues precede to be detected visual targets, there may actually be no response tendency at all. Thus, the speeded motor inhibition hypothesis may only apply to unimodal settings, which implies that major task differences

Table 1. *Predictions Regarding Cuing Effects on RT (a Positive Cuing Effect+, IOR−), the P1 Component (Enhancement for Cued+, Suppression for Cued−), and Onset of the s-LRP and the r-LRP (Earlier for Cued+, Later for Cued−, 0 for No Effect) in the Visual Detection and Discrimination Tasks Preceded by Visual and Auditory Cues[a]*

	Simple detection		Discrimination	
Measure	Visual cues	Auditory cues	Visual cues	Auditory cues
Delayed attention withdrawal				
RT	−	−	+	+
P1	−	−	+	+
s-LRP	−	−	+	+
r-LRP	0	0	0	0
Speeded motor inhibition				
RT	−	+	+	+
P1	+	+	+	+
s-LRP	−	+	− /0	+
r-LRP	+/0	0	0	0

[a]The predictions regarding effects of auditory cues are based on the assumption that the attentional mechanism invoked by auditory and visual cues is supramodal.

should only be present in unimodal but not in crossmodal settings (see Table 1).

In the current study, visual targets (triangles) pointing up- or downward were displayed at presentation units relatively far above and below a central fixation unit.[4] The targets were preceded by irrelevant visual onsets (stripes) or auditory onsets (bursts of white noise) at one of the units (see Figure 1) with short SOAs varying from 210 to 390 ms. The onsets were unpredictive with regard to the forthcoming target location. Cues and targets were presented along the vertical midline to avoid a possible confounding between effects on perceptual and motor processes (see Prime & Ward, 2004; Van der Lubbe et al., 2005). An important deviation from the standard detection task concerns the fact that the required button press, which varied from trial to trial, was indicated at the start of each trial (see Van der Lubbe et al., 2005; for a comparable procedure see Miller & Low, 2001), which enables the setting of a premotoric baseline.
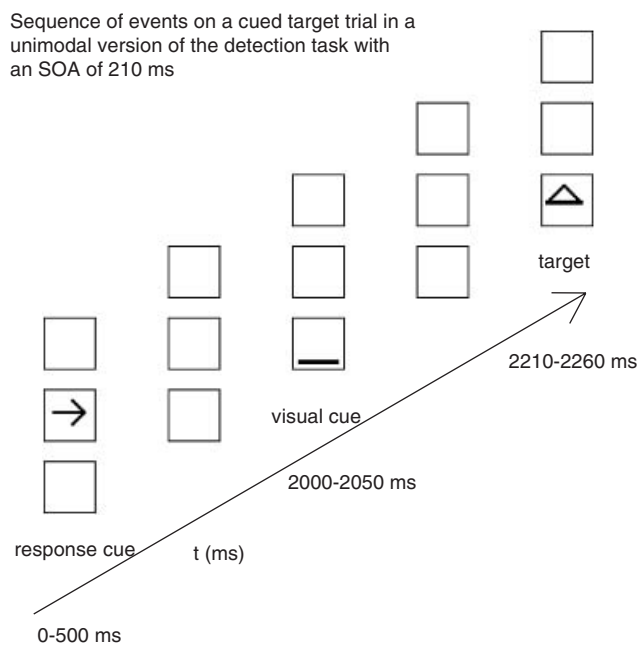
Methods

Participants
Informed consent was obtained from 14 participants recruited from the local student population. Three of them were removed from the analyses because of excessive eye movements (> 50%), which left 11 participants (all female) with a mean age of 20.4 years. All but two were right-handed. They received €35 for their participation. The study was approved by a local ethics committee of the University of Utrecht.

Stimuli
The stimuli were presented on three units (21 × 12 cm), consisting of a sound passing 8 × 8 green LED grid (10 × 10 cm) in

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[4]Stimuli were presented far from fixation (15.9° above or below the to-be-fixated box) to optimize crossmodal orienting effects. An implication is that ERPs evoked by stimuli above or below fixation will largely differ, as upper stimuli will be projected to more inferior areas whereas lower stimuli will be projected to more superior areas (e.g., see Di Russo, Martínez, & Hillyard, 2003).

Sequence of events on a cued target trial in a
unimodal version of the detection task with
an SOA of 210 ms

target

2210-2260 ms

visual cue

2000-2050 ms

response cue   t (ms)

0-500 ms

Figure 1. A scheme of the sequence of events on a trial in the unimodal version of the detection task is displayed. Three units were located along the vertical midline, here indicated as squares. The sequence started with an arrow, which indicates for the presented trial that the target should be detected by pressing a right button. Two seconds after arrow onset, a cue appeared equiprobable at the upper or the lower unit, which, after a variable SOA (210–230–. . .–390 ms), could be followed by a target (i.e., a triangle) at the cued (here) or the uncued unit. In the discrimination task, a central warning bar (i.e., the start stimulus) appeared instead of an arrow, and choice responses were dependent on the orientation (pointing up- or downward) of the triangle. Finally, in the crossmodal versions of the detection and discrimination task, the cues were exchanged by auditory cues at the upper or lower units.

front of a loudspeaker. Units were placed at a distance of 145 cm in front of the participant in a vertically arranged semicircle at 40 cm from each other. The visual angle between the upper and lower units relative to the middle fixation unit amounted to 15.9°. Trials commenced with a start stimulus presented for 500 ms in the center of the fixation unit, either a left or right pointing arrow (2.4° × 2.3°) in the detection task or a warning bar (2.8° × 0.4°) in the discrimination task. Two seconds after onset of the start stimulus a visual or an auditory cue was presented for 50 ms at the upper or lower unit. The visual cue was a bar (3.4° × 0.9°) presented at the bottom row of the LED grid, and the auditory cue was a burst of white noise. After a random SOA ranging from 210 to 390 ms (with step sizes of 20 ms) the target (a triangle 3.4° × 1.8° pointing up- or downward) appeared for 50 ms on the upper or lower unit, although on some catch trials no target occurred. The next trial started between 2010 and 2590 ms after cue onset.

Tasks

Detection and discrimination tasks were administered. In the detection task, the direction of the arrow presented at the start of each trial, which varied randomly from trial to trial, indicated the required key press after target (i.e., the triangle) detection (see Figure 1). A left-pointing arrow meant that after target detection the left button had to be pressed with the left hand whereas a right-pointing arrow meant that the right button had to be

pressed with the right hand. In our discrimination tasks, the instruction was to press a left or right key with the corresponding left or right hand when the triangle pointed up- or downward, respectively, irrespective of its location with regard to fixation. The modality of the cue was varied between blocks. Target and cue locations and target orientation varied randomly from trial to trial, which implies that the location of the cue was unpredictive with regard to the locus of the forthcoming target. Together with the 10 different SOAs, the combination of factors per task and cue modality implies 80 different trial types (cue location × target location × required response × SOA), each presented six times. Twenty-four (4.8% of 504 trials per task) additional catch trials (cues without targets) were employed per task and cue modality. As a consequence, the total number of trials per participant amounted to 2016 trials. Participants were required to respond as fast and accurately as possible, to avoid premature responses and to minimize eyeblinks and keep their eyes at the central unit from cue onset until target offset.

Procedure and Design

Each participant performed all tasks in the course of one day. The order of the tasks was counterbalanced. Each task consisted of four blocks of 126 trials, which took approximately 10 min per block and were separated by three breaks of 1 min. Breaks between tasks were adjusted to the participant's needs but took at least 10 min. Before the start of the experiment, all participants had to indicate the locus (up/down) of auditory targets, and a score of at least 95% correct was required to participate in the experiment.

Recording and Data Processing

Participants were seated in a comfortable chiropodist armchair in a silent and darkened chamber. Response keys were fixed in two response boxes, which were placed in a comfortable position at the left and right side on a hand rest in front of the participant, approximately 25 cm apart. Reponses were made by the index fingers of the left and right hand positioned on the response keys. Presentation of visual and auditory stimuli and triggers signaling the moment and the type of the stimulus were controlled by a CMO-module (version 3.7f, developed in cooperation with IGF, Physics Department, Utrecht University; see also Santangelo et al., 2006; Van der Lubbe & Postma, 2005). Key presses and triggers were measured by Vision Recorder (version 1.0b). EEG and EOG were recorded continuously from Ag/AgCl ring electrodes by a Brain-Amp amplifier (Brain Products GmbH) at a rate of 250 Hz. EEG was measured from the following 58 standard electrode positions: Fpz, AFz, Fz, FCz, CPz, Pz, POz, Oz, Fp1, F1, FC1, C1, CP1, P1, O1, AF3, F3, FC3, C3, CP3, P3, PO3, F5, FC5, C5, CP5, P5, AF7, F7, FT7, T7, P7, PO7, Fp2, F2, FC2, C2, CP2, P2, O2, AF4, F4, FC4, C4, CP4, P4, PO4, F6, FC6, C6, CP6, P6, AF8, F8, FT8, T8, P8, and PO8. The electrodes were on-line referenced to Cz, but were off-line referenced to the average across all EEG electrodes. EOG was measured both vertically from above and below the left eye (vEOG) and horizontally from the outer canthi of both eyes (hEOG). Electrode resistance was kept below 5 kΩ. Measured activity was digitally filtered on-line (TC = 5.0 s, low-pass filter of 100 Hz) by Vision Recorder, installed on a Pentium III computer.

Data Analysis

Behavioral data. Vision Analyzer (1.03) was used to remove trials with detectable eye movements (exceeding 60 μV in the

EOG channels) from cue onset until target offset, which left 77.7% of the trials. Trials with premature responses (RT < 100 ms), too slow responses or misses (RT > 1500 ms), and incorrect responses were removed from RT and EEG analyses. The obtained behavioral data were statistically evaluated by analyses of variance (ANOVA) for repeated measurements on RTs, percentage correct (PC), and premature responses, with the factors task (detection vs. discrimination), cue modality (auditory vs. visual), target position (above or below fixation), and cue (cued or uncued). In addition, analyses were performed per task and cue modality averaged across target position and across two consecutive SOAs, leaving the factors SOA (5) and cue, to examine whether the positive cuing effect or inhibition varied as a function of SOA. Huynh–Feldt epsilon correction was applied whenever appropriate (also for the EEG analyses).

EEG data. The EEG analysis was performed by using Vision Analyzer, MATLAB, and software developed by Durk Talsma. Trials were selected that fulfilled the RT criteria and had no EEG artifacts within the critical intervals in the relevant channels. EEG was corrected for ocular artifacts due to eye movements outside the critical windows from cue onset until target offset by employing the method of Gratton, Coles, and Donchin (1983).

In a first analysis, lowest allowed activity was 0.10 µV for 50 ms; minimum/maximum allowed amplitude was ± 200, 150, and 100 µV, for frontal, central, and parietal electrodes, respectively. The initial baseline was set from − 200 to 0 ms relative to cue onset. ERPs were computed time locked to cue onset and to target onset with windows from − 500 to +600 ms. Target ERPs were corrected for overlap of the cue by applying the adjacent-response (ADJAR level 2) filter developed by Woldorff (1993).[5] The taper value was set at 8 ms. The maximum number of iterations was set at 5000, but the actual number was always less than 700. After applying this filter, a new baseline was set from − 200 to 0 ms relative to target onset.

ANOVAs were carried out on estimated mean amplitudes within a 40-ms window from 80 to 120 ms after target onset with the factors task (2), cue modality (2), cue (2), target position (2), and hemisphere (2; PO7 vs. PO8). We chose these electrodes, as attentional effects have been shown to be maximal at these sites (e.g., see Prime & Ward, 2004; Van der Lubbe et al., 2005). We additionally examined the influence of task, cue modality, cue, and target position for the POz electrode and performed control analyses for the vEOG. Spline maps were determined on average activity from 80 to 120 ms after target onset. P1 peak latency was additionally determined for the PO7 and PO8 electrodes within a window from 60 until 160 ms after target onset, and was evaluated with the factors task, cue modality, cue, target position, and hemisphere.

In a second analysis, we used EEGs for the C3 and C4 electrodes per response hand for each cue modality and cue, averaged across target position on trials with correct responses without artifacts and eye movements, separately per task. First, we determined the pre-LRP in the detection tasks by averaging the arrow-locked contra-ipsilateral difference waves for left hand (i.e., C4–C3) and right hand trials (C3–C4), thereby subtracting the activity unrelated to the required response side. We examined whether activity within the detection tasks differed from baseline, determined from − 100 to 0 ms relative to arrow onset. Additionally, we controlled whether this possible deviation differed as

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[5]This filter (version adjar13.exe) was implemented by Durk Talsma.

a function of the anticipated cue. The time window for this analysis was based on inspection of the grand averages.

For the subsequent s-LRP and r-LRP analyses, we first controlled whether LRP activity in the detection tasks for the − 100–0-ms interval before target onset, with the baseline set from − 500 to − 400 ms before target onset (i.e., at least − 110 to − 10 ms before cue onset), was not affected by cue and did not deviate from baseline to evaluate whether this time window would be appropriate as the final baseline for all tasks, which appeared to be the case (see Results). Next, for all tasks, the s-LRP was determined by averaging the target-locked contra-ipsilateral difference waves, and the r-LRP was determined by averaging the response-locked contra-ipsilateral difference waves. A low-pass filter of 4 Hz, 12 dB/oct was applied to eliminate high-frequency artifacts (e.g., see Prime & Ward, 2004; Van der Lubbe et al., 2005). Onset and baseline activity of the s-LRP and r-LRP were determined in MATLAB on the basis of individual averages by fitting two lines and using a least squares method (see Mordkoff & Gianaros, 2000; Schwarzenau, Falkenstein, Hoorman, & Hohnsbein, 1998). The first straight line estimates baseline activity (the intercept), and the second line connects the (to-be-estimated) onset of the LRP with the peak of the LRP. Time windows for employing the fitting procedure for the s-LRP and r-LRP were based on inspection of the grand averages including all participants. In the detection tasks with auditory and visual cues, a window was chosen from − 100 to 248 ms and from − 100 to 348 ms relative to target onset, respectively. In the discrimination tasks, a window was chosen from − 100 to 400 ms after target onset. For the r-LRP, theses windows were set at − 500 to − 100 ms relative to the response. Separate *t* tests were performed to test the predictions regarding the s- and r-LRP specified in Table 1. As an additional test, we determined the moment at which 50% of the peak amplitude (the 50% criterion) of the s- and r-LRPs was reached by means of linear interpolation. In that case, the 50% criterion was determined within the window from − 100 to 500 ms in the detection task with auditory cues and within the window from − 100 to 600 ms in the other tasks. For the previous analyses on the s-LRP and r-LRP, data were omitted from statistical analyses and determination of the displayed grand means in our figures when obtained values fell outside the aforementioned time windows.

Results

Behavioral Data

The percentage of premature responses (< 100 ms) in the detection task with auditory and visual cues amounted to 0.4 and 0.6%, whereas no premature responses were observed in the discrimination task. Slow responses (> 1500 ms) in the detection task were present on 0.7% and 0.6% of the trials in case of auditory and visual cues, and for the discrimination task, these percentages were 1.4% and 1.3%.

Mean RTs and results of separate *t* tests on cuing effects per task, cue modality, and target position are provided in Table 2. Responses were faster in the detection task (376 ms) than in the discrimination task (615 ms), $F(1,10) = 72.0$, $p < .001$, and faster after auditory cues (476 ms) than after visual cues (515 ms), $F(1,10) = 7.8$, $p = .019$. No main cuing effect was found, $F < 0.1$, but interactions were observed between task and cue, $F(1,10) = 16.5$, $p = .002$, and cue modality and cue, $F(1,10) = 31.3$, $p < .001$, and a second order interaction was found between

Table 2. *Mean RTs in Milliseconds for Cued and Uncued Targets for Each Task, Cue Modality, and Target Position, and Statistical Results of Paired t Tests*

| Task	Cue modality	Target position	Cued	Uncued	$t(10)$	P
Detection	Auditory	Above	346	360	−2.6	.025
		Below	336	352	−3.7	.004
	Visual	Above	432	389	2.9	.016
		Below	424	371	3.4	.006
Discrimination	Auditory	Above	585	616	−4.6	.001
		Below	593	618	−5.5	.000
	Visual	Above	635	640	−0.6	.54
		Below	616	615	0.1	.92

task, cue modality, and cue, $F(1,10) = 7.2$, $p = .023$. In case of visual cues, an interaction between task and cue was found, $F(1,10) = 12.7$, $p = .005$, due to inhibition (-48 ms) in the detection task, and no positive cuing effect (but see the analyses with SOA) in the discrimination task (2 ms). In case of auditory cues, also an interaction between task and cue was found, $F(1,10) = 8.4$, $p = .016$, but in that case the positive cuing effect was larger in the discrimination task (28 ms) than in the detection task (15 ms). Finally, a significant interaction was found between

cue modality and target position, $F(1,10) = 7.2$, $p = .023$. Separate analyses per cue modality revealed no position effect in case of auditory cues (3 ms), and a nearly significant position effect (524 ms above, 506 ms below) in case of visual cues, $F(1,10) = 4.7$, $p = .055$.

To examine whether cuing effects on RT varied over time, we additionally performed an analysis with SOA (210–230, 250–270, 290–310, 330–350, 370–390) and cue as factors (see Figure 2). In the detection task with auditory cues, we found a positive cuing effect, $F(1,10) = 21.1$, $p = .001$, and a just significant interaction between cue and SOA, $F(4,40) = 2.6$, $p = .05$, which indicates that the cuing effect was smaller at the intermediate SOAs. In case of visual cues in the detection task we found inhibition, $F(1,10) = 11.3$, $p = .007$, and responses became faster when SOA increased (from 420 to 402 ms), $F(4,40) = 6.1$, $\varepsilon = 0.75$, $p = .002$, but no interaction between cue and SOA was found. In the discrimination task with auditory cues we only found a positive cuing effect, $F(1,10) = 36.2$, $p < .001$. In the discrimination task with visual cues, we obtained a main effect of SOA, $F(4,40) = 4.6$, $\varepsilon = 0.70$, $p = .011$, which reflected faster responses when SOA increased (from 646 to 623 ms), and an interaction between cue and SOA, $F(4,40) = 3.6$, $\varepsilon = 1.0$, $p = .014$, which suggests that a positive cuing effect was only present for the longest SOAs (see Figure 2). A paired t test confirmed that responses at the longest SOAs (370–390 ms) for cued targets were
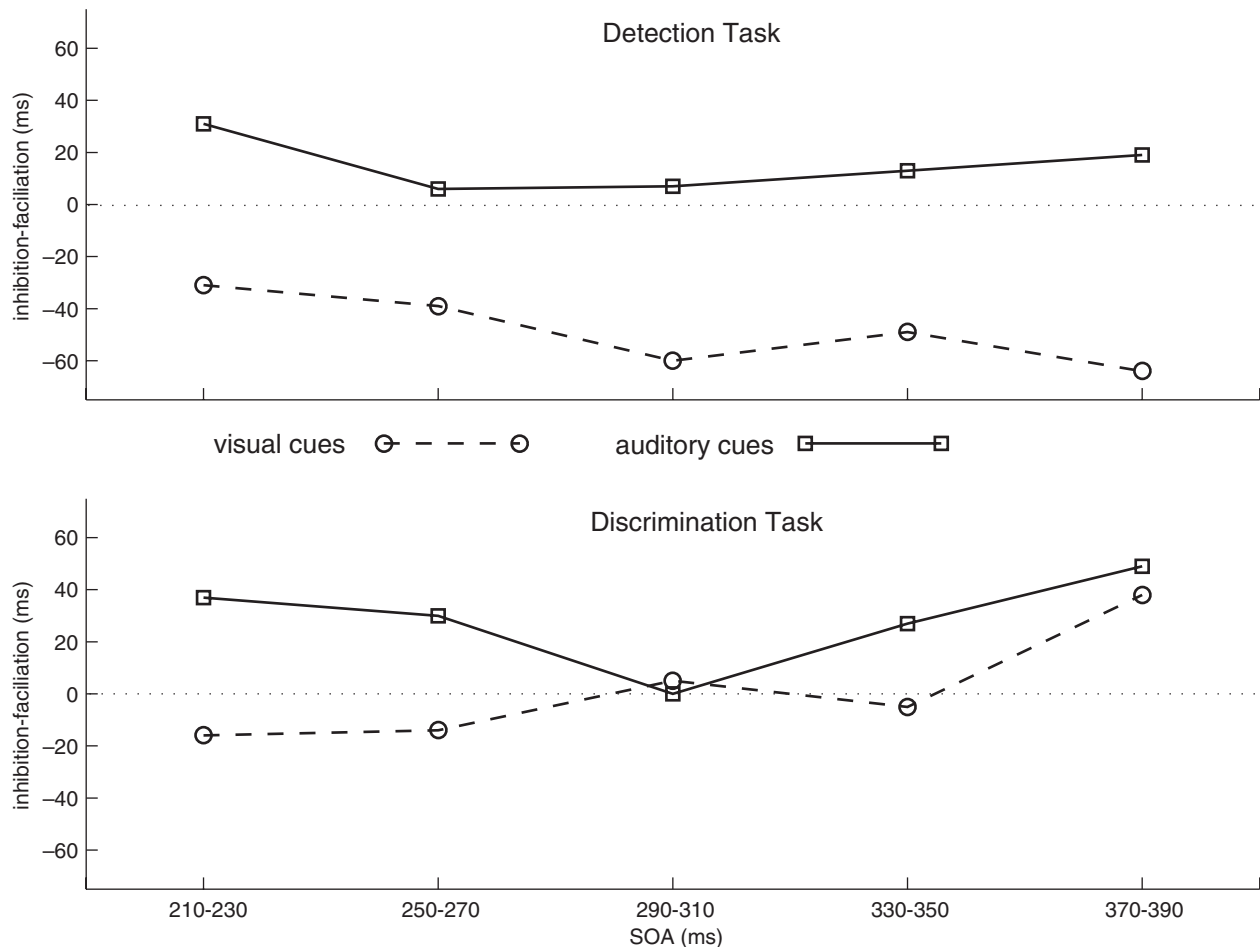
Figure 2. The magnitude (in milliseconds) of the cuing effect (cued–uncued), as a function of SOA between cues and targets when visual or auditory exogenous cues preceded visual targets in detection and discrimination tasks.
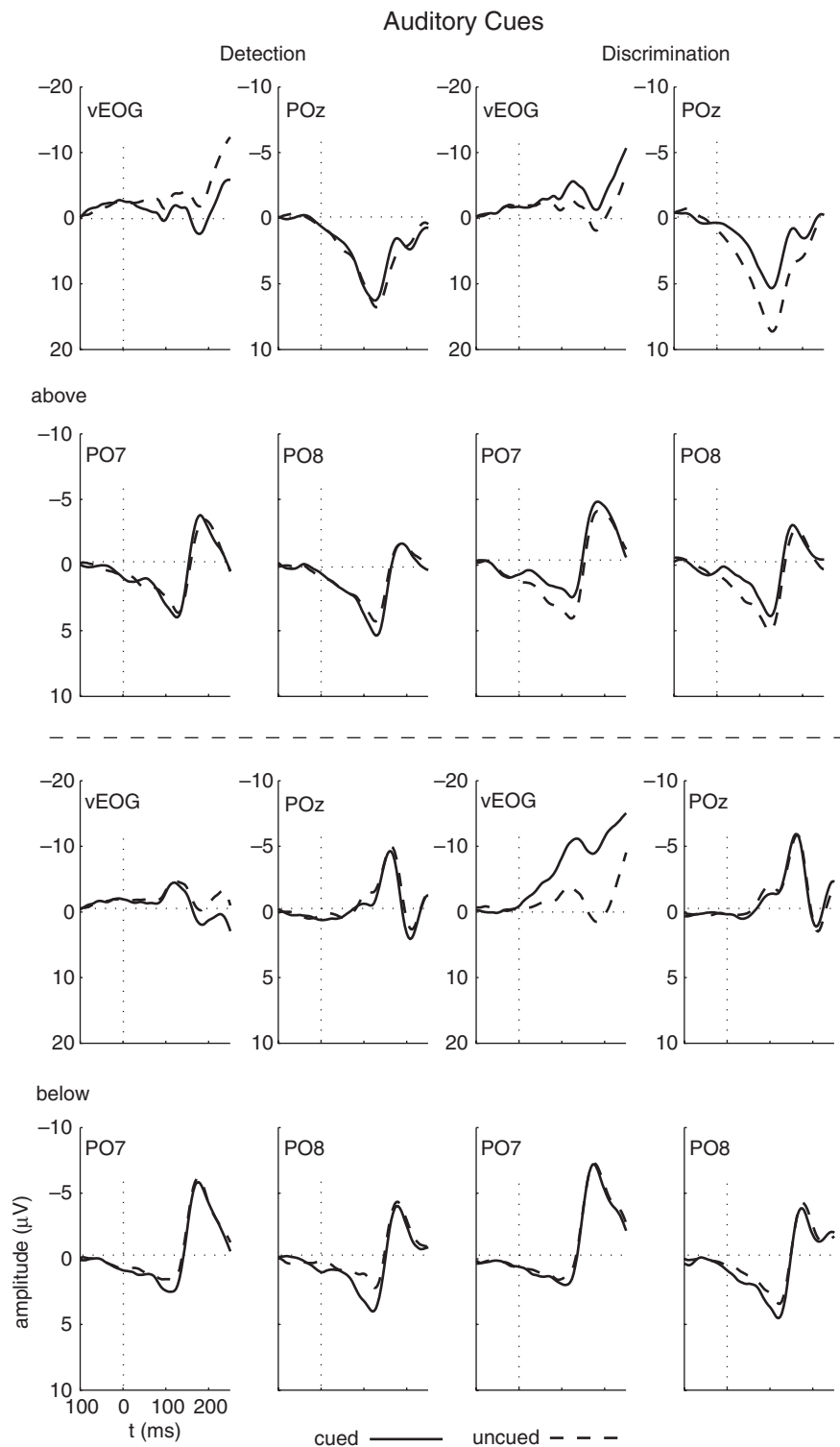
Auditory Cues

Figure 3. Target ERPs for the PO7, PO8, and POz electrodes in detection (left) and discrimination tasks (right) preceded by auditory cues near the same or at the opposite vertical location (cued vs. uncued). The ERPs were corrected for overlap from the cues by applying ADJAR. vEOG was additionally provided to check for eye movements during the windows of interest. Statistical analyses revealed that observed ERP effects could not be ascribed to small eye movements to the cued positions. In the upper panel, the data for targets presented above fixation, and in the lower panel the data for targets presented below fixation are displayed.

faster than for uncued targets, $t(10) = -2.4$, $p = .035$, whereas no cuing effects for the other SOAs were found, $p > 0.10$.

Analyses on the proportion of correct responses only revealed that responses were more accurate in the detection task (98.1%) than in the discrimination task (96.7%), $F(1,10) = 5.4$, $p = .042$. A separate analysis for the discrimination task with the factors cue modality, cue, and target position revealed no significant effects, $F(1,10) < 2.4$, $p > 0.16$, indicating that effects reported in
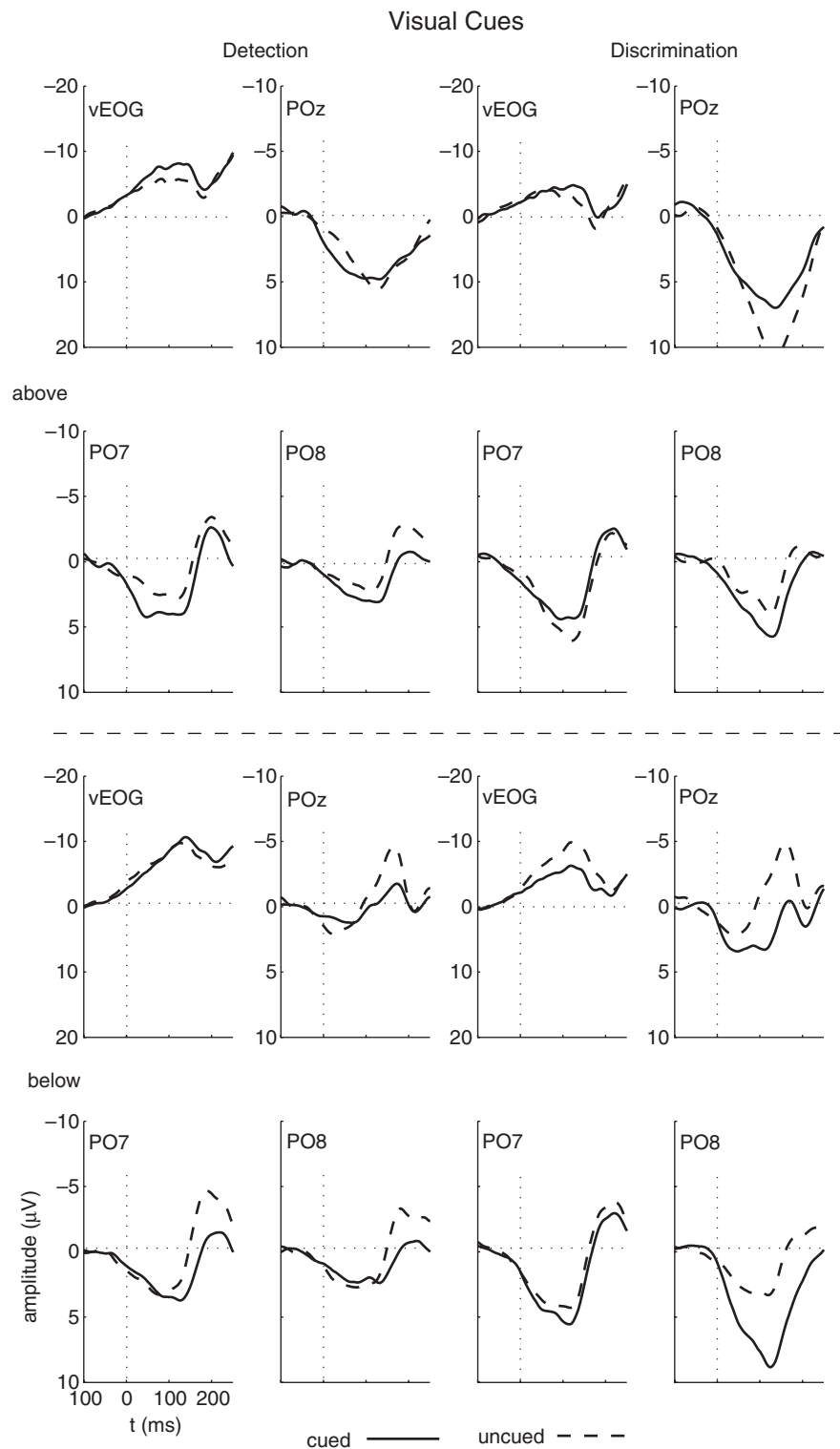
Visual Cues

Figure 4. ERPs for cued and uncued targets measured on the PO7, PO8, and POz electrodes and the vEOG, which were corrected for overlap from preceding visual cues.

Table 2 are not due to speed–accuracy trade-off. More premature responses were made in the detection task (0.5%) than in the discrimination task (0.0%), $F(1,10) = 5.9$, $p = .035$. Finally, on 6.2% of the catch trials, participants could not withhold making a key press.

EEG Data

The percentage of trials without artifacts and eye movements within the critical intervals with correct responses for the ERP data amounted to 66%. For the LRP data this percentage amounted to 74%.

Targets below fixation preceded by Auditory Cues
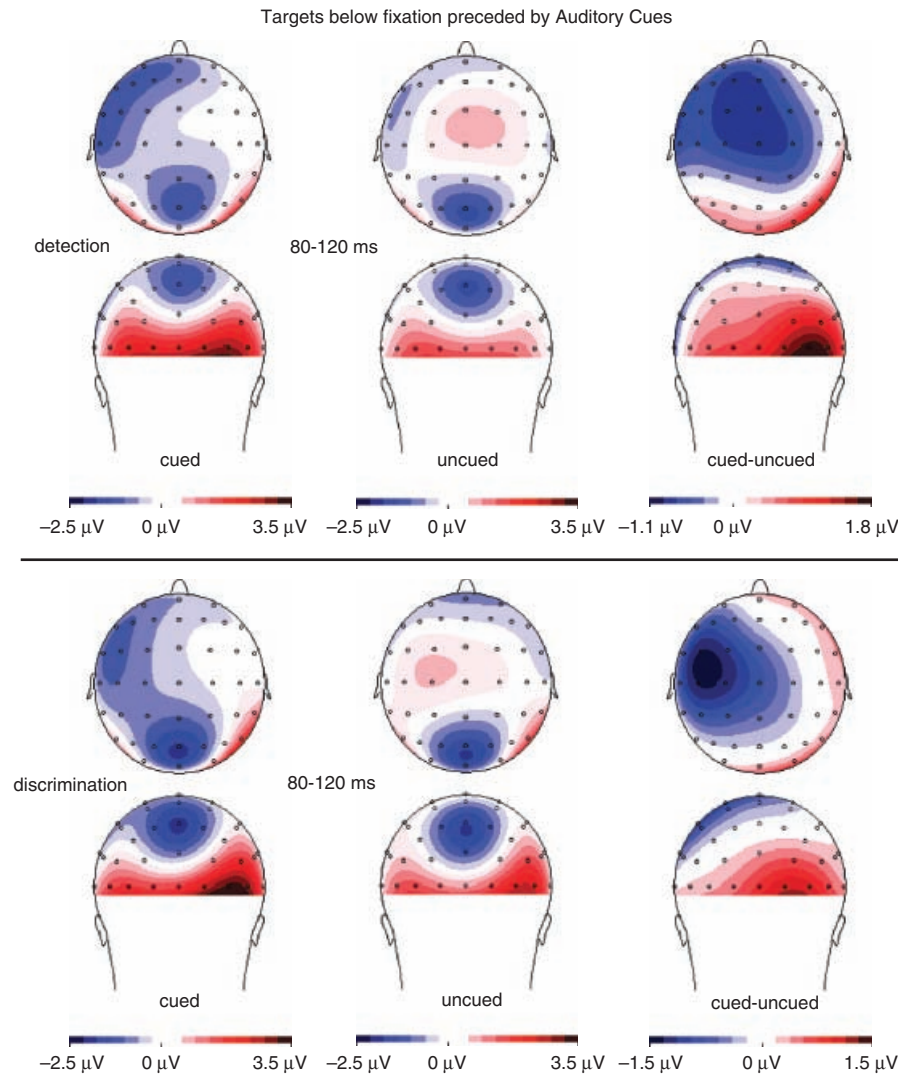
Figures 5. Targets below fixation preceded by auditory cues. Spline maps are displayed for the average of the ERPs from 80 to 120 ms after target onset, in case of cued targets (left panel), uncued targets (middle panel), and their difference wave (right panel). Scaling was not always the same, indicated by the bar below the spline map, as the size of the effects varied between the different conditions.

ERPs. Target ERPs for the PO7, PO8, and POz electrodes and vEOG from -100 ms before target onset until 250 ms after target onset are displayed in Figures 3 and 4. Spline maps for ERPs elicited by cued and uncued targets and their difference wave averaged from 80 to 120 ms after target onset for all relevant conditions are displayed in Figures 5–8.

Effects on P1 amplitude at the PO7 and PO8 sites were evaluated by focusing on the mean amplitudes per participant from 80 until 120 ms after target onset. A main effect of cue was found, $F(1,10) = 5.0$, $p = .049$, which reflected increased positivity for cued (4.6 μV) as compared to uncued targets (3.4 μV). An interaction was found between cue modality and cue, $F(1,10) = 6.5$, $p = .029$, which reflected a larger difference between cued and uncued targets in the case of visual cues (2.0 μV), than in the case of auditory cues (0.4 μV). These effects are not due to eye movements, as revealed by analyses on the vEOG, $F(1,10) < 3.1$, $p > .11$. None of the analyses on the PO7 and PO8 sites including the factors task and cue revealed significant effects, but trend effects were found between task, cue, and hem-

isphere, $F(1,10) = 3.9$, $p = .075$, and between task, cue modality, cue, and hemisphere, $F(1,10) = 3.8$, $p = .081$.

Separate analyses were performed per cue modality, as task-dependent cuing effects might differ. No interactions involving the factors cue and task were present in the case of auditory cues, and also no main cuing effect was found. The interaction between target position and cue, $F(1,10) = 6.2$, $p = .032$, indicated that a cuing effect was present for targets below fixation (see Figures 3 and 5), but not when they occurred above fixation. In the case of visual cues, a main cuing effect was found, $F(1,10) = 6.1$, $p = .034$, and a trend to an interaction was found between task, cue, and hemisphere, $F(1,10) = 4.2$, $p = .067$, which seems to reflect a left focus of the cuing effect in the detection task and a right focus in the discrimination task (e.g., see Figure 7).

For the POz electrode, a main effect of target position was found, $F(1,10) = 16.8$, $p = .002$, reflecting positivity when targets occurred above fixation (8.2 μV) and a slight reversal when targets occurred below fixation (-0.6 μV). This pattern is probably not due to the C1 component (see Di Russo et al., 2003), as this

Targets above fixation preceded by Auditory Cues
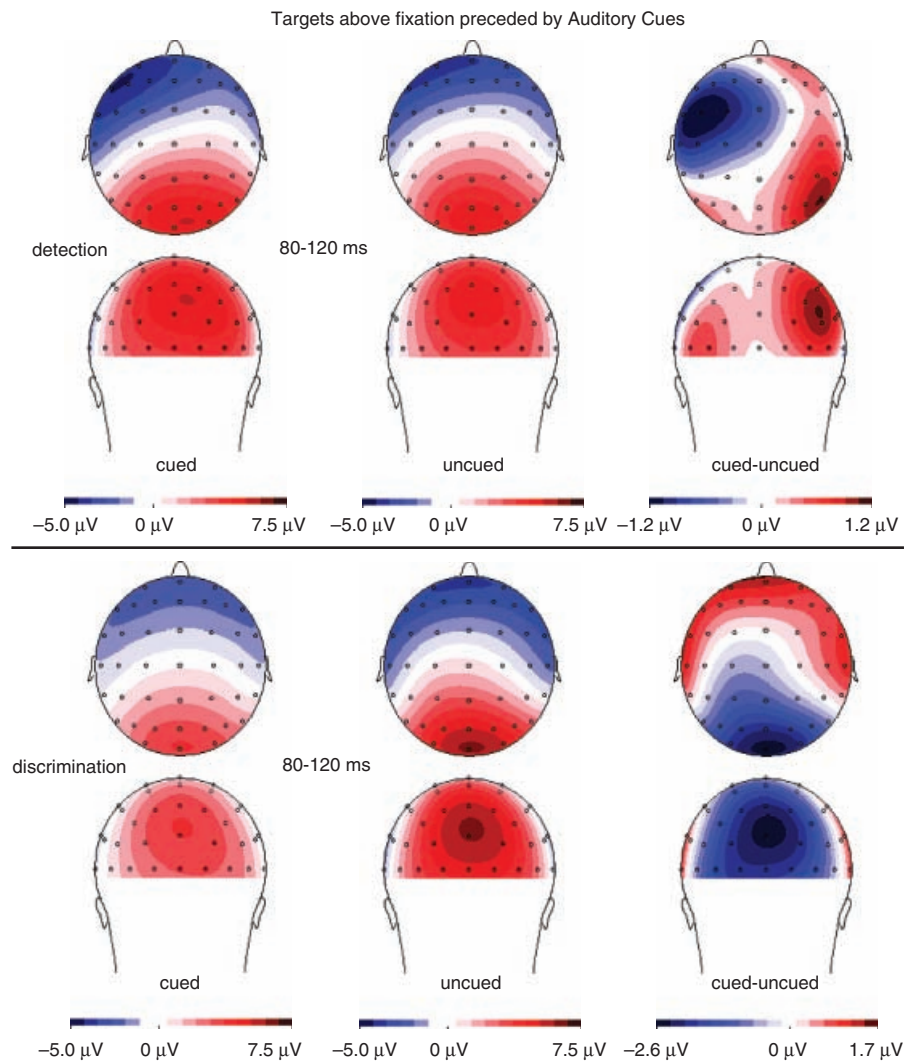
Figure 6. Targets above fixation preceded by auditory cues. See Figure 5 for details.

component rises earlier (at about 50 ms), is much smaller, and has an opposite position effect. An interaction was found between cue modality and cue, $F(1,10) = 5.2$, $p = .046$, due to increased positivity for cued relative to uncued targets (0.9 µV) in the case of visual cues and an inverted effect (-0.5 µV) in the case of auditory cues.

We also analyzed P1 peak latencies as estimated within a window from 60 until 160 ms after target onset. An interaction between cue modality and hemisphere was found, $F(1,10) = 5.8$, $p = .037$, which additionally interacted with task, $F(1,10) = 8.6$, $p = .015$. The difference in P1 latency between the left and right hemispheres was largest (107 vs. 119 ms) in the discrimination task for targets preceded by visual cues and slightly opposed when preceded by auditory cues (118 vs. 113 ms), whereas no hemispherical differences seem present in the detection tasks for both types of cues (119 vs. 116 ms in the case of auditory cues, and 109 vs. 111 ms in the case of visual cues). Finally, an interaction between cue, target position, and hemisphere was found, $F(1,10) = 6.5$, $p = .029$. No hemispherical differences are present when targets occurred below fixation, whereas a slight advantage (3 ms) for the right hemisphere in the case of uncued targets reversed to an opposite effect (-6 ms) in the case of cued targets.

LRP. The upper panel of Figure 9 shows the pre-LRP while anticipating the cues and targets in the detection tasks. A positive deflection is present around 500 ms after arrow onset, being confirmed by an analysis on activity within a window from 400 to 600 ms with the factors cue modality and cue, $F(1,10) = 16.6$ $p = .002$. This deflection is probably related to the late directing attention positivity (LDAP), which has a posterior maximum and may arise from the ventral intraparietal sulcus (e.g., see Van der Lubbe, Neggers, Verleger, & Kenemans, 2006). A negative deflection around 1000 ms after arrow onset was present (900–1100 ms, $F[1,10] = 7.4$, $p = .032$), which probably reflects motor activation (e.g., see Van der Lubbe et al., 2001), although the interaction between cue modality and cue, $F(1,10) = 6.2$, $p = .032$, indicated that this deviation was not present in all conditions. No effects are visible shortly before cue onset.

For the s-LRP and r-LRP analyses, we first performed control analyses to verify whether cuing effects were present from -100 to 0 ms before target onset in the detection tasks, and whether activity deviated from baseline. No cuing effects were found ($p > .35$), and no deviations from baseline were observed ($p > .28$). As a consequence, both for the detection and the discrimination tasks, the final baseline could be set at -100 to 0 ms
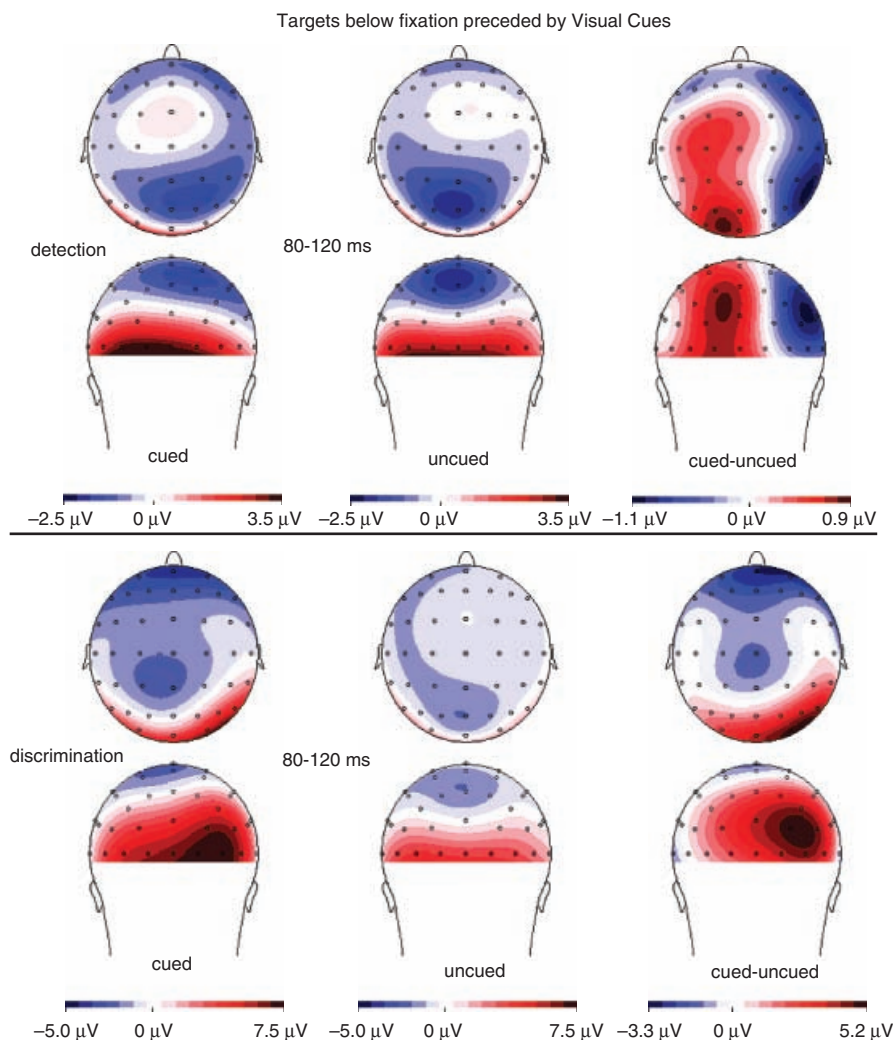
Figure 7. Targets below fixation preceded by visual cues. See Figure 5 for details.

before target onset. Mean s-LRPs and r-LRPs as a function of task, cue modality, and cue with these final baselines are displayed in Figure 9 and Figure 10, respectively. Fitting of the individual s- and the r-LRPs to determine onset of the LRP was not always successful, which is reflected in the reported *df*s in Table 3 and the captions of Figures 9 and 10. Results of additional tests, in which we determined the moment at which the 50% amplitude criterion of the s-LRP and the r-LRP was reached, are indicated in Table 4.

An overall analysis on onset of the s-LRP revealed a nearly significant task effect, $F(1,4) = 7.1$, $p = .056$, with an earlier onset in the detection tasks (92 ms) than in the discrimination tasks (178 ms); an effect of cue modality, with earlier motor activity with auditory (108 ms) as compared to visual cues (162 ms), $F(1,4) = 10.2$, $p = .033$; and an interaction between task and cue, $F(1,4) = 8.4$, $p = .044$, which reflected an opposite cuing effect in the detection tasks (-66 ms) as compared to the discrimination tasks (13 ms). The overall analysis on the 50% criterion, which included more participants (see also Table 4), confirmed the previous results: effects of task (219 vs. 381 ms), $F(1,7) = 26.4$, $p = .001$, cue modality (276 vs. 324 ms), $F(1,7) = 26.9$, $p = .001$, and an interaction between task and cue, $F(1,7) = 6.2$, $p = .041$ (cuing effects: -40 ms in detection tasks, 13 ms in discrimination tasks). Both separate tests on the cuing effect in the detection task

with visual cues (see Tables 3 and 4) indicate that motor activation started earlier for uncued than for cued targets, whereas no such effect was present in the case of auditory cues. Not surprisingly, separate analyses per task and cue modality on individually estimated baselines of the s-LRP revealed no cuing effects ($p > .16$).

Mean r-LRPs as a function of task, cue modality, and cue are displayed in Figure 10. Overall analyses on the onsets of the r-LRP only revealed a nearly significant task effect, $F(1,4) = 7.2$, $p = .055$, with possibly an earlier rise in detection tasks (-270 ms) as compared to discrimination tasks (-235 ms). This effect, however, was no longer present for the moment at which 50% of the peak amplitude was reached, $F(1,4) = 2.0$. Results of separate *t* tests on cuing effects per task and cue modality are provided in Table 3 and Table 4. A significant cuing effect was present for the moment at which the 50% criterion was reached in the discrimination task, but no such effect was observed for onset of the r-LRP. We have no explanation for this effect, and doubt whether this effect is replicable given the small size of the cuing effect.

Discussion

In our introduction, we mentioned that previous findings may indicate that exogenous cuing effects induced by irrelevant onsets, which become apparent in performance measures like RT,

Targets above fixation preceded by Visual Cues
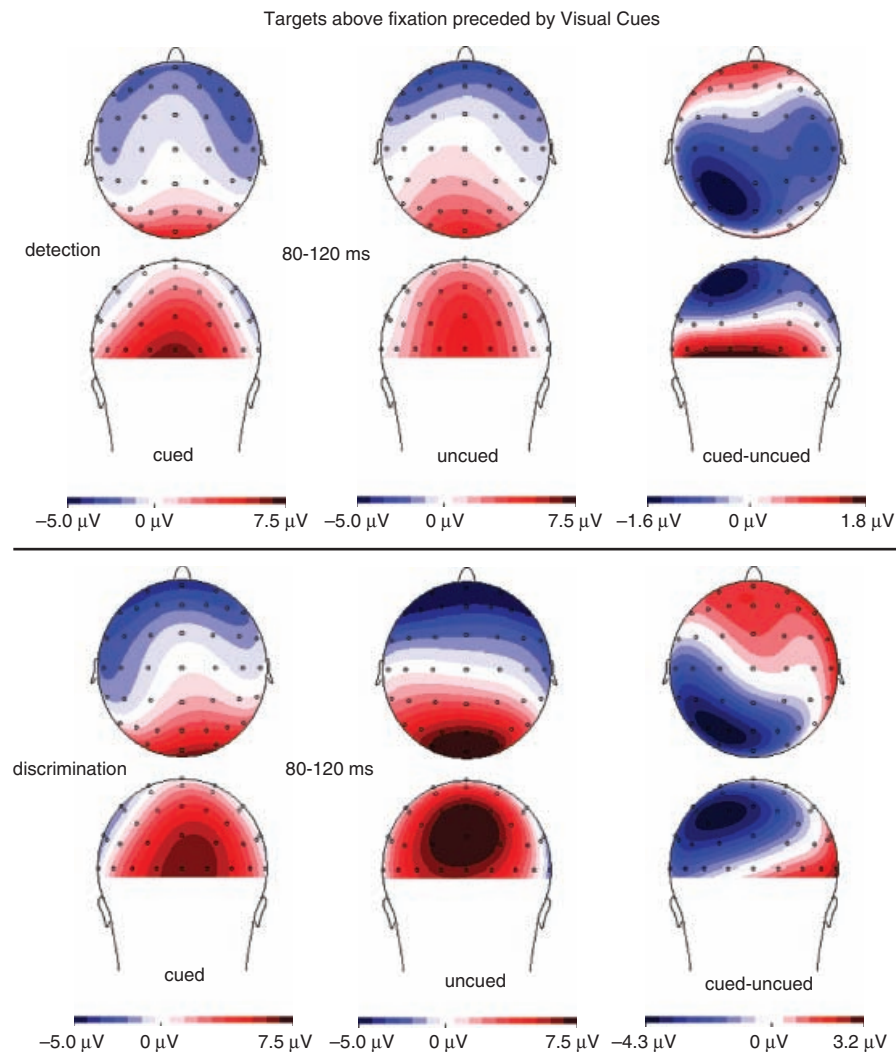
**Figure 8.** Targets above fixation preceded by visual cues. See Figure 5 for details.

are not necessarily due to an influence of attention on perception. Several studies revealed that exogenous cuing effects are highly dependent on the task setting, as IOR has mainly been observed in simple detection tasks, whereas a positive cuing effect has predominantly been found in discrimination tasks. In an earlier study (Van der Lubbe et al., 2005) we revealed that these task-dependent effects may already be present at short SOAs. Due to the design of that study, we could not answer the question of whether these early task-dependent exogenous cuing effects were due to a delayed withdrawal of attention from exogenously cued locations in discrimination tasks or to speeded motor inhibition in detection tasks, as might have been inferred on the basis of ERPs. In the current study, we varied SOAs within short cue–target intervals, which may enable an answer. We additionally raised the question concerning the generality of the phenomenon, as task-dependent effects may be affected by the modality of the cue according to the speeded motor inhibition hypothesis but not according to the delayed attention withdrawal hypothesis (see Table 1).

First, we will focus on the results obtained in the unimodal setting with visual exogenous cues. In line with previous studies (see the introduction) we obtained different effects of visual exogenous cues in our detection and discrimination tasks on RT.

IOR of nearly 50 ms was found in the detection task, but no positive cuing effect was observed in the discrimination task. The latter finding was unexpected, although a more specific analysis including the factor SOA revealed a positive cuing effect for the longest SOAs (see Figure 2).[6] These findings raise the possibility that the visual cues may have masked the forthcoming target (i.e., forward masking), although this potential effect was never large enough to invert to inhibition. The ERPs, however, provide no support for a masking effect (or sensory refractoriness), as the interaction between cue and cue modality was in an opposite direction, and increased positivity was found for visually cued targets (see Figure 4). Most importantly, the strong inhibition in the detection task cannot be ascribed to this factor, as the possible influence of masking should have been more detrimental for cued targets in discrimination tasks, which leaves two hypotheses for the task-dependent cuing effects: delayed attention with-

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[6]This interaction could imply a problem for the correction of the target ERP for the preceding cue ERP, as in that case the assumption is made that effects for the interval of interest are the same. However, as no interaction effect was present in the detection task, the cause of this interaction is more likely to have a nonperceptual source. Nevertheless, some caution with regard to the use of long SOA ranges to enable correction for overlap from the preceding cue appears to be required.
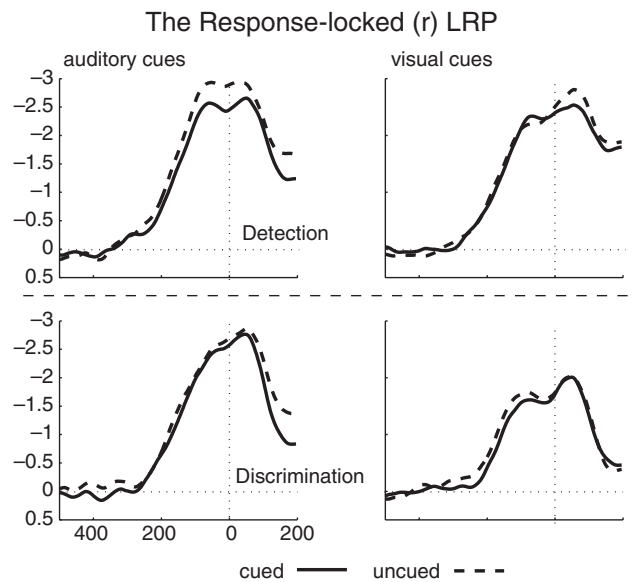
The Stimulus-locked (s) LRP
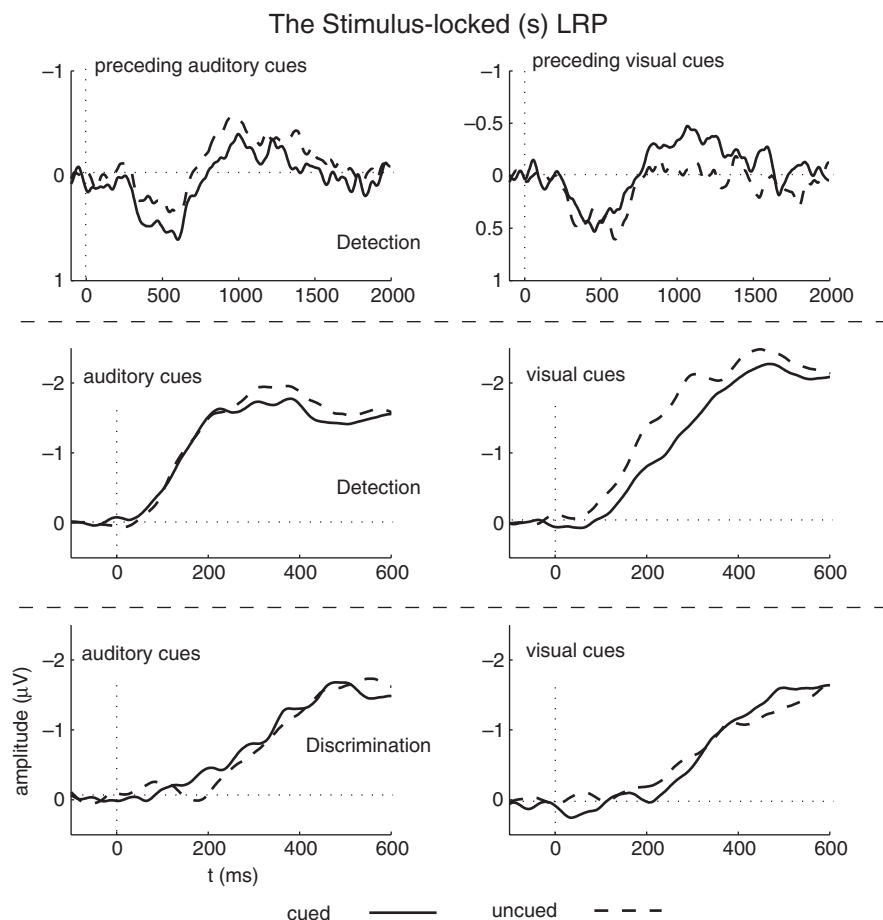
Figure 9. The stimulus-locked LRPs for cued and uncued targets in the detection and discrimination tasks when they were preceded by auditory cues (left panel) or visual cues (right panel). In the middle and lower panels, LRPs are aligned to target onset, whereas in the upper panel, they are aligned to onset of the arrow that signaled the required detection response. The averages in the upper panel are based on 11 participants. For the detection tasks with auditory and visual cues in the middle panel, grand averages are based upon 11 and 8 participants, respectively. For the discrimination tasks, the grand averages consisted of 6 and 7 participants.

drawal in discrimination tasks or speeded motor inhibition in detection tasks. In the case of delayed attention withdrawal we should observe task-dependent cuing effects on the P1 ERP component (see Table 1). Our statistical analyses, however, revealed that cuing effects on the posterior P1 components were relatively independent of task type. When targets occurred below fixation, increased posterior positivity for cued targets was found both in detection and discrimination tasks (see Figure 4, lower panel, and the spline maps in Figure 7), which replicates previous studies with short SOAs (e.g., see Hopfinger & Mangun, 1998, 2001). Nevertheless, some task-dependent hemispherical differences may be present (reflected in trend effects on P1 amplitude and effects on P1 peak latency), as the right hemisphere seems more involved in the discrimination task whereas an opposite pattern appears present for the detection task. This marginally significant pattern, however, does not point to a withdrawal of attention in the detection task. Rather different are the ERPs when targets occurred above fixation (Figure 4, upper panel, most clearly visible in the spline maps of Figure 8), although the cuing effect within the 80–120-ms window was comparable to the effect when targets occurred below fixation. These deviant ERPs are probably due to the much more inferior projections in occipital cortex, as targets occurred far above fixation. Again, some

hemispherical differences may be present, but clearly no opposite effect was found in the detection task (see Figure 8). Together, these findings on the P1 component point to rather comparable exogenous cuing effects in detection and discrimination tasks with visual cues, suggesting that task-dependent effects are not due to an influence on perceptual processes within early visual brain areas. The LRP findings again provide support for a pre-motoric locus of inhibition, due to significant effects on s-LRP onset and the 50% amplitude criterion. As a consequence, our findings with visual cues seem mostly in line with the speeded motor inhibition hypothesis.

We argued in our introduction that task-dependent exogenous cuing effects on RT might be absent when auditory cues are used, in line with the speeded motor inhibition hypothesis (see Table 1). At a behavioral level, cuing effects in detection and discrimination tasks were comparable, although the positive cuing effect was larger in the discrimination task. These findings are evidently not in accordance with the idea that the time course of attentional allocation is highly dependent on the task at hand, at least in the case of short SOAs. Instead, the modality of the cue appears to be crucial for demonstrating qualitatively different cuing effects in detection and discrimination tasks, in line with the view that motor inhibition depends on a rough similarity

Figure 10. The response-locked LRPs for cued and uncued targets in the detection and discrimination tasks when they were preceded by auditory cues (left panel) or visual cues (right panel). The averages in the detection tasks are based on 8 (in case of auditory cues) and 9 participants, and in the discrimination tasks they consist of 6 and 8 participants.

between cues and targets. Cuing effects on the P1 component were present when targets occurred below fixation,[7] but an opposite pattern seems to be present when targets occurred above fixation. Again, there was no indication that the cuing effect for targets in the lower field differed between tasks, which additionally suggests that processing within early visual areas is not strongly dependent on the task at hand. In short, the aforementioned findings suggest that task-dependent exogenous cuing effects with short SOAs should be ascribed to speeded motor inhibition in unimodal detection tasks and not to delayed attention withdrawal in discrimination tasks.

Although the two tasks with auditory cues provided clear exogenous cuing effects, we could not demonstrate on the basis of the s-LRP that these effects have a premotoric locus. On the other hand, we could also not reveal that these effects are located at motoric processes (no effects on the r-LRP), which, however, would be unexpected. How should we interpret this null finding? The easiest explanation is that effects on behavior, which varied from 14 to 31 ms, were simply too small to be detectable with the s-LRP. Another possibility is that motor processes start before perceptual processing of the target is finished. Given the relatively early onset in the crossmodal detection task, this may indeed be the case.

What are the implications of the current results? Of course, we do not want to account for all task-dependent exogenous cuing effects in terms of speeded motor inhibition, as there are also clear indications that the withdrawal of attention may indeed be affected by the type of task, especially in the case of long SOAs (see the introduction). However, this explanation is apparently insufficient for short SOAs. Apart from that, we also do not think that all inhibition in the case of short SOAs reflects motor

[7]This finding seems well in accordance with the supramodal view and extrapolates the findings of McDonald et al. (2005) to the Posner paradigm.

Table 3. *Mean s-LRP and r-LRP Onsets in Milliseconds for Cued and Uncued Targets for Each Task and Cue Modality*[a]

Task	Cue modality	Cued	Uncued	df	t	p
s-LRP						
Detection	Auditory	45	44	10	0.1	.48
	Visual	139	61	7	2.0	.043
Discrimination	Auditory	169	167	5	0.03	.511
	Visual	199	176	6	0.33	.624
r-LRP						
Detection	Auditory	− 268	− 280	7	0.4	.735
	Visual	− 244	− 286	8	1.1	.296
Discrimination	Auditory	− 267	− 270	5	0.3	.797
	Visual	− 258	− 281	7	1.5	.179

[a]For the s-LRP, statistical results are provided of a one-sided *t* test in line with the predictions of Table 1. For the r-LRP, results of a two-sided *t* test are reported.

inhibition, as the study by Tassinari and Berlucchi (1993) clearly revealed that sensory interactions may play a role. As a consequence, in the case of inhibition in a detection task with visual exogenous cues, several mechanisms may be involved, which should limit enthusiasm for applying these tasks to patient groups or to study the effects of pharmacological manipulations (e.g., see Moritz & von Mühlenen, 2005; Witte, Davidson, & Marrocco, 1997), as inhibition effects are difficult to interpret. For example, due to a specific brain lesion, inhibitory motor control may be affected, which might erroneously be interpreted as an effect on attentional orienting mechanisms. Application of a crossmodal visual detection task with auditory exogenous cues, however, seems to avoid most of the aforementioned problems. Earlier studies have already pointed to the possible involvement of motor inhibition in detection tasks (Harvey, 1980; Spence et al. 2000), but mostly it was thought that motor inhibition plays no role when catch trials are included or when cues and target do not resemble each other (Pratt et al., 2001). In the current study, catch trials were used, and cues and targets were clearly different, but, apparently, a weak resemblance between cues and targets may already be sufficient to trigger a response and induce inhibitory effects.

In conclusion, our data revealed that qualitatively different cuing effects in detection and discrimination tasks were only

Table 4. *The Moment (in Milliseconds) at which 50% of the Peak Amplitude of the s-LRP and the r-LRP Was Reached (the 50% Criterion) for Cued and Uncued Targets For Each Task and Cue Modality*[a]

Task	Cue modality	Cued	Uncued	df	t	p
s-LRP						
Detection	Auditory	191	174	10	0.7	.25
	Visual	267	226	10	2.5	.016
Discrimination	Auditory	361	378	7	− 0.8	.225
	Visual	385	395	9	− 1.1	.15
r-LRP						
Detection	Auditory	− 143	− 160	8	1.1	.29
	Visual	− 166	− 167	8	0.1	.934
Discrimination	Auditory	− 178	− 188	6	4.0	.007
	Visual	− 174	− 150	6	− 1.3	.243

[a]For the s-LRP, statistical results are provided of a one-sided *t* test in line with the predictions of Table 1. For the r-LRP, results of a two-sided *t* test are reported.

present in a unimodal but not in a crossmodal version of the exogenous cuing paradigm. The task-dependent exogenous cuing effects on RT could not be explained by effects on the P1 component, and IOR in the detection task appeared to have a pre-motoric locus. Together these new data support the view that, in the case of short SOAs between cues and targets, task-dependent cuing effects are due to speeded motor inhibition in the detection task that critically depends on a rough similarity between cues and targets and not to an earlier withdrawal of attention in the detection task. In the case of longer SOAs, however, IOR in detection and discrimination tasks may very well be due to a withdrawal of attention from the cued location.

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