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THE IMPACT OF SOCIAL PRESENCE ON VOLUNTARY AND INVOLUNTARY CONTROL OF SPATIAL ATTENTION

Peter Wühr
Technische Universität Dortmund, Dortmund, Germany

Lynn Huestegge
RWTH Aachen University, Aachen, Germany

The present study examined whether and how the presence of an invisible person can affect the control of visuospatial attention on the basis of cues. In two experiments, participants reported the identity of a target letter that was shown at variable peripheral locations. In Experiment 1, a central (i.e., symbolic) cue reliably informed participants about the location of the subsequent target stimulus; central cues are typically used to control attention endogenously. In Experiment 2, a peripheral (i.e., physical) cue preceded the target stimulus with equal probability at the valid or at the invalid location; peripheral cues are known to attract attention exogenously. Crucially, in both experiments the experimenter was either present in the laboratory room or not. The results showed that the presence of the experimenter did not affect the processing of peripheral cues, but disrupted the use of central cues, probably because of competition for limited working memory and/or attentional resources.

In every moment, both the environment and our body provide us with an immense number of stimuli. However, only some of them are relevant with respect to our present goals. Thus, in order to facilitate the control of our behavior, we need to select an appropriate subset of stimuli for further processing. This selection of potentially important or goal relevant information has been termed selective attention (see Allport, 1980, 1992; Pashler, 1998, for reviews). Research on the mechanisms of selective attention has provided evidence that attention can be directed to perceptual objects (e.g., Duncan, 1984; Scholl, 2001), to perceptual dimensions

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Correspondence concerning this article should be addressed to Peter Wühr, TU Dortmund, Institut für Psychologie, Emil-Figge-Strasse 50, 44227 Dortmund, Germany. E-mail: peter.wuehr@tu-dortmund.de.

(e.g., Allport, 1971; Müller, Heller, & Ziegler, 1995), or to spatial locations (e.g., Posner, Snyder, & Davidson, 1980).

Until now, research has studied the control of spatial attention in isolated individuals; that is, by measuring responses of participants who sat alone in an experimental chamber. Outside the laboratory, however, people are frequently required to control their attention in the presence of other individuals. This is evident in school, for example, where pupils need to control attention both in the presence of teachers and other students. Despite the obvious importance of this topic, research has not yet addressed the possible effects of social presence on the control of spatial attention. The purpose of the present study is to provide a first step in this direction. In particular, we investigated how the presence of a person that remained outside the participants' field of view affected the control of voluntary and involuntary visuospatial attention.

The most widely used experimental paradigm for investigating the control of visuospatial attention is the *spatial-cueing paradigm*, introduced by Posner and colleagues (e.g., Posner, 1978, 1980; Posner & Cohen, 1984). The basic idea is to examine the benefit of indicating to the participants the location at which a subsequent target stimulus would appear by using a cue stimulus. The cue contains probability information about the location of the forthcoming target and can either appear at the location of the current fixation (central cue) or at one of the potential target positions (peripheral cue). Central cues (e.g., arrowheads, location words) are usually symbolic in that interpretation is needed to determine the location they refer to, whereas peripheral cues (e.g., light flashes at one of the possible target locations) indicate position physically. In the classic experiments (see Posner et al., 1980), the main independent variable was the validity of the cues; that is, the probability that the cue does, in fact, indicate the subsequent target position. Typically, subjects were faster to respond to targets that were preceded by valid as compared to invalid or uninformative location cues (i.e., the cueing effect). It is assumed that the cues either voluntarily or involuntarily manipulate the participants' expectation with regard to the most likely location of a target stimulus, subsequently modulating the efficacy of target processing.

More specifically, in a typical cueing experiment participants are first presented with a cue that indicates the possible location of a subsequently presented target stimulus appearing at a variable location in the visual field. For example, the target stimulus may be the letter H or K presented either to the left or to the right of fixation. Prior to stimulus onset, the cue (e.g., an arrow symbol) is presented to manipulate the participant's expectations concerning the target location. This cue points to the correct target location in 80% of the trials (cue validity). When the cues are effectively used, target-discrimination performance will have shorter response times (RTs) and/or higher accuracy in valid as compared to invalid trials (e.g., Posner et al., 1980).

The most widely accepted explanation for spatial-cueing effects likens selective attention to a "spotlight" (e.g., Posner et al., 1980; see Cave & Bichot, 1999, for a critical review). According to this view, attention facilitates information processing at the attended location. In this context, cueing effects can be explained by assuming that a spatial cue is used for directing the attentional spotlight to the cued location in advance of the stimulus display. In a valid condition, attention is already at the target location when the target appears, thereby facilitating both detection and identification of the target. In contrast, in an invalid condition attention is directed to an empty location. This in turn leads to the need to shift attention from the incorrect to the correct location, or the need to process the target stimulus without attention, which negatively affects processing speed and/or accuracy.

Empirical findings suggest that symbolic and physical location cues are processed differently. First, nonpredictive symbols produce smaller cueing effects as compared to nonpredictive physical cues. The effect of symbolic cues therefore strongly depends upon their usefulness. In particular, if the cue is not predictive (i.e., 50% valid vs. 50% invalid trials in experimental settings with two possible target locations) there is no or at least only a comparatively small cueing effect (Jonides, 1981, Experiment 2; Ristic, Friesen, & Kingstone, 2002). Symbolic cueing effects increase with the predictiveness of the cue (e.g., Posner et al., 1980), and the largest cueing effects can be expected when performance in settings with 100% cue validity is compared to performance with an uninformative symbol (e.g., a diamond). The effects of physical cues depend much less upon their usefulness than do symbolic cues and even completely nonpredictive cues can produce substantial cueing effects (e.g., Jonides, 1981; Remington, Johnston, & Yantis, 1992).

Second, working-memory load interferes with the processing of symbolic cues only, whereas it does not affect the processing of physical cues (e.g., Jonides, 1981, Experiment 1). Third, participants can voluntarily attenuate the processing of symbolic cues, but they cannot suppress the processing of physical cues as effectively (Jonides, 1981; see also Kingstone, Smilek, Ristic, Friesen, & Eastwood, 2003, for a critical discussion). Fourth, investigations on the effect of the stimulus-onset asynchrony (SOA) between the cue and the target stimulus revealed that cueing effects with symbolic and with physical cues follow different time courses, respectively (Müller & Rabbitt, 1989). In particular, effects of physical cues develop at a much faster rate than do effects of symbolic cues. To account for these differences, several researchers suggested that symbolic cues are processed in a more controlled or voluntary fashion, and automatic processes play a significant, but only a comparatively small role (see also Gibson & Bryant, 2005; Hommel, Pratt, Colzato, & Godijn, 2001; Tipples, 2002). In contrast, physical cues are assumed to be processed in a much more automatic or involuntary fashion, although some influence of current task-related goals has been demonstrated (e.g., Folk, Remington, & Johnston, 1992; Folk, Remington, Wright, 1994; Pratt & Hommel, 2003). Taken together, this implies that the processing of symbolic cues requires both the intention to process the cues and working-memory capacity, whereas the processing of physical cues does to a much lesser extent require intention or working-memory capacity (e.g., Luck & Vecera, 2002; Müller & Rabbitt, 1989). Thus, symbolic cues are particularly suited for studying voluntary attentional orienting, whereas physical cues can be used to examine more automatic attentional orienting.

Previous research provided several lines of evidence for a modulation of attentional orienting based on the presence of other individuals. For example, it has been demonstrated that the perceived gaze direction of others leads to an observer's shift of attention. This was shown in cueing paradigms with abstract face drawings (Friesen & Kingstone, 1998) and with real faces (Driver et al., 1999; Langton & Bruce, 1999; see also Frischen, Bayliss, & Tipper, 2007 for a review). Similar effects were also attained by using spatial gestures as cues (see Langton & Bruce, 2000).

Another line of evidence indicating social effects on attentional orienting comes from studies investigating the effects of social presence on performance in the Stroop task. In a typical Stroop task, participants are required to report the ink color of word stimuli (Stroop, 1935; see MacLeod, 2005). Typically, color-naming latencies are slower when the meaning of the word is incongruent with its color (e.g., the word RED in blue color), compared to neutral conditions (e.g., the letter string XXXX in blue color), or compared to congruent conditions (e.g., the word BLUE in blue color). The most widely accepted explanation for Stroop interference assumes that word reading rests on automatic processes, whereas color naming requires deliberate (i.e., controlled) processing, producing an asymmetric pattern of interference effects in color-naming and word-reading tasks (e.g., MacLeod & MacDonald, 2000).

Huguet and colleagues reported evidence suggesting that the mere presence of a person can reduce interference from irrelevant information in the Stroop task (Huguet, Galvaing, Monteil, & Dumas, 1999). Huguet et al. (1999) observed a significant reduction of the Stroop effect in a condition in which participants performed a Stroop task in the presence of an invisible audience (Stroop effect = 101 ms), compared to a condition in which participants performed the Stroop task alone (Stroop effect = 170 ms). In contrast to the gaze cueing effects reported above, this effect emerged even though the other person was outside the participants' field of view. The authors interpreted their findings in terms of an attentional focusing framework on the effects of social presence (e.g., Baron, 1986). According to this view, the presence of others leads to a focusing of attention in order to avoid distraction. This facilitates easy tasks which only require the processing of a smaller number of relevant stimuli, because it likely diverts attention from other irrelevant stimuli. In contrast, difficult tasks which require the processing of many stimuli are impeded, because focusing may divert attention from some of the relevant stimuli.

Recently, however, Klauer, Herfordt, and Voss (2008) challenged the notion that the mere presence of another person causes attention to focus more strongly. They provided evidence suggesting that the reduction in Stroop interference, as reported by Huguet et al. (1999), actually resulted from a particular combination of circumstance, and not from a direct effect of social presence on the size of the attentional focus. In particular, Huguet and colleagues told their participants that they were mainly expected to give their general impression on a new kind of Stroop task to reduce the participant's feeling of being evaluated on the Stroop task. Moreover, Huguet et al. computed Stroop interference scores from comparing performance with incongruently-colored word stimuli to performance with colored strings of plus signs that served as neutral stimuli.

According to Klauer et al. (2008), however, the impression-formation instruction might have produced longer inspection times for the incongruent stimuli than for the neutral stimuli because the former stimuli were more distinct and interesting than the plus signs, thereby, increasing Stroop interference scores. In addition, Klauer et al. assumed that social presence might have interfered with the impression-formation task, reducing Stroop effects in this condition to normal levels, whereas the impression-formation instruction kept Stroop interference scores at an artificially high level in the alone condition. Consistent with their first claim, Klauer et al. (Experiment 2) failed to observe an effect of social presence on Stroop interference scores when color-unrelated words were used as neutral stimuli in a Stroop task that did include the impression-formation instruction. Consistent with their second claim, Klauer et al. (Experiment 1) failed to observe an effect of social presence on Stroop interference scores without the secondary impression-formation instruction when the same stimuli were used as in Huguet et al. (1999). From these findings, Klauer et al. concluded that the presence of another person may have in fact interfered with performing the impression-formation task, rather than having caused a narrowing of the attentional focus. In particular, Klauer et al. interpreted their findings as "an effect of social presence on task selection. Participants prioritized the Stroop task and neglected the impression task when distracted by social presence" (p. 475). Therefore, the issue of effects of social presence outside the current field of view on attention remained unresolved.

The purpose of the present study was to investigate the effects of the presence of an invisible person on the processing of visuospatial cues. Experiment 1 investigated the effects of social presence on the use of symbolic (i.e., central) cues; Experiment 2 investigated the effects of social presence on the processing of physical (i.e., peripheral) cues. On the basis of previous theoretical conceptions, at least three different outcomes are feasible. From the perspective of an *attentional focusing framework* (e.g., Baron, 1986; Huguet et al., 1999), one could assume that the presence of a person leads to attentional focusing, so that cues that appear at the current fixation position are processed more intensely. This should in turn lead to a more efficient use of the symbolic cues, resulting in larger symbolic cueing effects when another person is present. On the other hand, peripheral cues should either be unaffected because they are processed in a more automatic fashion, or even be less effective since they do not appear at the position of the current fixation and might therefore fall out of the attentional focus.

A second framework, which we would like to call the *distraction framework*, would argue that social presence interferes with the processing of the symbolic cues, but not with the processing of the physical cues. Previous evidence suggests that using symbolic cues requires working memory (Jonides, 1981), which has limited capacity, and the processing of the presence of another person might compete for working memory capacity. In contrast, the processing of physical cues appears to run automatically, rendering an effect of another persons' presence unlikely.

Interestingly, the classic view on the effects of social presence on cognitive performance, advocated by Zajonc (1965), suggests a third alternative. According to this *habitual dominance framework*, the presence of others increases arousal, which in turn facilitates the execution of the dominant, habitual response to a stimulus or situation. Moreover, according to Zajonc, easy tasks can be defined as typically requiring a habitual response, whereas difficult tasks typically require a nonhabitual response. As a result, social presence will facilitate performance in easy tasks, but impede performance in difficult tasks. If one assumes that looking into the direction of an arrowhead, which was the symbol cue in Experiment 1, is a dominant response, then social presence might promote use of these cues, thereby increasing cueing effects. Similarly, if one assumes that looking onto a physically cued location (Experiment 2) is a dominant response, then social presence might as well increase this response tendency and increase cueing effects. The present experiments therefore contribute to decide whether attentional focusing, distraction, or habitual dominance provides the most satisfactory account for any effects of social presence on the deployment of visuospatial attention.

EXPERIMENT 1

The purpose of Experiment 1 was to investigate how the presence of an invisible person in the laboratory affects the use of symbolic cues for directing attention to the location of a subsequent target stimulus. Participants' task was to discriminate between the target letters H or K that were presented, with equal probability, to the left or to the right of the screen center. In half of the trials, an arrowhead presented at screen center and pointing towards the target location reliably informed participants about the location of the subsequent target (informative cue). In the other half of the trials, an uninformative cue (a square) was presented. The fact that the arrowhead was always valid provides a strong incentive for using the cue. The interval between cue and target stimulus onset (SOA) was fixed to 100 ms (see also Jonides, 1981, for similar SOA). Pilot work had shown that this setting produced highly reliable cueing effects, that is, an informative cue enabled the participants to discriminate the target stimulus faster as compared to an uninformative cue.

The main question was whether and how the presence of a person in the laboratory would affect the use of the symbolic cues for directing attention. To tackle this question, participants performed the cueing task either alone or in the presence of the experimenter. When the experimenter was present in the room, however, she sat behind and outside the field of view of the participant. Previous work suggests that, even though arrowheads are familiar location cues, they do not solely push attention in an automatic fashion, but their use appears to require both voluntary processes and working memory capacity (e.g., Jonides, 1981). Thus, if the presence of another person draws on cognitive resources, being it attention or working memory capacity, then cueing effects should be reduced in this condition. If, however, the presence of another person increases the readiness of habitual responses (i.e., the interpretation of arrowheads) or focuses attention at the central fixation position, then cueing effects should be larger in the presence than in the absence of an observer.

METHOD

Participants. Thirty-two students (18 female, 14 male) of the Friedrich-Alexander-University with a mean age of 23 years (range 19–30 years) participated for payment (3€). Psychology students were excluded from participation. All participants were naïve with respect to the purpose of the study and classified themselves as having normal (or corrected-to-normal) visual acuity. Eight female students (mean age 21 years) served both as experimenters and as passive observers in Experiment 1. Each experimenter tested four participants (two with each order of conditions). The experimenters only recruited participants that were not known to them before the experiment.

Apparatus and Stimuli. Participants sat in a dimly lit room in front of a 17-inch color monitor. A head-and-chin rest constrained viewing distance to 50 cm. A computer program (ERTS, BeriSoft, Frankfurt am Main, Germany) controlled stimulus presentation and collected responses. The informative cue was a filled triangle (arrowhead) pointing either to the left or right, measuring 5 mm in width × 10 mm in height. The uninformative cue was a filled square (5 × 5 mm). The target stimulus

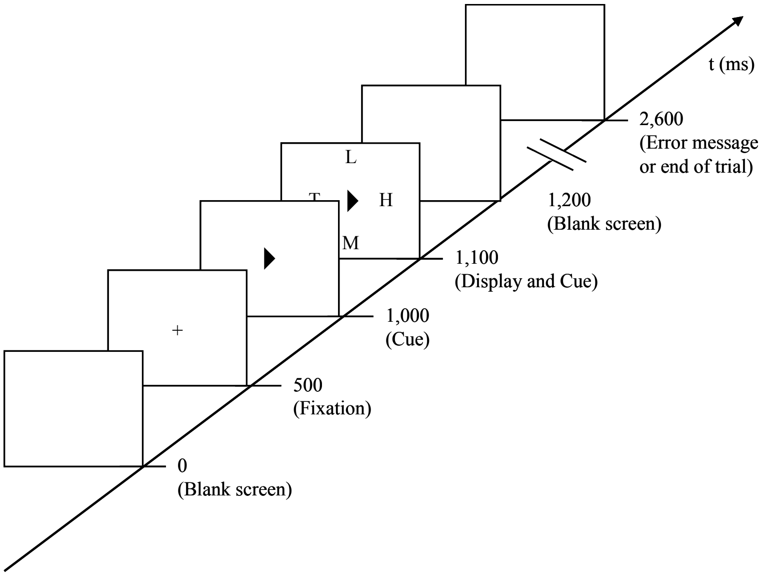

FIGURE 1. Sequence of trial events in Experiment 1. A valid symbolic informative cue (a filled triangle) or a noninformative cue (a square), presented at fixation, preceded a stimulus display by 100 ms. Participants had to judge whether the stimulus display contained the letter H or the letter K at the left or right location.

was the uppercase letter H or K (6 × 7 mm), presented either 55 mm to the left or to the right of fixation at the screen center. Three foil stimuli (i.e., the uppercase letters L, M, and T) were always presented simultaneously with the target at locations with the same eccentricity as the target location to prevent the sudden onset of the target to draw attention onto its location. One foil appeared at the horizontally opposite location, one above fixation, and the third below fixation (see Figure 1). All visual stimuli were shown in white on a black background. Participants responded by pressing the #2 or #8 keys on the number pad of a standard keyboard with the index finger of their right hand.

Two armchairs were positioned behind the participants' chair, one to the left and one to the right of a door. The distance between the participant and each armchair was about 2 meters. One chair was located to the right in the back of the participant, approximately 140° with regard to the participants' line of sight; the other chair was located to the left in the back of the participant, approximately 220° with regard to the participants' line of sight.

Procedure. At the beginning of the experiment, the instructions appeared on the screen and informed participants about the stimulus conditions and the task. The presence or absence of the experimenter was not mentioned. The experiment was divided into two parts. In each part, the participant worked through 5 blocks with 32 trials each. There were two additional warm-up trials at the beginning of each block that were not recorded. The experimenter started each part of the experiment by pressing a key. For half of the participants, the experimenter stayed in the room during the first part of the experiment, and left the participant alone during the second part. For the other half of the participants, the experimenter left the participant alone for the first part of the experiment, and stayed in the room during the second part. When the experimenter was present, she sat on the left chair for half of the participants, and on the right chair for the other half of participants.

A typical trial contained the following sequence of events. After a blank screen for 500 ms, the fixation point was presented at the center for 500 ms. Then either the informative or the noninformative cue was presented for 200 ms at the center. One hundred ms after the onset of the cue (SOA), the stimulus display was presented for 100 ms; that is, the cue and the display terminated simultaneously. The sequence of trials was randomized. Participants were instructed to report which of the two possible target letters (H or K) was presented at either of the two possible horizontal stimulus locations. The mapping of target letter (H or K) and corresponding key (#2 or #8) was counterbalanced across subjects. Participants were told that the informative cues were always valid and encouraged to use them for improving their performance. When a participant pressed the wrong key, or did not respond within one second, an error message was shown on the screen for one second. The whole session typically lasted between 20 and 30 minutes. At the end of the experiment, the participants were debriefed and were asked some general questions on the experiment (i.e., Did you have any difficulties with the task?; Did you notice anything special?).

Design. Experiment 1 was based on a 2 × 2 × 2 mixed design, where Cue Type (informative vs. noninformative) and Experimenter Presence (experimenter present vs. absent) served as within-subjects variables, and the Order of experimenter-presence conditions (i.e., experiment present in first or second half of the experiment) served as a between-subjects variable. The relative location of the experimenter (left vs. right), and the mapping of target letter to the response keys were independently counterbalanced across participants.

RESULTS

To eliminate outliers, we removed all trials in which RTs were either below 100 ms or above 1,200 ms for each participant. Averaged across participants, less than 2.0% of trials with very fast responses, and less than 1.0% of trials with very slow responses were excluded from analysis. We excluded the results of two participants from the analysis because they showed *negative* cueing effects (i.e., slower RTs with informative rather than noninformative cues) without audience. Please note, however, that including these two participants did not qualitatively alter the pattern of results. Table 1 shows mean RTs and mean error percentages as a function of the experimental conditions in Experiment 1. Interestingly, no participant spontaneously reported on the presence or absence of the experimenter when filling out the form at the end of the experiment.

RTs. A three-way ANOVA was computed on RTs from error-free trials, with Cue Type, Experimenter Presence, and Order of experimenter-presence conditions as independent variables. The main effect of Cue Type was significant, $F(1,28) = 19.84$, $MSE = 272.83$, $p < .001$, indicating shorter target-discrimination RTs with informative cues (M = 565 ms) than with noninformative cues (M = 579 ms). The main effects of Experimenter Presence and Order were not significant (both Fs < 1). All the two-way interactions were significant. First, the significant Presence × Order interaction, $F(1,28) = 23.50$, $MSE = 1{,}627.32$, $p < .001$, reflected a simple training

TABLE 1. RTs in ms and Error Percentages (in parentheses) Observed in Experiment 1 as a Function of Cue Type and Social-Presence Condition

	Experimenter	
	Absent	Present
Informative Cue	558 (9.8)	572 (9.1)
Noninformative Cue	579 (10.1)	577 (9.7)
Cueing effect	21* (0.3)	5 (0.6)

Note. *Denotes a significant difference at $p < .001$.

effect. That is, participants responded more quickly in the second part compared to the first part of the experiment, regardless of whether the experimenter was present or absent. Second, the significant Cue × Order interaction, $F(1,28) = 6.12$, $MSE = 272.83$, $p < .05$, indicated a smaller cueing effect when the experimenter was present in the first session (informative cue: 566 ms; noninformative cue: 572 ms) rather than when the experimenter was present in the second session (informative cue: 565 ms; noninformative cue: 586 ms). Third, the significant Cue × Presence interaction, $F(1,28) = 9.73$, $MSE = 212.61$, $p < .01$, indicated a smaller cueing effect when the experimenter was present (informative cue: 559 ms; noninformative cue: 581 ms) compared to when the experimenter was absent (informative cue: 571 ms; noninformative cue: 577 ms). In fact, the cueing effect was significant when the experimenter was absent, $t(29) = 4.82$, $p < .001$, whereas it was not significant when the experimenter was present, $t(29) = 1.19$, $p = .243$.

Error Percentages. A three-way ANOVA on the error percentages only revealed a significant two-way interaction of Presence x Order, $F(1,28) = 18.71$, $MSE = 55.98$, $p < .001$. Again, as in RTs, this interaction reflected a simple training effect: Participants responded more accurately in the second part of the experiment, regardless of whether the experimenter was present or absent (all other Fs < 1.1, all other ps > .30).

DISCUSSION

The results of Experiment 1 showed that participants used symbolic cues for directing attention to the indicated target location when they were alone, whereas the presence of the experimenter in the laboratory eliminated the use of these cues, even though this person was outside the field of view of the participant. The observation that the presence of a person disrupted the use of a reliable symbolic cue suggests that the experimenter's presence was distracting and demanded some limited resource, either attention or working memory capacity. The results are neither compatible with the attentional focusing account (Baron, 1986), nor with the habitual dominance account (Zajonc, 1965).

Interestingly, experimenter presence also had an asymmetric transfer effect on cue use. In particular, participants showed smaller overall cueing effects when the experimenter was present in the first rather than the second part of the experiment. This result indicates that the disruptive effect of experimenter presence on cue use transferred from the first part of the experiment where the experimenter was actually present to the second part of the experiment where the experimenter was no longer present.

The observation that experimenter presence did not impede the accuracy of target-discrimination performance indicates that the presence of the person had no general disruptive effect on performance, but rather selectively affects processing speed. Thus, the overall pattern of results suggests that, when the experimenter was present in the laboratory, participants decided to withdraw resources (attention or working memory) from processing the cues to represent or monitor the behavior of the invisible audience, whereas they kept the amount of resources devoted to the target-discrimination performance at a constant level.

EXPERIMENT 2

Experiment 2 explored how the presence of an invisible person in the laboratory room affects the processing of a physical (i.e., peripheral) cue that appeared at one of the two subsequent target locations. In contrast to the informative symbol cues in Experiment 1, the physical cues in Experiment 2 were not predictive with regard to the location of the subsequent target. That is, when the physical cue appeared at a particular location, the target was equally likely to appear at the same or at the opposite location. We reasoned that this should discourage participants from deliberately using these cues, thus allowing to primarily assess automatic processing. Previous research (including pilot work with the present setup) has shown that physical cues are processed even when they are nonpredictive, producing substantial cueing effects (e.g., Jonides, 1981; Remington, Johnston, & Yantis, 1992). We therefore expect target-discrimination latencies to be shorter after valid than after invalid cues. These cueing effects are typically attributed to the rather automatic, exogenous allocation of attention to the location of the physical cue (e.g., Jonides, 1981; Müller & Rabbitt, 1989). The question of interest was how the presence of the experimenter would affect cueing effects from physical cues. According to the habitual dominance account, the presence of an observer should increase the strength of habitual (orienting) responses (e.g., Zajonc, 1965), which in turn increases cueing effects. A second possibility is that the presence of an observer does not affect the processing of physical cues because the automatic processing of these cues does not require any limited resources that might be occupied by the presence of the observer. A third possibility is that the presence of the person leads to a focusing of attention, which might decrease the amount of processing dedicated to peripheral stimulation, subsequently leading to smaller cueing effects.

METHOD

Participants. Thirty-two students (15 female, 17 male) of the Friedrich-Alexander-University with a mean age of 23 years (range 19–34 years) participated for payment (3 €). None of these subjects participated in Experiment 1. All were naïve with respect to the purpose of the study and classified themselves as having normal (or corrected-to-normal) visual acuity. The same group of students as in Experiment 1 served as experimenters and as passive observers in Experiment 2.

Apparatus and Stimuli. The apparatus and stimuli were the same as in Experiment 1, with the exception that peripheral rather than central cues were used in Experiment 2. The cues consisted of a pair of horizontal lines, one presented above and the other line below the possible location of a target stimulus. Each line was 1 mm thick and 10 mm long. The vertical distance between the two lines was 10 mm. All visual stimuli were shown in white on a black background.

Procedure. The procedure in Experiment 2 was the same as in Experiment 1, except for the fact that peripheral cues instead of central cues preceded each stimulus display in Experiment 2. Accordingly, the sequence of events in Experiment 2 was the following. First, after a blank screen for 500 ms, the fixation point was presented at screen center for 500 ms. Then the cue was presented for 50 ms at either the left or the right stimulus location. One hundred milliseconds after cue onset (SOA), the stimulus display was presented for 100 ms. The cue and target appeared at the same location in 50% of the trials (valid cue conditions), and at opposite locations in the remaining 50% of the trials (invalid cue conditions). The sequence of trials was randomized. Participants were explicitly told that the cues were not informative and could be ignored. A typical session lasted between 20 and 30 minutes. As in Experiment 1, the participants were debriefed and were asked some general questions at the end of the experiment.

Design. Experiment 2 was based on a 2 × 2 × 2 mixed design, where Cue Type (valid vs. invalid) and Experimenter Presence (experimenter present vs. absent) served as within-subjects variables, and the Order of experimenter-presence conditions (i.e., experiment present in first or second half of the experiment) served as the between-subjects variable. The relative location of the experimenter (left vs. right), and the mapping of target letter to the response keys were independently counterbalanced across participants.

RESULTS

Averaged across participants, less than 2.0% of trials with very fast responses (i.e., RT < 100 ms), and less than 1.0% of trials with very slow responses (i.e., RT > 1,200 ms) were excluded from the analyses. Table 2 shows mean RTs and mean error percentages as a function of the experimental conditions in Experiment 2. Only two participants from 32 spontaneously commented on the presence or absence of the experimenter when filling out the form at the end of the experiment.

RTs. A three-way ANOVA was computed on RTs from error-free trials, with Cue Type, Experimenter Presence, and Order of experimenter-presence conditions as independent variables. Only the main effect of Cue Type was significant, $F(1,30) = 71.62$, $MSE = 309.37$, $p < .001$, indicating shorter target-discrimination RTs with valid cues (M = 551 ms) than with invalid cues (M = 577 ms). Thus, virtually identical cueing effects were observed both when the experimenter was absent, valid cues: 550 ms; invalid cues: 577 ms; $t(31) = 6.14$, $p < .001$, and when the experimenter was present, valid cues: 552 ms; invalid cues: 578 ms; $t(31) = 6.95$, $p < .001$. The remaining F tests revealed nonsignificant results (Cue × Order: $F = 1.80$, $p = .189$; all other Fs < 1.0, all other ps > .35).

TABLE 2. RTs in ms and Error Percentages (in parentheses) Observed in Experiment 2 as a Function of Cue Type and Social-Presence Condition

	Experimenter	
	Absent	Present
Valid Cue	550 (9.4)	552 (7.6)
Invalid Cue	577 (9.9)	578 (9.5)
Cueing effect	27* (0.5)	26* (1.9)

Note. *Denotes a significant difference at $p < .001$.

Error Percentages. A three-way ANOVA on the error percentages revealed a significant two-way interaction of Presence × Order, $F(1,30) = 7.13$, $MSE = 54.70$, $p < .05$, reflecting a training effect. That is, participants responded more accurately in the second part of the experiment (experimenter absent: 7.86%; experimenter present: 6.84%) than in the first part of the experiment (experimenter absent: 11.43%; experimenter present: 10.25%). There was also a marginal effect of Cue Type, $F(1,31) = 3.66$, $MSE = 12.52$, $p = .065$, suggesting lower error rates (i.e., higher accuracy) with valid cues (M = 8.5%) than with invalid cues (M = 9.7%). The results of the remaining *F* tests were not significant (all *F*s < 2.5, all *p*s > .10).

Comparison of RTs across Experiments 1 and 2. We finally compared the effects of experimenter presence on cueing effects in RTs across experiments in a three-way ANOVA with Cue Type, Experimenter Presence, and Experiment as independent variables. We will only focus on F tests that involve Experiment as an independent variable. Neither the main effect of Experiment nor the two-way interaction of Experiment × Experimenter Presence was significant (both $F < 1$). However, the Experiment × Cue Type interaction was significant, $F(1,60) = 8.65$, $MSE = 319.12$, $p < .01$, indicating a larger Cueing effect in Experiment 2 (valid cues: 551 ms; invalid cues: 577 ms) compared to Experiment 1 (informative cues: 565 ms; noninformative cues: 578 ms). Finally, the most important result was a significant three-way interaction, $F(1,60) = 4.01$, $MSE = 209.421$, $p = .050$. The three-way interaction reflects the fact that experimenter presence reduced (i.e., eliminated) a cueing effect in Experiment 1 (symbolic cues), but not in Experiment 2 (peripheral or physical cues).

DISCUSSION

The major result of Experiment 2 was that the presence of an invisible audience did not affect the exogenous orienting of spatial attention to the location of a physical cue that preceded a target stimulus by 100 ms. This result differs from the findings in Experiment 1 where the presence of an invisible audience had eliminated the deliberate processing of symbolic cues. Consistent with the results of Experiment 1, however, the presence of another person again did not affect the accuracy of target-discrimination performance. These results of Experiment 2 are consistent with the highly automatic character of processing physical cues that appear at possible target locations. Thus, the presence of the experimenter either grabbed resources (e.g., working memory or attention) that were not needed for the processing of the physical cues, or the presence of the experimenter occupied resources (e.g., spatial attention) that were timely redirected to the location of the physical cues when they appeared in the visual field. These results clearly do not support the predictions of the habitual dominance account (Zajonc, 1965), which predicted an increase of cueing effects in the presence of another person. Furthermore, also the attentional focusing account is at odds with the present findings, although one might argue that attentional focusing is not strong enough to modulate the automatic reallocation of attention to peripheral cues.

GENERAL DISCUSSION

The aim of the present study was to investigate how the presence of a person that remained outside the participants' field of view affects the control of voluntary and involuntary visuospatial attention. In both experiments, we found the typical cueing effects for physical and symbolic cues when the subjects were alone in the laboratory room (e.g., Jonides, 1981; Posner et al., 1980; Posner & Cohen, 1984).

However, across experiments we found evidence for differential effects of social presence on the allocation of attention, depending on the cue type. Whereas physical cues (Experiment 2) were unaffected by the presence or absence of a person in the laboratory, the processing of symbolic cues was disrupted by the presence of another person, even though this person remained outside the field of view of the participant.

Overall, the results are neither compatible with the habitual dominance account (Zajonc, 1965), nor with the attentional focusing account (Baron, 1986). The habitual dominance account assumes that social presence should lead to an increase of drive and arousal, subsequently enhancing the processing of dominant, habitual responses. If one assumes that the redirection of attention according to a cue is a habitual response, this should enhance the use of the cue and increase cueing effects, regardless of the cue type. However, both experiments clearly do not support this prediction.

The attentional focusing account states that social presence leads to a focusing of attention resulting from a perceived threat of distraction (see also Huguet et al., 1999). However, any focusing of attention should result in an enhancement of processing at the currently fixated position, whereas peripheral events should be (at least to some extent) neglected. This framework predicts greater cueing effects for central cues, but smaller cueing effects for peripheral cues. Again, these predictions are not compatible with the present findings.

The results of our experiments quite nicely fit the assumption that the processing of symbolic cues relies on (limited) working memory resources (Jonides, 1981), and that the same resources are likely to play a role in monitoring and representing the behavior of another person in the same room, even (or especially) when this person is not directly visible. An alternative explanation of the present results might be that the experimenter attracts spatial attention in a somewhat similar way as peripheral cues do, which subsequently interferes with the response to the symbolic cues. This would mean that in Experiment 1, a (constantly present) physical cue interferes with the symbolic cues, in turn attenuating its effectiveness. This would imply that attentional capacity is limited, and that both types of cues compete for access to these resources. Such an explanation could be further evaluated on the basis of more elaborate measures of the allocation of attention, such as eye movements.

It is not clear whether the presence of the experimenters caused evaluation threat in the participants (e.g., Feinberg & Aiello, 2006; Guerin, 1989) and, thus, whether such evaluation threat was involved in interfering with the processing of symbolic location cues in Experiment 1. However, we do not believe that evaluation threat was very large in our experiments for at least four reasons. First, participants had good reasons for attributing the presence of the experimenter to convenience (i.e., there was no waiting facility outside the laboratory) rather than to the purpose of monitoring their behavior. Second, participants could easily realize that experimenters should have difficulties in monitoring their performance because they blocked the experimenters view on the monitor which was the only source for monitoring the participants' performance. Third, almost no participant complained about the experimenter presence in the interview performed after the experimental session. Fourth, experimenter presence never interfered with the participants' performance on the primary task (i.e., there were no significant main effects of experimenter presence), which could be expected if experimenter presence induced feelings of threat or anxiety in the participants. Thus, to summarize, we do not believe that the presence of the experimenter induced strong feelings of evaluation threat or anxiety in our participants. Rather, we believe that our participants were simply distracted by the mere presence of the experimenter, and this distraction interfered with processing symbolic location cues, but not with the processing of physical cues.

The present findings extend previous empirical evidence demonstrating social effects on the allocation of spatial attention. Research has shown that the gaze and/or gestures of other persons are used to align one's attention to that of the observed person (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Frischen et al., 2007; Langton & Bruce, 1999, 2000). However, these studies imply that the other person is within the participants' field of view, whereas the present results extend these findings by showing that even persons that remain outside the current field of view can modulate one's attentional functions.

Another line of research suggested that social presence also affects performance in the Stroop task, leading to fewer interference of irrelevant (word meaning) information on the processing of the relevant information (ink color of the word), which was explained within the attentional focusing framework (Huguet et al., 1999). However, a subsequent study (Klauer et al., 2008) questioned whether these results were indeed an effect of attentional focusing, but rather a byproduct of specific task instructions, therefore representing effects of social presence on the prioritization of specific task demands. Additionally, the Stroop task does not allow studying the effects of peripheral cues on attentional orienting. The present results therefore represent a more unequivocal demonstration of the effects of social presence on the control of spatial attention.

In sum, we showed that the presence of a person in the laboratory can disrupt the use of symbolic location cues, probably resulting from competition for limited working memory and/or attentional resources, whereas social presence failed to affect the more automatic processing of physical location cues.

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