Reversed effects of spatial compatibility in natural scenes

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Effects of spatial stimulus–response compatibility are often attributed to automatic position-based activation of the response elicited by a stimulus. Three experiments examined this assumption in natural scenes. In Experiments 1 and 2, participants performed simulated driving, and a person appeared periodically on either side of the road. Participants were to turn toward a person calling a taxi and away from a person carelessly entering the street. The spatially incompatible response was faster than the compatible response, but neutral stimuli showed a typical benefit for spatially compatible responses. Placing the people further in the visual periphery eliminated the advantage for the incompatible response and showed an advantage for the compatible response. In Experiment 3, participants made left–right joystick responses to a vicious dog or puppy in a walking scenario. Instructions were to avoid the vicious dog and approach the puppy or vice versa. Results again showed an advantage for the spatially incompatible response. Thus, the typically observed advantage of spatially compatible responses was reversed for dangerous situations in natural scenes.

Spatial compatibility research analyzes reaction time (RT) and accuracy for stimuli that share spatial features with the response (Fitts & Deininger, 1954). A usual finding is that two-choice reactions are faster and more accurate when stimulus sides and response sides correspond than when they do not (spatial compatibility effect; for an overview, see Proctor & Vu, 2006). Importantly, the spatial relation between stimuli and responses still affects performance when stimulus position is irrelevant for the task (Simon effect; see Simon, Hinrichs, & Craft, 1970). The irrelevant spatial information remains effective even when it belongs to a different spatial event (Hommel, 1996; Shiu & Kornblum, 1999) or different task (Müsseler, Koch, & Wühr, 2005; Müsseler, Wühr, & Umiltà, 2006).

American Journal of Psychology
Fall 2009, Vol. 122, No. 3 pp. 325–336 •

Especially the latter findings have inspired dual-route models to explain effects of spatial compatibility (Hommel, 1997; Kornblum, Hasbroucq, & Osman, 1990). These models postulate two independent routes of response selection. An indirect route processes the task-relevant stimulus feature and activates the assigned response in accordance with the task instruction. In addition to the indirect route, stimulus location is assumed to activate the spatially corresponding member of the current response set through a direct route. In spatially corresponding conditions, the stimulus position activates the correct response code, and the required response is quickly executed. However, in spatially noncorresponding conditions, the stimulus position activates a response different from that required by the relevant stimulus feature. The resulting response conflict increases the time needed to select the response and the probability of selecting a wrong response.

It is widely believed that position-based response activation through the direct route is an automatic process (Kornblum et al., 1990; Zhang, Zhang, & Kornblum, 1999). Automatic processes are defined as being independent of processing capacity (e.g., attention) and to be independent of the current intentions of the individual (cf. Brown, Gore, & Carr, 2002; Posner & Snyder, 1975; Shiffrin & Schneider, 1977). The results of electrophysiologic studies showing that task-irrelevant stimulus location can activate spatially corresponding hand areas in the primary motor cortex of humans (e.g., De Jong, Liang, & Lauber, 1994) seem to support the idea that position-based response activation in compatibility tasks occurs automatically. However, Valle-Inclan and Redondo (1998) observed that stimulus position did not activate spatially corresponding hand areas in the primary motor cortex when participants did not know the relevant stimulus–response (S–R) mapping for the upcoming trial (see also Valle-Inclan, Hackley, & de Labra, 2002). This result suggests that the effects of stimulus position on motor areas are somehow related to the participants' intentions (cf. Ansorge & Wühr, 2004; Hommel, 2000; Lavender & Hommel, 2007).

In this study the automaticity assumption of position-based response activation is addressed with stimuli associated with specific intentions. For example, Öhman, Flykt, and Esteves (2001) observed with a visual detection task that RTs are shorter for threatening stimuli (e.g., snakes or spiders) than nonthreatening stimuli (e.g., flowers or mushrooms) (see also Flykt, 2006; Lipp, Derakshan, Waters, & Logies, 2004). The authors assumed an evolutionary advantage of processing fear-relevant stimuli in order to be prepared for actions (cf. LoBue & DeLoache, 2008; Öhman, 1993). Other studies cast doubts on the evolutionary basis of the effect, because the RT advantage was also observed with modern threatening stimuli (e.g., guns and knives) (Blanchette, 2006; Brosch & Sharma, 2005) and with nonthreatening, positively valenced stimuli (e.g., puppies or kittens) (Tipples, Young, Quinlan, Broks, & Ellis, 2002).

A related finding is that stimulus valence is linked preferentially with avoidance or approach behavior. For example, in a study by Chen and Bargh (1999; see also Eder & Rothermund, 2008; Lang, Bradley, & Cuthbert, 1990; Rinck & Becker, 2007), participants were asked to evaluate negative and positive target words by moving a lever toward the body (approach response) or away from it (avoidance response). For positive words, pulling movements were faster than pushing movements, but for negative words pushing movements were faster than pulling movements. Consequently, the authors suggested that positive stimuli activate approach behavior in an automatic manner, and negative stimuli activate avoidance behavior (cf. the affective Simon effect; e.g., De Houwer, Crombez, Baeyens, & Hermans, 2001).

Investigations of spatial compatibility with stimuli of negative and positive valence are rare. An exception is a recent study by Lavender and Hommel (2007) in which participants carried out approach and avoidance responses to either the valence or the spatial orientation of affectively charged pictures. Under affective instruction the positive–approach, negative–avoid mapping yielded faster responses than the positive–avoid, negative–approach mapping, but no effects were observed with regard to the spatial orientation. Conversely, effects of spatial orientation were obtained under spatial instruction, with no effects of the affective components. However, in the study by Lavender and Hommel, orientation was the spatial stimulus feature, whereas stimulus position is the spatial feature in most spatial compatibility research.

In the present study, the position of stimuli was explicitly varied to further examine spatial effects with stimuli of positive and negative valence. Two natural contexts were chosen as experimental scenarios (driving a car and taking a walk). While driving a car, for example, the driver often has to react immediately to visual information that is spatially localized. However, research on spatial compatibility has widely ignored driving situations. Exceptions are studies by Wang and colleagues (see also Bayliss, 2007). Wang, Proctor, and Pick (2003) analyzed the influence of auditory warning signals on steering wheel responses. Participants were told that tones presented to the left or right ear were warning signals from a collision avoidance system and were instructed to respond to the signals "as if they were driving their own car" (Wang et al., 2003, p. 228). They were instructed that the signals indicated the location of the danger source, from which they were to turn away, or the escape direction, toward which they were to turn. Spatial compatibility effects predict that it would be most beneficial to have the tone correspond to the desired response direction. Because of the stimulus valence of warning signals—you typically turn away from sounds created by hazards—an avoidance behavior, that is, turning away from the warning tone, might be more compatible than responding toward it. Wang et al. found a typical spatial compatibility effect, suggesting that spatial compatibility was the primary factor influencing performance.

More recently, though, Wang, Pick, Proctor, and Ye (2007) found that when participants engaged in a simulated driving scenario, they were faster at turning away from the collision avoidance signal than toward it. This latter result suggests that when they are driving, people's responses to warning signals may follow valence principles, not the principles of spatial compatibility. However, response latencies in this study were long (about 4s) because participants typically waited until they perceived the encroaching vehicle to respond, implying that the results may have been due to participants directing attention in the direction of the impending threat to facilitate its detection.

The aim of Experiments 1 and 2 was to further analyze whether effects of spatial compatibility hold for critical situations in driving. During driving, the visual information necessitating drivers' responses can often have a negative valence (e.g., an incautious pedestrian who might bump into the car from the left or right side) or positive valence (e.g., picking up a friend at the left or right side of the street). Applying spatial compatibility assumptions, automatic activation of the ipsilateral response should take place independently from stimulus valence, and if the situation arises, the response tendency has to be corrected for an appropriate contralateral response (e.g., in order to avoid hitting the incautious pedestrian). This should result in an increase of RTs and errors. Because for ethical reasons the driving situation allows only an avoidance response and not an approach response to an incautious pedestrian, a walking scenario was chosen in Experiment 3 to generalize and extend the finding.

EXPERIMENT 1

In the present experiment a simulated taxi driver scenario was used. In short videos from the driver's perspective, a pedestrian entered the street from the left or the right side, either calling a taxi by waving with the arm or causing a critical situation by carelessly entering the street. Participants were instructed to react as quickly as possible by turning the steering wheel clockwise or counterclockwise, either toward the person (to pick the person up) or away from the person (to avoid hitting the person).

The primary purpose of Experiment 1 was to examine whether driving responses in the described scenario follow the assumptions of spatial compatibility. The automaticity assumption of spatial compatibility suggests that to avoid hitting an incautious pedestrian, the ipsilateral response tendency has to be corrected for an appropriate contralateral response. In other words, it predicts an advantage of the ipsilateral response elicited by a person calling a taxi. The alternative would be that spatial compatibility is overruled by stimulus valence, that is, the contralateral response has an RT advantage in order to avoid hitting an incautious pedestrian. Additionally, a control condition with neutral stimuli was introduced through the use of geometric figures as imperative stimuli.

METHOD

Participants

Thirty volunteers (19 female, 11 male) with a mean age of 20.6 years ($SD = 2.6$) were paid for participating in the experiment (10 euros). All participants in the present and subsequent experiments reported normal or corrected-to-normal vision. The group of participants in the present experiment consisted of 16 novices and 14 experienced drivers (driving experience less than 2 years vs. more than 2 years). However, because driving experience did not affect RTs and errors in the subsequent analyses, data were collapsed across this factor.

Apparatus and stimuli

The experiments were carried out in a dimly lit chamber and were controlled by a Macintosh computer with Matlab using the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997). Stimuli were presented on a 22" color CRT monitor (Iiyama MA 203 DTD, 100 Hz, 1,024 × 768 pixels). Participants sat at a table, 500 mm in front of the monitor. They initiated a trial by stepping on an accelerator pedal and responded by turning a steering wheel (Logitech Racing Wheel, 250 mm in diameter). A 45°-deviation of the steering wheel from the home position (straight ahead) determined RT.

The stimuli were either short movies showing traffic scenes (experimental condition) or geometric figures (control condition). Movies were presented at a size of 364 × 284 mm and showed a slow straight-ahead driving scene in different one-way streets from the car drivers' perspective. However, participants' steering wheel rotations did not change the perspective of the scene depicted in the movie. After about 2 s the movie stopped and a picture of a pedestrian (170 × 90 mm, with transparent background in front of the one-way street), who either waved at the street or stepped carelessly on the street, was superimposed 12° to the left or right of the screen center (Figure 1). The waving person was presented frontally, making eye contact with the driver; the careless pedestrian was photographed laterally. A mirrored version of the pictures ensured that the pedestrian entered the scene equally from the left or right.

The geometric figures of the control condition were gray diamonds or squares, which were sized (95 × 95 mm) to be comparable to the distinguishing features of the pedestrians. Figures were also presented 12° from screen center.

FIGURE 1. Stimulus film depicting a driving scene, with a picture of a pedestrian who either waved at the street (bottom picture) or stepped carelessly into the street (upper picture) superimposed to the left or right of the screen center, Experiment 1

Procedure

In the traffic condition, trials started with a static one-way street scene. Two natural scenarios were introduced by instruction: Participants were told to grasp the steering wheel with their preferred hand at the top. In this position, the hand movement and steering wheel direction corresponds to the driving direction (for different results with regard to the hand position, see Guiard, 1983; Proctor, Wang, & Pick, 2004; Stins & Michaels, 1997). When the participant stepped on the accelerator pedal, the movie started. After about 2 s a pedestrian appeared to the right or left side of the street, and participants had to react with a steering wheel movement. The instruction told participants to act as taxi drivers. They were informed that they were driving exclusively on one-way streets, where stopping on the left side was also allowed. They were told to turn toward the side of waving pedestrians to pick them up (compatible S–R relationship). When a careless pedestrian stepped into the street, they were to avoid hitting the pedestrian by turning the steering wheel to the opposite side (incompatible S–R relationship). After the steering wheel response, the screen cleared and participants returned the steering wheel to the home position (straight ahead).

In the control condition the presentation of the movies was omitted; after the step on the accelerator pedal and a 2-s delay, the critical geometric figures (diamonds or squares) were presented, and participants reacted with left or right steering wheel movements. The figures disappeared when the response was made. Participants were instructed to turn away from the stimulus when a diamond was presented (spatially incompatible relationship) and toward the stimulus when a square was presented (spatially compatible relationship).

In all conditions, instructions stressed that participants were to react as quickly as possible. Error feedback was given when participants made a wrong steering wheel response or when RT exceeded 1,500 ms.

Design

The experiment had a two-factorial design with situation (traffic vs. control) and spatial compatibility (ipsilateral vs. contralateral S–R mapping) as within-participant variables. Traffic situation and control situation were presented in separate blocks, with the sequence of blocks balanced between participants, whereas conditions of spatial compatibility were randomized within blocks. In each block, participants performed 192 trials preceded by 16 practice trials.

RESULTS

Median RTs and percentage errors for each participant were entered into two-factorial analyses of variance (ANOVAS). The analysis of RTs showed a significant main effect for situation, $F(1, 29) = 9.8$, $MSE = 3{,}040.1$, $p = .004$, and, more important, a significant interaction of situation and compatibility, $F(1, 29) = 27.8$, $MSE = 339.8$, $p < .001$. The situation main effect indicated shorter RT in the traffic condition (593 ms) than in the control condition (625 ms; Figure 2). Moreover, the interaction between the situation and compatibility revealed a spatial compatibility effect with geometric figures: RTs were 15 ms shorter in the compatible condition than in the incompatible condition, $t(29) = 2.33$, $p = .027$ (always two-tailed). In the traffic situation a reversed effect was observed: RTs were 21 ms shorter in the incompatible condition than in the compatible condition, $t(29) = 2.63$, $p = .014$. In other words, participants were faster at avoiding pedestrians by turning the steering wheel in the opposite direction than they were at picking up pedestrians by turning the wheel toward them.

The analysis of percentage errors basically confirmed the findings in the analysis of RTs. The main effect of compatibility was significant, $F(1, 28) = 6.74$, $MSE = 6.06$, $p = .015$, as was the interaction of situation and compatibility, $F(1, 28) = 6.39$, $MSE = 5.44$, $p = .017$. This interaction indicates that in the traffic condition, the error rate was 2.2% lower in the incompatible condition than in the compatible condition, $t(29) = 3.19$, $p = .003$. Participants reacted more accurately when they had to avoid hitting the pedestrian

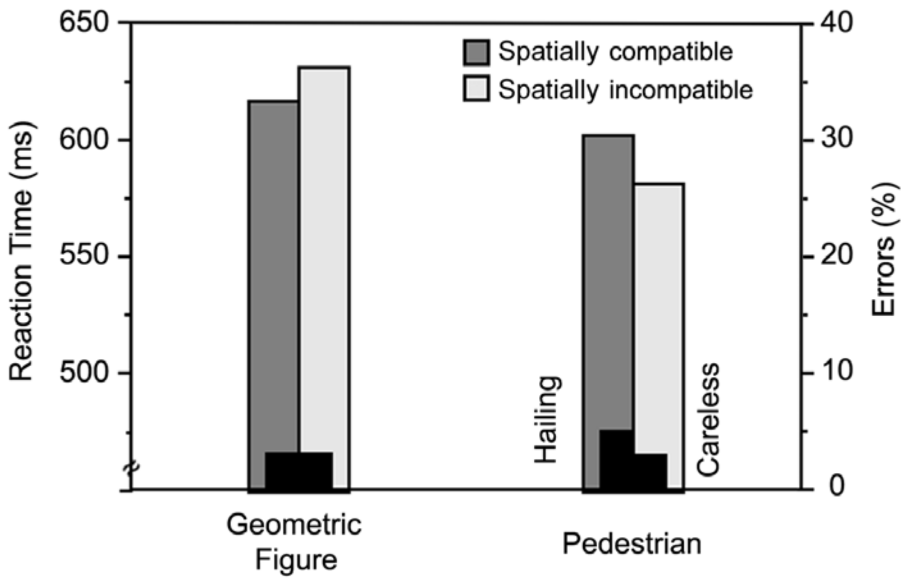

FIGURE 2. Mean reaction times and percentage errors with geometric figures and pedestrians, Experiment 1

by turning the steering wheel in the opposite direction than when they had to approach a waving person at the side of the street by turning the steering wheel toward them. With geometric figures no appreciable difference was observed in the error rates.

DISCUSSION

In the control condition a typical spatial compatibility effect was found, with 15-ms faster ipsilateral responses than contralateral responses. The small size of the spatial compatibility effect is probably due to the trials with compatible and incompatible mappings being mixed (Yamaguchi & Proctor, 2006). The main finding, though, was that driving situations produced a reversed compatibility effect. Spatially contralateral responses (turning the steering wheel away from the person in order to avoid hitting her or him) were faster and more accurate than spatially ipsilateral responses (turning the steering wheel toward the person in order to pick her or him up). In other words, in critical driving situations the usual effect of spatial compatibility is reversed, whereas in the neutral situation, where no stimulus valence existed, the spatial position of the geometric figures yielded superior performance in compatible conditions.

The reversed compatibility effect is evidence against the assumption that the position of a stimulus automatically activates a corresponding response code in critical driving situations. Instead, the response tendency seems to be overruled by stimulus valence. However, whereas the valence of a careless pedestrian is negative in a traffic context, the valence of the alternative target (i.e., a waving person) is not necessarily positive. Nevertheless, the difference between conditions led obviously to the advantage of the critical driving situation with the careless pedestrian.

One might argue that the difference between the two conditions does not reflect a difference in valence. The situation of a person hailing a taxi may not be interpreted as a time-pressured task, in contrast to the task of avoiding a careless pedestrian. So if a taxi driver picks up a passenger, he or she usually aims to park the car nearby the person and does so by estimating the time to contact, which is determined by the optical flow of objects in the movie. This might have slowed down the response compared with the situation in which a driver avoids hitting a careless pedestrian, necessitating an immediate response. However, the instructions were to respond as quickly as possible to both stimuli. We will address this issue again in the discussion of Experiment 2, in which the pedestrians were shifted more to the periphery. This manipulation should not affect the estimated point of contact but the valence, as pedestrians were outside the dangerous area.

One less central finding was observed in Experiment 1. Although the movies and people in the traffic condition had a higher information density than the geometric figures in the control condition, participants showed faster responses in the traffic scenes. Maybe the valence of the traffic scenes generally facilitated response processing, but it is also possible that participants were more prepared to respond through the nearly constant 2-s duration of the traffic movies. In the control condition the presentation of the movies was omitted, and therefore the point in time at which to respond was less specified.

EXPERIMENT 2

The same method was used as in Experiment 1; the only difference was that the photos of the pedestrians were shifted more to the periphery. Now the people appeared closer to the roadside and thus were outside the dangerous area. Consequently, we expected that the more peripheral presentation of the people would reduce or even eliminate their valence for driving and strengthen the role of position in terms of spatial compatibility. Elimination of the reversed spatial compatibility effect in this experiment would provide evidence that the reversal in Experiment 1 was not due to the time to contact to the hailing pedestrian. It also would rule out other factors such as the careless person being easier to identify and the pointing direction of the person crossing the street corresponding with the contralateral response, because such factors are all present in Experiment 2. Thus, elimination of the reversed spatial compatibility effect would strengthen the case that stimulus valence was the critical factor in Experiment 1.

METHOD

Participants

Sixteen participants (10 female, 6 male) with a mean age of 22.9 years (*SD* = 2.3) took part in the experiment.

Stimuli, procedure, and design

The experimental setting was as in Experiment 1 except that the critical stimuli were placed more to the periphery. The movies were scaled down by about 25% to a size of 280 × 218 mm. The pedestrians' pictures and the geometric figures were also scaled down by 25% and appeared 16° to the right or left from the screen center. To be presented at the roadside, pedestrians overlapped with the edge of the movie. As a consequence, they were perceptually not crossing the roadway anymore, as in Experiment 1. With regard to the design, driving experience was omitted from analysis because it did not exert an influence on RT and errors in Experiment 1.

RESULTS AND DISCUSSION

The ANOVA on RTs revealed a main effect of spatial compatibility, with faster reactions in compatible conditions than in incompatible conditions, $F(1, 15) = 6.50$, $MSE = 1{,}211.06$, $p = .022$ (Figure 3). No main effect of situation and, in accordance with assumptions, no interaction between compatibility and situation were observed. In the control condition, RT for compatible (toward) reactions was 559 ms and for incompatible (away) reactions was 585 ms, $t(15) = 2.84$, $p = .006$ (one-tailed). In the traffic condition, RTs were 546 ms for spatially compatible reactions and 564 ms for incompatible reactions, $t(15) = 1.79$, $p = .047$. The ANOVA on percentage errors did not show any significant effects, $F\text{s} < 2$, $p\text{s} > .10$.

In sum, results showed a spatial compatibility effect in the traffic context and in the neutral control. In accordance with our assumption, the more peripheral presentation of the traffic-related pedestrians may have led to a non–danger-related perception of the traffic situation and reduced the tendency for avoidance behavior. However, it might also be that the greater spatial separation of the stimuli increased the contribution of position coding. Either way, results showed a shift in relative weightings of valence and position between Experiments 1 and 2. Moreover, the positive spatial compatibility effect in Experiment 2 provides evidence that the advantage for the incompatible mapping in Experiment 1 was not due to the careless person being identified faster than the waving person or to the directional component of that person's depiction having a strong correspondence with the contralateral response direction. Furthermore, it provides evidence that the time to contact to the person hailing a taxi is not essential for the results of Experiment 1.

EXPERIMENT 3

One shortcoming of Experiment 1 is that the driving situation allows only for single mappings of

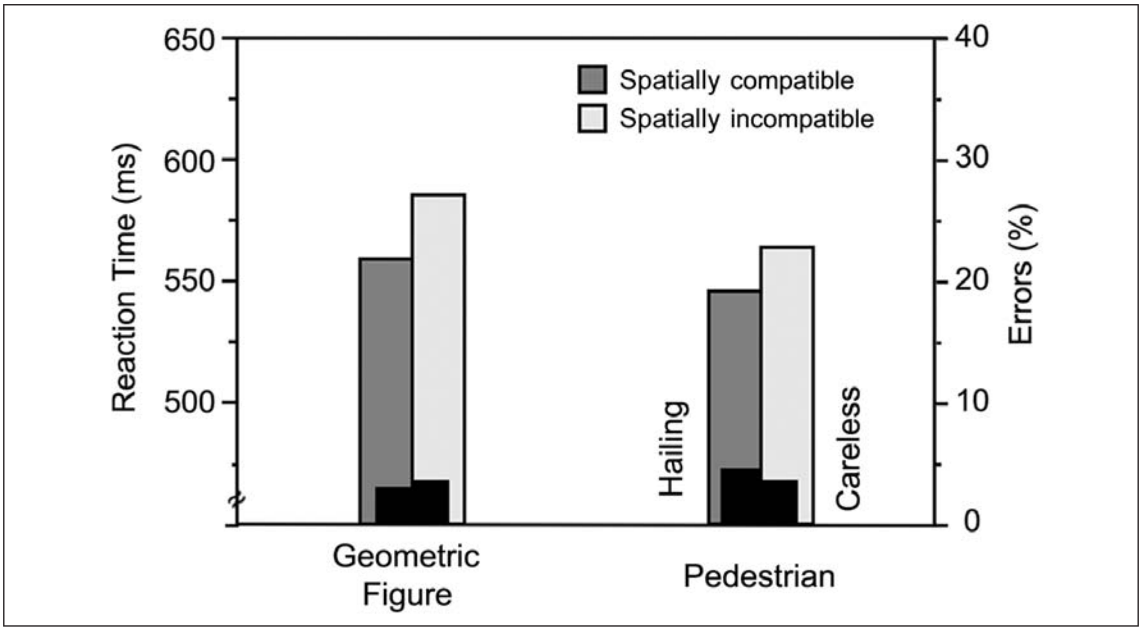

FIGURE 3. Mean reaction times and percentage errors with geometric figures and pedestrians, Experiment 2

stimuli and responses. A careless pedestrian has to be mapped with an avoidance response, and reverse mapping is inappropriate for ethical reasons. It could be that in driving situations a general response tendency exists to respond in opposite directions. In this case the opposite response is favored independently from the stimulus presented.

To prevent this shortcoming and to generalize the findings, the taxi driver scenario was replaced in Experiment 3 by a walking scenario in which pictures of dangerous and harmless dogs were shown. In one condition, photos of a vicious rabies-infected dog and a puppy were presented, and participants were told to avoid the vicious rabies-infected dog and to approach the puppy. The other condition was reversed by instruction: Participants were to avoid the rabies-infected puppy but approach the dangerous-looking one, which they were told was harmless ("his bark is worse than his bite"). A joystick movement in the direction of the dog was defined as approach behavior (spatially compatible response), a joystick movement in the opposite direction as avoidance behavior (spatially incompatible response). In accordance with the previous findings, we expected that spatial compatibility would be overruled by stimulus valence.

METHOD

Participants

Forty participants (25 female, 15 male) with a mean age of 25.9 years ($SD = 7.4$) participated. Participants were randomly assigned to two instruction groups.

Stimuli

The same presentation conditions were used as in Experiment 1, except for the following modifications: Walks through landscapes replaced the traffic scenes. The corresponding movies showed a slow zoom into different landscapes from a walker's perspective. After the movies' presentation, valence stimulation was performed with two dog pictures from the International Affective Picture System (Lang, Bradley, & Cuthbert, 1999). Pictures were displayed in the landscape scene 14° to the left or the right of the screen center. The first picture (160 × 177 mm) showed a vicious-looking Alsatian dog, the second picture (130 × 155 mm) showed a puppy (each with transparent background in front of the landscape scene). Both dog pictures were also used in a mirrored version to enter the scene equally from the left or right. The dogs were introduced to the observers with two different scenarios. Participants' responses were gathered with a joystick (Logitech Attack 3). A 30-mm deviation of the joystick from the home position and its direction determined RT and accuracy.

Procedure and design

The instruction introduced two natural scenarios: One group of observers was told that the Alsatian dog was rabies infected and had kidnapped a puppy. Therefore, they were told to avoid the vicious dog and approach the puppy. The other group of observers was told the reverse: They should approach the vicious-looking Alsatian dog, which was actually quite harmless, but they should avoid the rabies-infected puppy. A joystick movement in the direction of the dogs was defined as approach behavior (spatially compatible response), a joystick movement in the opposite direction as avoidance behavior (spatially incompatible response). Thus, the experimental design results from the between-participant variable instruction and the within-participant variable spatial compatibility.

Participants were instructed to hold the joystick in their dominant hand. The trials started with the presentation of a landscape scene. After participants pressed a button at the top of the joystick, the walk through the landscape started. After about 2 s the picture of a dog was presented on the right or left side, and participants were told to react as quickly as possible with a joystick movement.

RESULTS AND DISCUSSION

The ANOVA on RTs revealed a significant interaction between group and spatial compatibility, $F(1, 38) = 4.40$, $MSE = 1{,}101.08$, $p = .043$ (Figure 4). With the vicious dog, RTs were 25 ms shorter in the spatially incompatible condition than in the compatible condition, $t(19) = 2.53$, $p = .02$ (two-tailed). In other words, when participants had to avoid the vicious dog by moving the joystick in the opposite direction, they were faster than when they had to approach the dog by moving the joystick toward it. With the puppy, RTs did not differ between compatibility conditions, $t < 1$, *ns*. The analysis of percentage errors basically confirmed the RT findings, although only the compatibility factor yielded significance, $F(1, 38) = 4.63$, $MSE = 5.30$, $p = .038$.

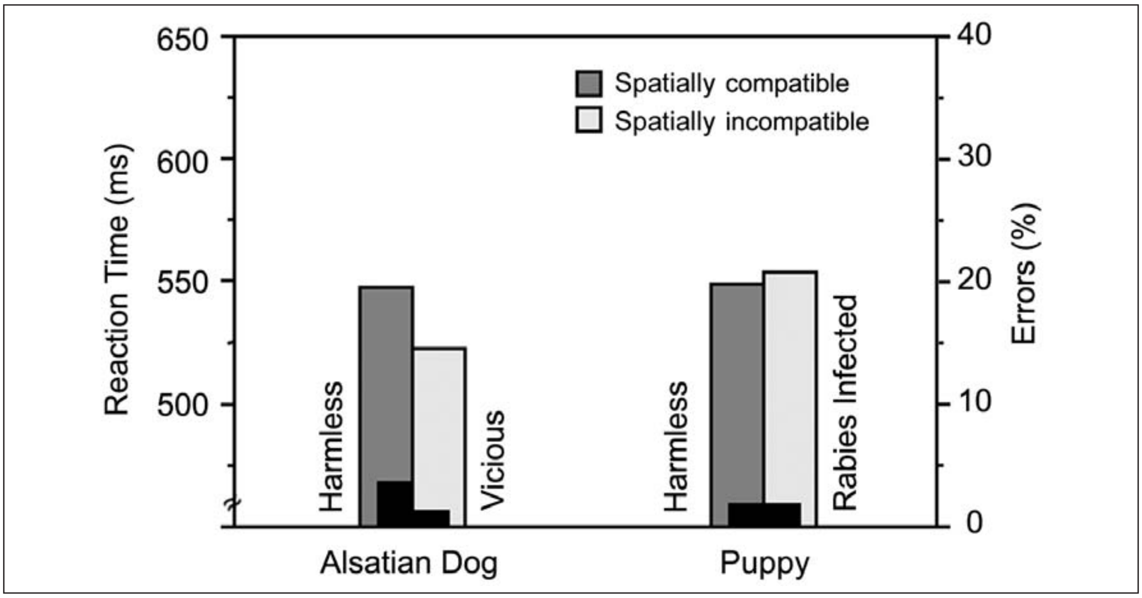

FIGURE 4. Mean reaction times and percentage errors for Alsatian dog and puppy stimuli as a function of mapping instruction, Experiment 3

In accordance with the findings in Experiment 1, the present results with the vicious dog showed that participants' performance was superior when a negatively valenced stimulus had to be avoided, that is, when spatial compatibility was incompatible. Differences were not observed with the puppy. Obviously, this stimulus was not able to elicit approach and avoidance behavior as the vicious dog did.

GENERAL DISCUSSION

Explanations of spatial S–R compatibility often assume that the ipsilateral response is favored by an automatic response tendency elicited by the position of the stimulus. The present experiments examined this automaticity assumption with positively and negatively valenced stimuli in natural scenes. The findings of Experiments 1 and 3 revealed a reversed compatibility effect. Participants showed faster and more accurate reactions when they had to avoid a negatively valenced stimulus such as the careless pedestrian or the dangerous dog. In contrast, with the neutral conditions of Experiment 1, where geometric forms were presented, and with the conditions of Experiment 2, where people were placed further in the visual periphery, superior performance was found with spatially compatible S–R sets compared with spatially incompatible S–R sets. The assumption underlying Experiment 2 was that the more peripheral presentation of the pedestrians led to a nondangerous perception of the traffic situation and thereby eliminated the likelihood of avoidance behavior. This seemed to be the case.

The results are in accordance with other studies suggesting that "automatic" position-based activations require participants' intentions and goals (Ansorge & Wühr, 2004; Hommel, 2000; Lavender & Hommel, 2007). In our experiments intentions and goals were determined with respect to the valence of the stimuli, and results showed that spatial compatibility could be overruled with negative and positive stimuli. It is noteworthy that automaticity has also been used to explain effects with negative and positive stimuli. For example, Neumann, Förster, and Strack (2003) proposed an automatic motivational system, which allows fast and efficient avoidance strategies in dangerous situations and approach strategies in positive situations. It was assumed that higher cognitive processes do not affect this primitive motivational system, which processes stimulus valence automatically in subcortical structures (see also Chen & Bargh, 1999; LeDoux, 1996). Other studies have cast doubt on this conclusion and delivered empirical evidence favoring the mediating role of intentions and goals

(Klauer & Musch, 2002; Rotteveel & Phaf, 2004). As a consequence, Lavender and Hommel (2007) recently concluded that studies of both spatial compatibility and affective valence compatibility point to intentional processes, which set the stage for automatic S–R translation. In their view automaticity is achieved only by virtue of the intentional implementation of the relevant task set (see also Hommel, 2000). Using this as a starting point, the authors developed an approach (an affectively enriched version of the theory of event coding; cf. Hommel, Müsseler, Aschersleben, & Prinz, 2001) able to account for both affective and nonaffective compatibility phenomena.

It might also be that the observed S–R compatibility effects of the present experiment reflect processes other than direct motor activation. According to the response discrimination account (Ansorge & Wühr, 2004; Wühr & Ansorge, 2007), compatibility effects do not necessarily arise from direct interactions between spatial stimulus codes and spatial response (motor) codes but rather from the interaction between spatial stimulus codes and codes representing responses in working memory. The authors demonstrated that participants could flexibly represent responses in working memory (cf. the theory of event coding; Hommel et al., 2001), opening the possibility that the source of the observed interferences in the present experiments is beyond response activation.

Another question that deserves closer attention is why in our experiments left and right movements with the steering wheel or joystick achieved positive and negative valence at all. Movement valence seems to be obvious with movements toward the body (positive valence, approach reaction) or away from it (negative valence, avoidance reaction). Instead, left or right movements may fulfill a distance-regulating function of the motor behavior toward and away from liked and disliked people or animals. An alternative was recently formulated by Eder and Rothermund (2008). They proposed an evaluative response coding view of approach–avoidance behavior and assumed that evaluative implications of response instructions and action goals assign affective codes to motor representations on a representational level that could either match or mismatch the valence of the stimuli reacted to. According to this approach, a steering movement away from a careless pedestrian may be facilitated by a negative connotation of the movement goal (or movement instruction) "away," and a steering movement toward a waving pedestrian might be facilitated by the positive connotation of the action concept "toward." An implication of this approach is that affective motor modulations can be observed with any motor behavior that relies on evaluative coding and that direct correspondence relations between evaluative S–R codes sufficiently explain affective congruency effects without additionally assuming motivational S–R translation systems.

NOTES

We wish to thank Ulrich Ansorge and Andreas Eder for their constructive comments on a previous version of this article and Sina Anders, Claire-Michelle Loock, Markus Röwenstrunk, and Eva Skottke for carrying out the experiments. This research was supported by a grant from the Deutsche Forschungsgemeinschaft (Mu 1298/5) to Jochen Müsseler and Gisa Aschersleben.

Address correspondence about this article to Jochen Müsseler, Psychology Department, RWTH Aachen University, Jägerstrasse 17–19, 52056 Aachen, Germany (e-mail: muesseler@psych.rwth-aachen.de). Received for publication August 27, 2008; revision received November 25, 2008. Action Editor: Donelson E. Dulany.

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