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The (Not So) Social Simon Effect: A Referential Coding Account

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The joint go-nogo Simon effect (social Simon effect, or joint cSE) has been considered as an index of automatic action/task co-representation. Recent findings, however, challenge extreme versions of this social co-representation account by suggesting that the (joint) cSE results from any sufficiently salient event that provides a reference for spatially coding one's own action. By manipulating the salient nature of reference-providing events in an auditory go-nogo Simon task, the present study indeed demonstrates that spatial reference events do not necessarily require social (Experiment 1) or movement features (Experiment 2) to induce action coding. As long as events attract attention in a bottom-up fashion (e.g., auditory rhythmic features; Experiment 3 and 4), events in an auditory go-nogo Simon task seem to be co-represented irrespective of the agent or object producing these events. This suggests that the cSE does not necessarily imply the co-representation of tasks. The theory of event coding provides a comprehensive account of the available evidence on the cSE: the presence of another salient event requires distinguishing the cognitive representation of one's own action from the representation of other events, which can be achieved by referential coding—the spatial coding of one's action relative to the other events.

Keywords: joint Simon effect, action representation, referential response coding, theory of event coding

Studies on human cognition and action have a long tradition of investigating single individuals while they perform tasks that matter mainly for themselves (or the experimenter) and that they can carry out without the help of others. Except for studies explicitly targeting social interactions, the presence of other people is commonly considered a possible experimental artifact that is to be avoided as much as possible. However, recent research has started to address the issue whether and how the cognitive representation of, and the performance on a task might change in the presence of other individuals working on the same task, whether people automatically coordinate their actions, and how they manage to engage in joint action requiring such coordination (e.g., Zajonc, 1965; Bond & Titus, 1983; Guerin, 1986; Liepelt & Prinz, 2011; Liepelt, Stenzel, & Lappe, 2012; Sebanz, Bekkering, & Knoblich, 2006; Sebanz & Knoblich, 2009). One of the most prominent paradigms used to investigate the cognitive representation of coactors is known as the "joint/ social Simon task," which has been developed by Sebanz, Knoblich, and Prinz (2003). In this paradigm, two participants share a task that is commonly used for investigating single participants: the Simon task (Simon & Rudell, 1967; Simon, Hinrichs, & Craft, 1970).

In the standard Simon task, single participants carry out spatially defined responses (e.g., left and right key presses) to nonspatial stimulus attributes (e.g., auditory pitch or visual color) that randomly appear on the left or right side of some reference point (e.g., the center of a screen or a fixation mark). Although stimulus location is entirely irrelevant, responses are faster when they spatially correspond to the stimulus signaling them—the (standard, "solo") Simon effect (Simon & Rudell, 1967). Most models account for this effect by assuming that a match between spatial stimulus locations and spatial response locations facilitates response selection, be it because of a direct association between (e.g., De Jong, Liang, & Lauber, 1994; Kornblum, Hasbroucq, & Osman, 1990) or the identity of the codes representing these locations (e.g., Hommel, 1993; Hommel, Müsseler, Aschersleben, & Prinz, 2001), or because attentional shifts prime spatially corresponding responses (e.g., Nicoletti & Umiltà, 1989, 1994). However, a mismatch between stimulus and response locations is assumed to create competition between the primed response and the response required by the instruction (dual-route model; Korn-

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blum et al., 1990). If participants respond with one response to only one of the two stimuli, rendering the task a "go-nogo task," the individual Simon effect disappears under most circumstances (Hommel, 1996).[1] Most interesting for our purposes, however, the effect reappears if the same go-nogo Simon task is distributed over two participants, so that each of them operates one of the two responses (Sebanz et al., 2003)—the so-called social Simon effect (SSE).

The discovery of the SSE has been considered to demonstrate automatic action/task co-representation (Tsai & Brass, 2007) and, more generally, "the fundamental social nature of perception and action" (Knoblich & Sebanz, 2006). However, an increasing number of observations do not seem to fit with the implications of such co-representational accounts (Dolk et al., 2011; Guagnano, Rusconi, & Umiltà, 2010; Hommel, Colzato, & van den Wildenberg, 2009; Kuhbandner, Pekrun, & Maier, 2010; Liepelt, Wenke, Fischer, & Prinz, 2011; Liepelt, Wenke, & Fischer, 2012; Vlainic, Liepelt, Colzato, Prinz, & Hommel, 2010). For instance, Guagnano et al. (2010) found that the SSE occurs only if the two coactors are sitting side-by-side in reaching distance, but not if the distance increases further. The authors account for this observation by assuming that coactors provide a kind of automatically induced spatial reference frame if, and only if, they are located within a participant's peripersonal space. According to this logic, it is this (peripersonal) reference frame that renders the participant's own action as "left" or "right," whereas without such referential frame, the action would not be spatially coded. Given that the Simon effect is considered to reflect the match or mismatch between spatial stimulus and response codes, it presupposes the existence of spatial response codes, so that in a go-nogo task the effect would appear only if the participant is coding his or her action as left or right, which he or she does as a consequence of the presence of a close-by coactor.

Although Guagnano et al.'s (2010) consideration that the presence of coactors might induce particular spatial reference frames is important (and we will get back to this later), it is insufficient to explain the impact of a number of situational variables on the SSE. For instance, from their approach, it is difficult to understand why the SSE is insensitive to the visibility of the coactor (Vlainic et al., 2010), but highly affected if the participant is in a bad mood (Kuhbandner et al., 2010), or has a negative relationship with the coactor (Hommel et al., 2009). Moreover, a previous study of ours suggested that even the presence of a coactor may be irrelevant for the SSE to occur. In fact, Dolk et al. (2011) demonstrated a Simon-like effect even in the absence of any coactor. They combined an auditory social Simon task with a manipulation of the perceived ownership of a coacting hand. In a first experiment, two individuals coperformed each on one of the stimuli, with one of their hands, while the other hand was hidden from view. Before each trial, the participant's occluded left hand was either synchronously or asynchronously stimulated to the coactors left hand—a manipulation that commonly increases and decreases, respectively, the perceived ownership of other body parts, known as the "rubber hand illusion" (Botvinick & Cohen, 1998). Results showed that the SSE was smaller in the synchronous, as compared with the asynchronous, stroking condition. This finding suggests that the SSE reflects or relies on the separation of spatial action events rather than the integration of the other person's action. It is interesting that reliable SSEs were also found when the coactor did not actively participate in the task and even when there was no other person physically present. However, as the stroking manipulation was still running in the latter condition, it might have induced some sort of action ownership (e.g., over the stroking procedure), so that one might argue that the experimental situation still comprised two active "agents" or "effectors." Nevertheless, it seems clear that the physical presence of another individual—be it within or outside peripersonal space—is not necessary for the SSE to occur.

The observation that the go-nogo Simon effect can be elicited as a consequence of both social and nonsocial action events (Dolk et al., 2011) renders the term social Simon effect potentially misleading and unnecessarily theoretically biased. Accordingly, in the present article, we adopted the more neutral task typology suggested by Donders (1969) and will refer to single and joint go-nogo Simon tasks as "cSE" tasks (as they qualify as Donders' "type c" tasks). Consequentially, we will distinguish between single and joint effects by reserving the term "cSE" (or single cSE for clarity) for the individual go-nogo Simon effect and using the term "joint cSE" for effects resulting from the same go-nogo Simon task when carried out by more than one person.

The aim of the present study was to provide empirical evidence and theoretical arguments for a radical alternative to the available social interpretations of the (joint) cSE: humans may perceive other humans, and even themselves, just like any other event, be it social or nonsocial in nature (Dolk et al., 2011; Hommel et al., 2009). As we will argue, and explain in more detail below, performing a task like the Simon task requires the preparation and selection of intentional actions, which, according to ideomotor theories, are accessed through the activation of the codes representing their perceivable effects (Hommel, 2010; Hommel et al., 2001; Prinz, 1987). In other words, action control operates on perceptual representations of events. Even though these events happen to be produced by, and are thus under the control of, the actor, their representations are not different from the representations of events that are not under the actor's control.

This implies that action control faces a discrimination problem: the actor needs to select the one event representation that is associated with the required action from the set of all currently active event representations.[2] In psychological experiments, care is taken to avoid more stimulation than necessary, so that the selection process will be easy and straightforward. But bringing in another actor, effector, and/or action is likely to challenge the action selection process by introducing other active event representations into the actor's cognitive work-

[1] The only condition under which individual participants can be observed to produce a Simon effect in a go-nogo task is when they have used the alternative response relatively recently (e.g., in the previous trial or just a few trials ago; Hommel, 1996). This observation fits with the claim that we will develop in the present article: that single responses are spatially coded (which is a necessary precondition for the Simon effect to occur) only if sufficiently salient alternative events are cognitively represented, so that the individual needs to discriminate between the representations of this event and the actually required response.

[2] Strictly speaking, this would also include the stimuli used to signal the responses in a task. However, there are reasons to assume that stimulus representations are integrated to some degree with the representations of the responses they signal (Wenke, Gaschler, & Nattkemper, 2007), which renders it unnecessary to select responses "against" stimuli.

space. Solving this selection problem is not unlike selecting stimuli in a task in which relevant targets are mixed with irrelevant distractors, such as in visual search or flanker tasks. Such tasks are commonly assumed to require "directing attention" to the relevant information, which is another term used to refer to the prioritized processing of the attributes of the selected event. To select an event representation against competitors requires the specification of the selection criterion, which in many attentional tasks is assumed to be spatial in nature (Bundesen, 1998; Treisman & Gelade, 1980). This means that introducing additional events to an experimental setting is likely to increase the task relevance of the location of the required response(s). Moreover, the stimuli in a standard Simon task vary in a horizontal location, which renders the horizontal dimension particularly salient. As task relevance can be assumed to increase the weight of codes of event features (Hommel et al., 2001: intentional weighting principle; see Memelink & Hommel, in press) and thereby increase their impact on information processing (i.e., receiving "more attention"), increasing the task relevance of the (horizontal) response location is likely to induce the Simon effect where it otherwise would not occur or increase its size. If so, any sufficiently salient event in a Simon task can be suspected to increase the task relevance of spatial response location and thereby induce a Simon effect or increase its size, especially if the event falls onto the same horizontal dimension as the response.

In contrast to previous approaches to the joint cSE, which all require the presence of another person (e.g., Guagnano et al., 2010; Sebanz et al., 2003; Sebanz, Knoblich, & Prinz, 2005), our radical event alternative denies the necessity of some degree of "socialness" of the experimental situation. In fact, it suggests that any event can produce a (single or joint) cSE, even though social events may be particularly powerful in doing so. In the following, we present five experiments aimed at testing this prediction by systematically decreasing the social nature of the cSE-inducing event. Thereafter, we present our theoretical approach in more detail and discuss how it accounts for the available evidence.

Experiment 1

The aim of Experiment 1 was to investigate whether even a nonsocial coactor on the left can produce a go-nogo Simon effect (cSE) by providing a spatial reference in the horizontal plane that renders the participant's own action on the right. To that end, we had single subjects perform an auditory go-nogo Simon task (as in Dolk et al., 2011) in the presence or absence of a salient nonsocial action event located to their left. This event consisted of a Japanese waving cat, which was present in one block of trials and absent in another. We assumed that the presence of the cat would be sufficiently salient to induce an alternative event representation into the participant's cognitive workspace. To resolve the resulting competition, participants should be more likely to select their response with respect to its relative location (i.e., relative to the cat), which again should render the response location task relevant, and, as a consequence, induce a Simon effect. Accordingly, we expected a Simon effect in the "cat present" condition, but not in the "cat absent" condition.

Method

Participants. Sixteen healthy undergraduate students (eight female; 21–29 years of age (mean [*M*] age = 24.3, standard deviation [*SD*] = 2.3 years), with no history of neurological or hearing problems, participated. All subjects were right-handed as assessed by the Edinburgh Inventory scale (laterality score range: +77 to +100 over a range of −100 (fully left-handed) and +100 (fully right-handed); Oldfield, 1971), had normal or corrected-to-normal vision, were naive with regard to the hypothesis of the experiment, and were paid for their participation.

Task and statistical analysis. Two acoustic signals (A and B), designed by van Steenbergen (2007) were chosen as go and no-go stimuli in an auditory cSE-task and presented via two loudspeakers separated by a distance of one meter at approximately 60 dB to either the left or right side of the subjects. The acoustic signal consisted of two spoken Dutch color words ("groen" [green] and "paars" [purple]) that were compressed and played in reversed order, leading to easily distinguishable sounds (sounding like "oerg" and "chap") without any obvious semantic meaning. Prior to the instruction phase of the experiment, the subjects were seated on the right, next to an empty left chair, and asked to place their right index finger on a response button (25 cm in front of and 25 cm to the right of the midline of a computer monitor), while placing their left hand underneath the table on their left thigh (see Figure 1).

To familiarize subjects with the task, the experiment started with an instruction phase (~5 min) including the presentation of the two signals, their assignment as go and nogo's and a training of eight trials in total. After the instruction phase was completed, the experimental phase started either with the cat present or the cat absent condition; the order was counterbalanced across subjects. During the cat present condition, a golden Japanese waving cat (height: 12.5 cm, width: 9 cm, depth: 7 cm) was placed 50 cm from the subject's response button on the right (see Figure 1), which was the only response button present. The cat kept waving with her left arm at a frequency of 0.4 Hz and an angle of 50° in the vertical plane throughout the entire experimental condition. Participants were able to see the cat in the peripheral visual field (subtending a visual angle of 35.2° × 21.34°) and to hear the (unpredictable and nonmetrical) sound produced by the waving. The cat absent condition was identical except that the Japanese waving cat was removed, leaving the table on the subject's left empty. In both conditions, subjects were instructed to respond exclusively to the assigned stimulus sound irrespective of its location (left or right) and to keep fixating a white fixation cross in the center of a computer monitor in front of them (subtending a visual angle of 1.9° × 1.9°; Figure 1).

There were four blocks of 64 trials for each go and nogo-signal (32 with a spatially compatible stimulus–response (S–R) relationship and 32 with a spatially incompatible S–R relationship). Each trial began with the presentation of a warning sound for 300 ms. After 700 ms, the critical sound—either signal A or B—was presented for 300 ms to the right or the left side of the subject, who was instructed to respond as quickly and as accurately as possible to their individual target signal (either signal A or B, balanced across subjects). After a response was given or 1700 ms had

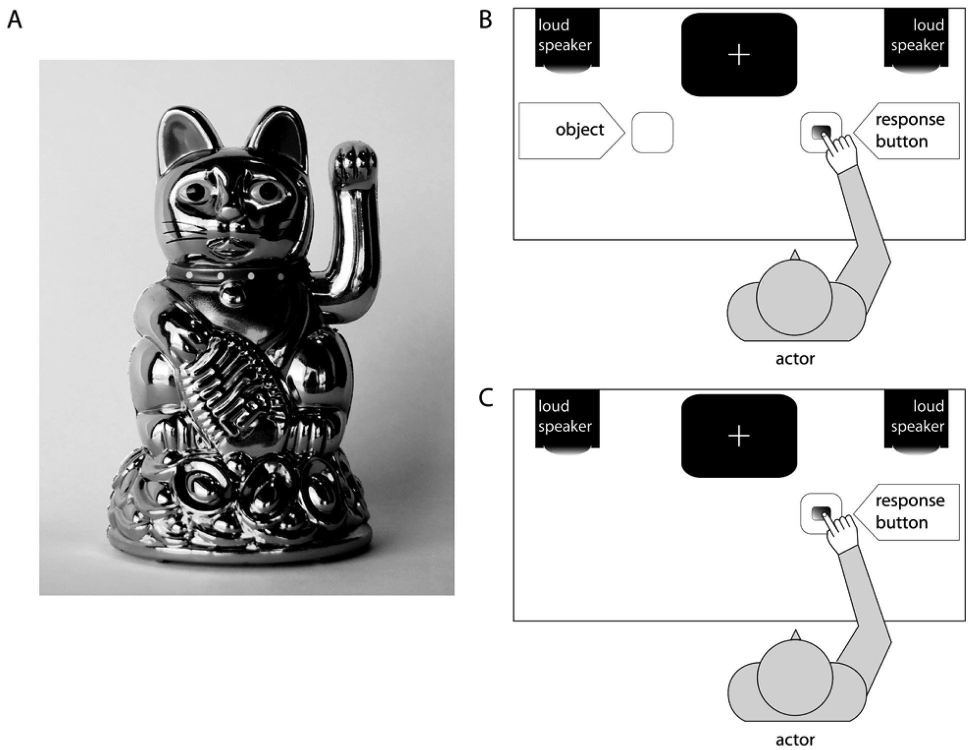

Figure 1. Experimental setting. (A) Implemented object in (B) the cat present condition; (C) illustrates the cat absent condition.

passed, a 1000-ms interstimulus interval (ISI) followed. The whole experiment took approximately 40 min.

For statistical analysis, we excluded all trials in which the responses were incorrect (0.1%) and/or the reaction times (RTs) were above or below 2.5 *SD* of the individual RT mean per design cell (2.3%). Responses were coded as compatible (stimulus ipsilateral to the correct response side) and incompatible (stimulus contralateral to the correct response side). To investigate the cSE, correct RTs were submitted to a repeated-measures analysis of variance (ANOVA) with the within-subjects factors compatibility (compatible, incompatible) and condition (cat present, cat absent). To gain insights into the temporal dynamics of the auditory cSEs, we ran additional bin analyses. To that end, we computed, separately for each condition and participant, the RT distributions, which we divided into four bins (quartiles). These data were analyzed by means of an ANOVA with condition, S–R mapping, and bin as factors.

Results

Reaction times. The ANOVA revealed a significant main effect of compatibility, $F(1, 15) = 18.90$, $p < .01$, partial $\eta^2 = 0.56$, showing that responses were faster with S–R compatibility (mean RT = 336 ms) than with S–R incompatibility (mean RT = 349 ms), leading to an overall cSE of 13 ms. More important, the compatibility effect varied between conditions, as indicated by a significant interaction of Compatibility × Condition, $F(1, 15) = 5.24$, $p < .05$, partial $\eta^2 = 0.26$ (see Figure 2). The 19-ms compatibility effect observed in the cat present condition was significant, $F(1, 15) = 23.86$, $p < .001$, partial $\eta^2 = 0.61$, whereas the 7-ms compatibility effect in the cat absent condition was not, $F(1, 15) = 3.28$, $p > .05$, partial $\eta^2 = 0.18$ (see Figure 2). The main effect of condition was far from significant, $F(1, 15) < 1$, partial $\eta^2 = 0.06$. To check for possible task order effects, we performed an additional ANOVA with order as a between-subjects factor, but the three-way interaction was not reliable, $F(1, 14) = 2.16$, $p > .05$, partial $\eta^2 = 0.13$.

Reaction time distribution. Apart from significant main effects of compatibility, $F(1, 15) = 20.72$, $p < .001$, partial $\eta^2 = 0.58$, and bin, $F(3, 45) = 136.35$, $p < .001$, partial $\eta^2 = 0.90$, the

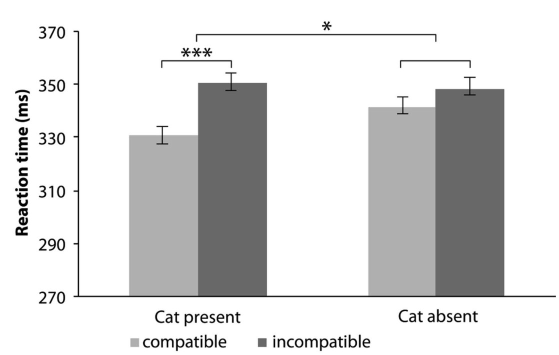

Figure 2. Mean RT as a function of condition (cat present, cat absent) and spatial S–R compatibility (compatible, incompatible). Error bars represent standard errors of the mean differences. * $p < .05$. *** $p < .001$.

analyses revealed a significant interaction between compatibility and condition, $F(1, 15) = 5.53$, $p < .05$, partial $\eta^2 = 0.27$ (for details see RT results and Table 1). No further main effect or interaction reached significance (all *p*s > 0.05).

Error rates. Neither the effects of compatibility, $F(1, 15) = 2.45$, $p > .05$, partial $\eta^2 = 0.14$, and condition, $F(1, 15) < 1$, partial $\eta^2 = 0.01$, nor the interaction of Compatibility × Condition, $F(1, 15) < 1$, partial $\eta^2 = 0.01$, were significant.

Discussion

Experiment 1 investigated whether a nonsocial action event would be able to produce an cSE. Consistent with our hypothesis, the results showed a reliable cSE in the cat present condition, but not in the cat absent condition. This effect, however, was unaffected by response speed. Even though this demonstrates that the presence of a human coactor is unnecessary for the effect to occur, one might argue that the cat's face and arm movement induced a certain degree of socialness, which might be sufficiently similar to the presence of a human being. To rule out this possibility, we conducted a second experiment.

Experiment 2

The aim of Experiment 2 was to determine whether the results obtained in Experiment 1 were due to the "social/biological" movement features of the Japanese waving cat. To that end, we repeated Experiment 1 with an irrelevant action event that was devoid of any social or biological features: a clock.

Method

Sixteen new healthy undergraduate students (10 female; 20–32 years of age, $M = 24.5$, $SD = 3.0$ years) with no history of neurological or hearing problems participated in Experiment 2. They fulfilled the same criteria and were treated in the same way as the participants in Experiment 1. The experimental set-up, including design, task, stimuli, and amount of trials, and the procedure were as in Experiment 1, except that the Japanese waving cat was replaced by a golden clock (height: 12.0 cm, width: 8.0 cm, depth: 8.0 cm) that contained a visible continuously rotating element and emitted an audible ticking sound (see Figure 3).

Results

Reaction times. A 2 (compatibility: compatible, incompatible) × 2 (condition: "clock present," "clock absent") repeated-measures ANOVA revealed a significant interaction of Compatibility × Condition, $F(1, 15) = 6.77$, $p < .05$, partial $\eta^2 = 0.31$ (see Figure 4). The 10-ms compatibility effect observed in the clock present condition was significant, $F(1, 15) = 9.87$, $p < .01$, partial $\eta^2 = 0.40$, whereas the 1-ms compatibility effect in the clock absent condition was not, $F(1, 15) < 1$, partial $\eta^2 = 0.01$ (see Figure 4). The main effects of condition, $F(1, 15) < 1$, partial $\eta^2 = 0.03$, and compatibility, $F(1, 15) = 4.23$, $p > .05$, partial $\eta^2 = 0.22$, were not significant. An additional ANOVA, with order as a between-subjects factor did not yield a reliable three-way interaction, $F(1, 14) < 1$, partial $\eta^2 = 0.01$.

Reaction time distribution. Apart from significant main effects of compatibility, $F(1, 15) = 4.60$, $p < .05$, partial $\eta^2 = 0.24$, and bin, $F(3, 45) = 299.94$, $p < .001$, partial $\eta^2 = 0.90$, the analyses revealed a significant interaction between compatibility and condition, $F(1, 15) = 6.95$, $p < .05$, partial $\eta^2 = 0.32$ (for details see RT results). Moreover, the three-way interaction of Compatibility × Condition × Bin was significant, $F(3, 45) = 3.97$, $p < .05$, partial $\eta^2 = 0.21$, indicating an increasing influence of mapping with increasing RTs between conditions (see Table 1). Single comparisons revealed a significant influence of S–R mapping only in the last bin, $F(1, 15) = 9.66$, $p < .01$, partial $\eta^2 = 0.39$. Note, however, as the last bin typically contains more vari-

Table 1
Reaction Times (RTs) as a Function of RT Quartile (Bin) and Stimulus–Response (S–R) Mapping for Each Condition and Experiment

Experiment	Condition	S–R mapping	Bin 1	Bin 2	Bin 3	Bin 4
1	Cat present	Compatible	258	303	347	415
		Incompatible	273	320	364	442
	Cat absent	Compatible	263	311	355	432
		Incompatible	269	316	362	444
2	Clock present	Compatible	241	281	324	391
		Incompatible	248	288	330	413
	Clock absent	Compatible	235	279	319	389
		Incompatible	240	283	318	386
3	Metronome present	Compatible	277	319	361	449
		Incompatible	281	329	372	456
	Metronome absent	Compatible	272	317	356	432
		Incompatible	271	316	354	425
4	Metronome left	Compatible	249	291	330	401
		Incompatible	255	299	339	408
	Metronome right	Compatible	257	298	339	416
		Incompatible	257	305	349	424
5	Metronome present	Compatible	262	303	340	417
		Incompatible	262	308	351	428
	Metronome absent	Compatible	260	299	344	428
		Incompatible	258	301	344	420

Note. All RTs in milliseconds.

Figure 3. Implemented object in the clock present condition of Experiment 2. For details see text.

ance, the significant effect for the last bin should be treated with caution (Zhang & Kornblum, 1997).

Error rates. Neither the effects of compatibility, $F(1, 15) < 1$, partial $\eta^2 = 0.05$, and condition, $F(1, 15) = 1.12$, $p > .05$, partial $\eta^2 = 0.07$, nor the interaction of Compatibility × Condition, $F(1, 15) < 1$, partial $\eta^2 = 0.02$, were significant.

Discussion

The aim of Experiment 2 was to investigate whether the results obtained in Experiment 1 were due to the "social/biological" movement features of the Japanese waving cat. Exchanging biological by nonbiological movement features revealed a significant cSE only in the presence of salient action events (clock present condition), which increased with increasing RT. To test whether the socialness increased the effect obtained in Experiment 1, we combined the data of Experiment 1 and 2 and performed an ANOVA with compatibility (compatible, incompatible) as a within-subjects factor and experiment (Experiment 1 – cat present condition, Experiment 2 – clock present condition) as a between-subjects factor. This analysis revealed no significant interaction. In line with previous findings (Dolk et al., 2011), the present results strongly suggest that even salient nonsocial events can produce an cSE in single conditions and suggests that the cSE in the Dolk et al. (2011) study was implemented by salient action events produced by the stroking device and not by some sort of ownership over the stroking device.

Experiment 3

Even though the outcome of Experiment 2 demonstrates that social cues are not necessary to produce an cSE, the bystander clock still performed some visible work (expressed by the rotation movement), which we aimed to eliminate in Experiment 3. We did so by replacing the clock by a metronome that still produced some sort of clicking sound but did not move in any way. According to our theoretical approach, the sound should still be salient enough to draw attention, so that we expected to find an cSE in the "metronome present," but not in the "metronome absent" condition.

Method

Sixteen new healthy undergraduate students (12 female; 20–32 years of age, $M = 24.8$, $SD = 3.8$ years) with no history of neurological or hearing problems participated in Experiment 3. They fulfilled the same criteria and were treated in the same way as the participants in the previous two experiments. The experimental set-up including design, task, stimuli, and amount of trials, and the procedure were the same as in Experiments 1 and 2, except that the clock was replaced by a black metronome (height: 9.5 cm, width: 6.5 cm, depth: 3.5 cm) without any moving components (see Figure 5). In the metronome present condition, the metronome was audibly ticking with 80 beats per minute.

Results

Reaction times. A 2 (compatibility: compatible, incompatible) × 2 (condition: metronome present, metronome absent) repeated-measures ANOVA revealed no significant main effect of compatibility, $F(1, 15) = 1.12$, $p > .05$, partial $\eta^2 = 0.07$. However, the compatibility effect varied between conditions, as indicated by a significant interaction of Compatibility × Condition, $F(1, 15) = 4.74$, $p < .05$, partial $\eta^2 = 0.24$ (see Figure 6). The 8-ms compatibility effect observed in the metronome present condition was significant, $F(1, 15) = 4.72$, $p < .05$, partial $\eta^2 = 0.24$, whereas the inverse compatibility effect in the metronome absent condition was not (−3 ms) $F(1, 15) < 1$, partial $\eta^2 = 0.05$ (see Figure 6). The main effect of condition was not significant, $F(1, 15) < 1$, partial $\eta^2 = 0.05$. An additional ANOVA with order as between-subjects factor did not yield a reliable three-way interaction, $F(1, 14) < 1$, partial $\eta^2 = 0.01$.

Reaction time distribution. The analysis revealed a significant main effect of bin, $F(3, 45) = 254.61$, $p < .001$, partial $\eta^2 =$

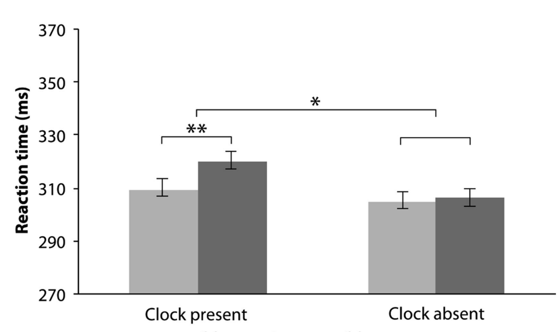

Figure 4. Mean RT as a function of condition (clock present, clock absent) and spatial S–R compatibility (compatible, incompatible). Error bars represent standard errors of the mean differences. * $p < .05$. ** $p < .01$.

Figure 5. Implemented object in the metronome present condition of Experiment 3. For details see text.

0.94, and a significant interaction of Compatibility × Condition, $F(1, 15) = 4.83$, $p < .05$, partial $\eta^2 = 0.24$ (for details see RT results and Table 1). No further main effects or interactions reached significance (all ps > 0.05).

Error rates. Neither the effects of compatibility, $F(1, 15) < 1$, partial $\eta^2 = 0.03$, and condition, $F(1, 15) < 1$, partial $\eta^2 = 0.04$, nor the interaction of Compatibility × Condition, $F(1, 15) = 1.46$, $p > .05$, partial $\eta^2 = 0.09$, reached significance.

Discussion

The aim of Experiment 3 was to test whether the cSE depends on some sort of visible movement produced by the object. However, eliminating all visible movement features still produced a reliable cSE, which was unaffected by response speed. It did not even affect the cSE-size: an additional ANOVA on the combined data from Experiments 2 and 3 involving experiment as a between-subjects factor did not reveal any significant interaction.

Experiment 4

The participants of Experiments 1–3 were all right-handed, so that all the manipulated salient objects were located to the left of the participants' dominant and active hand. According to our theoretical approach, this should not matter because actions would be mainly coded with respect to their relative location (however, see Hommel, 1993, for minor contributions of the identity of the hand when both hands are used). To test that assumption, we replicated the metronome-present condition of Experiment 3 but manipulated the metronome's spatial location ("metronome left" vs. "metronome right").

Method

Sixteen new healthy undergraduate students (11 female; 18–31 years of age, $M = 24.6$, $SD = 4.0$ years) with no history of neurological or hearing problems participated in Experiment 4. They fulfilled the same criteria and were treated in the same way as the participants in the previous experiments. The experimental procedure, as well as the statistical analysis, was as in Experiment 3, with the following exception: The metronome was always present, but located to the left of the subject in one condition (a direct replication of the metronome present condition of Experiment 3) and to the right of the subject in another condition. In the latter condition, subjects were seated on the left next to an empty chair on the right, with the metronome in front of it. In both conditions, which were counterbalanced across subjects, all subjects were instructed to put their right index finger on the response button in front of them, which was located 25 cm left or right to the midline of the computer monitor (see Figure 7). In the metronome right condition, go signals presented through the left loudspeaker were coded as response compatible and go signals presented through the right loudspeaker were coded as response incompatible. In the metronome left condition the coding was the other way around: go signals presented through the right loudspeaker were coded as response compatible and go signals presented through the left loudspeaker were coded as response incompatible.

Results

Reaction times. A 2 (compatibility: compatible, incompatible) × 2 (condition: metronome left, metronome right) repeated-measures ANOVA revealed a significant main effect of compatibility, $F(1, 15) = 29.56$, $p < .001$, partial $\eta^2 = 0.66$ (see Figure 8), showing that responses were faster with S–R compatibility (mean RT = 323 ms) than with S–R incompatibility (mean RT = 330 ms). The main effect of condition, $F(1, 15) < 1$, partial $\eta^2 = 0.02$, and the Compatibility × Condition interaction, $F(1, 15) < 1$, partial $\eta^2 = 0.01$, were not significant. To check for possible task-order effects, we performed an additional ANOVA with order as a between-subjects factor, but the three-way interaction was not reliable, $F(1, 14) < 1$, partial $\eta^2 = 0.01$.

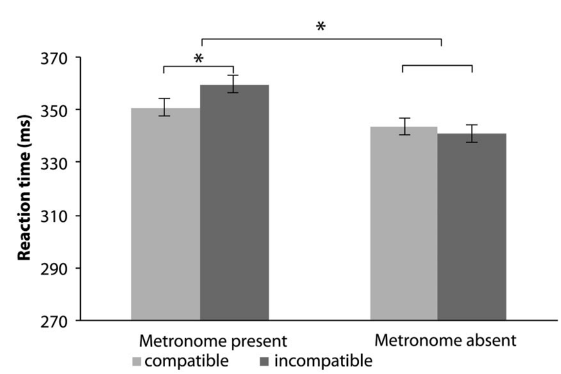

Figure 6. Mean RT as a function of condition (metronome present, metronome absent) and spatial S–R compatibility (compatible, incompatible). Error bars represent standard errors of the mean differences. * $p < .05$.

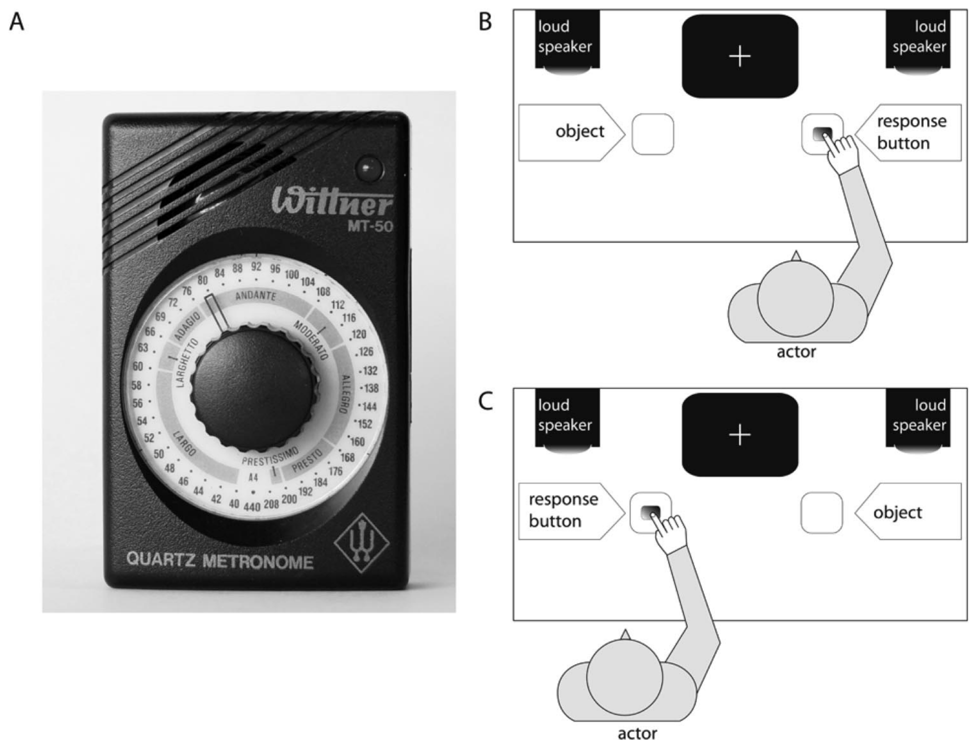

Figure 7. Experimental setting. (A) Implemented object in (B) the metronome left condition, and (C) the metronome right condition.

Reaction time distribution. Apart from a main effect of compatibility, $F(1, 15) = 30.38$, $p < .001$, partial $\eta^2 = 0.67$, and bin, $F(3, 45) = 121.25$, $p < .001$, partial $\eta^2 = 0.89$, the ANOVA revealed no further significant main effect or interactions (all *p*s > 0.05; Table 1).

Error rates. Neither the effects of compatibility, $F(1, 15) < 1$, partial $\eta^2 = 0.02$, and condition, $F(1, 15) < 1$, partial $\eta^2 = 0.04$, nor the interaction of Compatibility × Condition, $F(1, 15) = 1.09$, $p > .05$, partial $\eta^2 = 0.07$, were significant.

Discussion

Experiment 4 provides no evidence for the possibility that the absolute location of the salient object plays any role for the event-induced cSE. The extent of this effect was unaffected by response speed. Apparently, right-located events induce the cognitive coding of left responses as left no less than left-located events induce the cognitive coding of right responses as right.

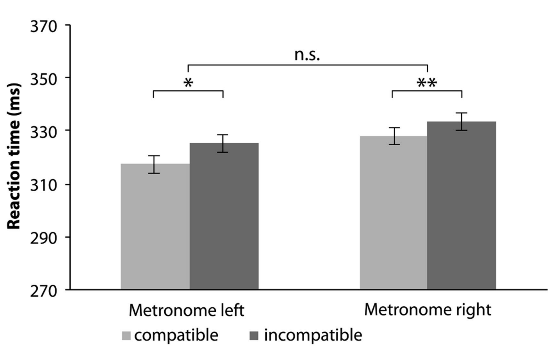

Figure 8. Mean RT as a function of condition (metronome left, metronome right) and spatial S–R compatibility (compatible, incompatible). Error bars represent standard errors of the mean differences. * $p < .05$. ** $p < .01$. n.s. = not significant.

Experiment 5

In all previous experiments, we did not only implement objects, but objects that behaved like events or agents by producing repeated sounds, and—as in the case of the Japanese cat and the clock—visual movements. From an event perspective, these features are important because they increase the eventhood of the manipulation, which we consider to induce or increase the difficulty to distinguish between the event the participant is producing him- or herself (i.e., the response) and an alternative, action-like event. However, other interpretations are possible. For instance, participants might interpret the presence of such relatively unusual objects as potentially meaningful, and the mere act of implementing this object as somehow social or socially relevant. If so, the event-like character of the sounds and movements may be irrelevant and any sufficiently unusual object may produce an cSE. To test this assumption, we designed Experiment 5, which replicated Experiment 3 except that the metronome was no longer producing any sound.

Method

Sixteen new healthy undergraduate students (12 female; 20–28 years of age, $M = 21.8$, $SD = 3.8$ years) with no history of neurological or hearing problems participated in Experiment 5.

They fulfilled the same criteria and were treated in the same way as the participants in the previous four experiments. The experimental set-up, including design, task, stimuli, and amount of trials, and the procedure were the same as in Experiments 1–3, except that the black metronome no longer produced any sound. The "metronome absent" condition was identical, except that the metronome was removed, leaving the table on the subject's left empty.

Results

Reaction times. A 2 (compatibility: compatible, incompatible) × 2 (condition: metronome present, metronome absent) repeated-measures ANOVA revealed neither a significant main effect of compatibility, $F(1, 15) < 1$, partial $\eta^2 = 0.04$ or condition, $F(1, 15) < 1$, partial $\eta^2 = 0.01$, nor a significant interaction of Compatibility × Condition, $F(1, 15) = 2..00$, $p > .05$, partial $\eta^2 = 0.12$. An additional ANOVA with order as between-subjects factor did not yield a reliable three-way interaction, $F(1, 14) < 1$, partial $\eta^2 = 0.01$.

Reaction time distribution. Apart from a significant main effect of bin, $F(1, 15) = 206.10$, $p < .001$, partial $\eta^2 = 0.93$, no further significant main effect or interactions were obtained (all $ps > 0.05$).

Error rates. Neither the effects of compatibility, $F(1, 15) < 1$, partial $\eta^2 = 0.07$, and condition, $F(1, 15) = 2.09$, $p > .05$, partial $\eta^2 = 0.12$, nor the interaction of Compatibility × Condition, $F(1, 15) < 1$, partial $\eta^2 = 0.01$, reached significance.

Discussion

The aim of Experiment 5 was to test whether implemented objects must possess some sort of event character to produce an cSE or whether the mere presence of an object is sufficient. In line with previous findings (Sebanz et al., 2003; Dolk et al., 2011), we did not find any evidence for an cSE in the absence of an attention-attracting event, suggesting that it is dynamic events that are responsible for the cSE.

General Discussion and a Referential Coding Account

The present study was conducted to determine whether the cSE relies on the presence of another social being, or even a human coactor, as assumed by almost all available theoretical accounts of the joint cSE (e.g., Guagnano et al., 2010; Sebanz et al., 2003; 2005). In contrast to this assumption, we were able to demonstrate reliable cSEs in the absence of biological coactors in Experiment 1–4 of this study. In Experiment 1, the mechanic arm movement of a Japanese waving cat was sufficient to induce the effect, as were the movement of a clock in Experiment 2 and the auditory rhythm of a nonmoving metronome in Experiments 3 and 4. Taken together, these findings provide strong evidence that any event, irrespective of its (non-)social or (non-)biological nature, can induce an cSE. Thus, as long as events attract attention and thereby providing a spatial reference frame that allows for coding the participant's own action as left or right, at least auditory S–R compatibility effects are observable. In contrast to this low-level, bottom-up induced modulation of task representation, one might argue that the fact of nonsocial action events implemented by a human experimenter established a deeply social experimental situation that influence an individuals task performance in a rather top-down fashion (see Roepstorff & Frith, 2004, for a more detailed discussion of this issue). However, in line with previous findings (Sebanz et al., 2003), eliminating the event character associated with the implemented object abolishes the cSE (Experiment 5), suggesting that the social setting of an experimental situation alone is unlikely to modulate task representations in a given go-nogo Simon task.

The RT distribution analyses showed that the cSE did not vary (Experiments 1, 3, 4, and 5) or increased with RT (Experiment 2). In contrast, the standard (two-choice) Simon effect commonly decreases with increasing RT (e.g., De Jong et al., 1994; Hommel, 1994), which has been attributed to the decay (Hommel, 1994) or active inhibition (Ridderinkhof, 2002) of the irrelevant spatial stimulus code: the longer it takes to respond, the more progressed is the decay or inhibition, and thus the lesser the impact of stimulus location. Go-nogo versions of the Simon effect show a different distribution profile in which the effect size is constant across, or even increases with the RT level (Hommel, 1996). This is indeed suggested by the widely shared idea that the Simon effect reflects competition between the response that is activated by the irrelevant stimulus location and the response that is intentionally selected (e.g., Kornblum et al., 1990): Response speed is slower in binary-choice tasks, which provides more operation space for spatial stimulus codes to decay. In contrast, responding is relatively fast in go-nogo tasks, so that participants will commonly have responded already before the decay process begins; as a consequence, the size of the effect is rather unaffected by relative response speed within the typical time range of go-nogo tasks (Hommel, 1996). Given that single cSEs tend to produce RT-invariant effect sizes, it is not surprising that joint cSEs do so as well (Liepelt et al., 2011), and the distributions obtained in the present study nicely fit with this pattern.

Before we turn to the theoretical implications of our findings, let us consider an alternative interpretation. Even though our main goal of adding an object or event to the experimental situation was to replace what in the standard joint cSE set up would be a coactor, one might argue that this added event mainly functioned as a distractor. It might have attracted attention and, in order to fully concentrate on the task, participants might have suppressed processing information from the area surrounding the distractor. Considering that this suppression might have affected the entire hemifield, this might have impaired the processing of stimuli presented on the left side. Given that participants operated the right key, this would mean that processing was more efficient for response-compatible than for response-incompatible stimulus locations, for reasons that might not have to do with response selection or a Simon-type effect. Rather, the effect we obtained might represent a kind of inhibition of return effect (IOR; e.g., Maylor & Hockey, 1985; Posner & Cohen, 1984)—an effect that is observed for locations that have been briefly attended and then ignored (i.e., if attention has been moved to another location). Might such a scenario account for our findings?

First, it is important to emphasize that the exact same scenario would also apply to the classical joint cSE (Sebanz et al., 2003; 2005), which then would also be nothing but a spatial attention effect. Even if that would be the case, our main argument would still hold: that the effect does not imply the obligatory and automatic co-representation of actions or other individuals, as suggested by Sebanz et al. (2006; Sebanz & Knoblich, 2009) and others (Tsai & Brass, 2007; Tsai, Kuo, Hung, & Tzeng, 2008; Tsai, Kuo, Jing, Hung, & Tzeng, 2006; Welsh, 2009). Second, even though IOR has also been demonstrated in social situations (Welsh et al., 2005; Welsh et al., 2007), it seems to rely on the perception of action events produced by the coactor to induce processes of selective attention (i.e., active inhibition), whereas joint cSEs have been demonstrated in the absence of any coactor and of any sensory feedback about the coactors' performance (Sebanz et al., 2003; Tsai et al., 2008; Vlainic et al., 2010). Third, it is well known that predictable, highly regular, and repetitive simulation induces habituation (e.g., Lorch, Anderson, & Well, 1984: for overviews, see Cowan, 1995; Näätänen, 1992), which renders it doubtful whether the continuous presence and repetitive sounds of a Japanese cat or a metronome attract attention to a degree that is necessary for IOR to occur. Finally, we know of no evidence suggesting that IOR is sensitive to the same factors that have been demonstrated to impact the joint cSE, such as body ownership (Dolk et al., 2011), self-construal priming (Colzato, de Bruijn, & Hommel, 2012), or religious belief (Colzato, Zech, et al., 2012). Hence, even though our findings do not provide direct evidence against an IOR account, it is rather unlikely to capture the available evidence on the joint cSE.

A more comprehensive account might be based on the referential-coding approach to the standard Simon effect, according to which the spatial stimulus codes that operate in a Simon task depend on the availability of, and reflect frames or objects of reference (Hommel, 1993). Our elaborated version of Hommel's (1993) referential-coding approach is based on the ideomotorically inspired theoretical framework of the theory of event coding (TEC; Hommel et al., 2001; Hommel, 2009). According to this framework, and to ideomotor theory in general (James, 1890; Shin, Proctor, & Capaldi, 2010; Stock & Stock, 2004), actions are cognitively represented by codes of their sensory consequences. In particular, TEC assumes that cognitive action representations consist of networks of codes that represent the features of all perceivable action effects, such as the seen or felt location, direction, and speed of an action, the effector it involves, and the object it may relate to ("action concepts" in the terminology of Hommel, 1997). As a consequence, if a given action is perceived to be left or right from some reference point, the representation of this action will be composed of a corresponding spatial code. If that code is shared by a stimulus, the processing of the stimulus will activate this code and, thus, prime the action, which explains why spatially varying stimuli facilitate spatially corresponding responses (Hommel, 2007). But when is a response or its perceivable effect coded as left or right?

Given that TEC makes no logical distinction between self-performed actions and other perceived events (Hommel et al., 2001), this question can be generalized to the question of when, how, and according to which principles people relate objects and events to each other. The most obvious requirement to relate two or more events is that they are comparable, meaning that they are defined by values on a shared dimension (Olson, 1970). For instance, relating an apple on a table to a sound emitted by a loudspeaker is impossible by referring to the shape or color of the apple or the pitch of the tone (except in a metaphorical way), as these are dimensions that apples and sounds do not share. This consideration makes space and time particularly interesting and privileged, as these are the only two dimensions that almost all conceivable objects and events are defined upon. Accordingly, it is not surprising that spatial, but not nonspatial, features determine people's choice of reference objects when referring to a target object (Miller, Carlson, & Hill, 2011). Within the spatial dimensions, horizontal and vertical, rather than diagonal, relations are particularly salient (e.g., Logan & Sadler, 1996). This suggests that, in a Simon task, in which stimuli typically vary in a horizontal plane, the horizontal dimension can be considered particularly salient.

However, in a standard go-nogo version of the Simon task (or of any other task), obvious reference events are lacking, so that participants are unlikely to code their single response alternative as left or right. Thereby, it seems reasonable that there is typically no overall cSE observed in the single cSE-task (Liepelt et al., 2011; Sebanz et al., 2003; Tsai et al., 2006). However, as soon as a sufficiently salient event affords the referential coding of the response, it becomes more likely that participants do code their response in relation to that event. As spatial location is not only the most obvious but, as in the case of a ticking metronome, often the only shared dimension, the relational code is likely to refer to the response's horizontal location relative to the reference event and its comprised features (e.g., perceivable action sounds)—leading to matches or mismatches of spatial S–R codes. Note, however, this is not to say that the coding of alternative action effects is restricted to the availability of responses (Kiernan, Ray, & Welsh, 2012). Because action effects are cognitively represented by codes of their sensory consequences and the motor pattern which are likely to generate them, responses (i.e., perceivable [auditory or visual] effects of e.g., key presses) are not unlike other sensory effects of an action, as long as they are perceived as the means of an action (e.g., the illumination of a left/right light).

The scenario of referential coding described above does not only account for our observation that nonsocial events are sufficient to produce an cSE in principle (see also, Dittrich, Rothe, & Klauer, 2012; Tsai, Knoblich, & Sebanz, 2011), it might also explain why the size of the cSE shrunk more or less consistently from Experiment 1 to Experiment 4 and finally disappeared in Experiment 5. Even though the corresponding comparisons did not render the differences reliable, it makes sense to assume that the stepwise decrease of the salience of the reference objects throughout Experiment 1–4 reduced the probability that participants generated horizontal relational codes for their actions or the activation levels of these codes. Moreover, in situations where shared action events are lacking, such relational codes appear unnecessary, as indexed by the disappearance of an cSE in Experiment 5. Along the same lines, it is reasonable to assume that different types of coactors or reference objects differ in salience. According to TEC, introducing other salient events introduces a discrimination problem (see Ansorge & Wühr, 2004 for a response discrimination account of the Simon effect): the participant now must discriminate between the event representation that refers to his or her own action and the representation of the other salient event. As we have argued, successful discrimination is likely to rely on relational spatial coding (i.e., on coding one's action as the left or right of the alternative events), which implies that the presence of other events make the emergence of spatial S–R compatibility effects more probable.

It makes sense to assume that discrimination will be more difficult (or necessary) the more similar the to-be-discriminated events are. This suggests that the similarity between stimulus and action events ascribed to the participant and coactor or reference object should matter; in such a way that greater similarity—sharing perceivable (imagined/expected or real; Vlainic et al., 2010) action events on a horizontal S–R dimension—should lead to greater saliency and a more pronounced cSE. Indeed, spatial cues and hints provided by other humans (or pictures thereof) attract more attention than nonpersonal spatial information (e.g., Friesen & Kingstone, 1998; Langton, Watt, & Bruce, 2000). Accordingly, it is not surprising that the (joint) cSE is more reliable if the coactor is a human rather than a computer (Tsai et al., 2008) or puppet (Tsai & Brass, 2007), and more with a puppet coactor after having seen the puppet performing human-like actions (Müller et al., 2011). Given that positive mood induces a more integrating processing style (Hommel, 2012) that can be assumed to increase the perceived similarity between actor and coactor, one would expect a well pronounced (joint) cSE under positive than under negative mood, which is exactly what has been observed by Kuhbandner et al. (2009). Likewise, it is reasonable to assume that a positive relationship between actor and coactor leads to greater perceived similarity (Heider, 1958), which explains why the (joint) cSE is more reliable with a positive than a negative relationship between the two (Hommel et al., 2009). If we further consider that irrelevant events attract more attention the closer they are to the relevant event (Eriksen & Eriksen, 1974; Miller, 1991), it also makes sense that the (joint) cSE increases as the distance between actor and coactor decreases (Guagnano et al., 2010). However, this is not to deny that jointly interacting with another social being on a cSE-task may add something unique to the cognitive representation of task events/demands (Liepelt et al., 2011). Whether top-down (e.g., Müller et al., 2011; Stenzel et al., 2012) or bottom-up processes (as may be suggested by the present findings) account for the discrimination problem that typically leads to a (joint) cSE, the available evidence suggests that it might in any case be achieved by referential response coding. To disentangle the contextual dependencies of the two types of processes clearly awaits further research.

More research is also needed to test whether the present findings, which were obtained with an auditory version of the cSE, can be extended to visual versions. On the one hand, there is no particular reason to believe that spatial action coding is different in auditory and visual tasks, so that manipulations of the implemented objects should yield equivalent findings. On the other hand, it is possible that using auditory stimuli has left more attentional capacity to process visual aspects of implemented events and/or primed participants to process the auditory aspects of those events, which would not be the case in visual Simon tasks. Moreover, the spatial coding of visual stimuli is easier and more prevalent than the spatial coding of auditory stimuli, which might suggest that visual tasks produce stronger effects than obtained in the present study.

Taken together, our considerations suggest that the cSE can be accounted for by applying the basic principle suggested by TEC, without claiming any special status of social situations and the socialness of a coactor or other salient events. As demonstrated, any (reasonably salient) event can produce an cSE, which means that the cSE does not necessarily imply the co-representation of tasks. Nevertheless, given the evidence that the size of the cSE is a function of the actual interpersonal relationship and the perceived interpersonal relationship, it does seem to be a valid diagnostic tool that may be taken to reflect the degree of interpersonal integration (Colzato et al., 2012; Colzato, Zech, et al., 2012; Dolk, Liepelt, Villringer, Prinz, & Ragert, 2012). Hence, although the cSE can occur in nonsocial situations, it seems to be sensitive to the socialness of a situation and might be useful to assess changes therein.

References

Ansorge, U., & Wühr, P. (2004). A response-discrimination account of the Simon effect. *Journal of Experimental Psychology: Human Perception and Performance, 30,* 365–377.

Bond, C. F., & Titus, L. (1983). Social facilitation: A meta-analysis of 241 studies. *Psychological Bulletin, 94,* 265–292.

Botvinick, M., & Cohen, J. (1998). Rubber hands "feel" touch that eyes see. *Nature, 391,* 756.

Bundesen, C. (1998). A computational theory of visual attention. *Philosophical Transactions of the Royal Society B, 353,* 1271–1281.

Colzato, L. S., de Bruijn, E., & Hommel, B. (2012). Up to "me" or to "us"? The impact of self-construal priming on cognitive self–other integration. *Frontiers in Psychology, 3,* 341.

Colzato, L. S., Zech, H., Hommel, B., Verdonschot, R., van den Wildenberg, W., & Hsieh, S. (2012). Loving-kindness brings loving-kindness: The impact of Buddhism on cognitive self–other integration. *Psychonomic Bulletin & Review, 19,* 541–545.

Cowan, N. (1995). *Attention and memory: An integrated framework*. New York, NY: Oxford University Press.

De Jong, R., Liang, C. C., & Lauber, E. (1994). Conditional and unconditional automaticity: A dual-process model of effects of spatial stimulus–response correspondence. *Journal of Experimental Psychology: Human Perception and Performance, 20,* 731–750.

Dittrich, K., Rothe, A., & Klauer, K. C. (2012). Increased spatial salience in the social Simon task: A response coding account of spatial compatibility effects. *Attention, Perception, and Psychophysics, 74,* 911–929.

Dolk, T., Hommel, B., Colzato, L. S., Schütz–Bosbach, S., Prinz, W., & Liepelt, R. (2011). How 'social' is the social Simon effect? *Frontiers in Psychology, 2,* 84.

Dolk, T., Liepelt, R., Villringer, A., Prinz, W., & Ragert, P. (2012). Morphometric gray matter differences of the medial frontal cortex influence the social Simon effect. *NeuroImage, 61,* 1249–1254.

Donders, F. C. (1969). On the speed of mental processes. *Acta Psychologica, 30,* 412–431.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16,* 143–149.

Friesen, C. K., & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review, 5,* 490–495.

Guagnano, D., Rusconi, E., & Umiltà, C. A. (2010). Sharing a task or sharing space? On the effect of the confederate in action coding in a detection task. *Cognition, 114,* 348–355.

Guerin, B. (1986). Mere presence effects in humans: A review. *Journal of Experimental Social Psychology, 22,* 38–77.

Heider, F. (1958). *The psychology of interpersonal relations*. New York, NY: Wiley.

Hommel, B. (1993). The role of attention for the Simon effect. *Psychological Research, 55,* 208–222.

Hommel, B. (1994). Spontaneous decay of response code activation. *Psychological Research, 56,* 261–268.

Hommel, B. (1996). S–R compatibility effects without response uncertainty. *Quarterly Journal of Experimental Psychology, 49,* 546–571.

Hommel, B. (1997). Toward an action-concept model of stimulus—

response compatibility. In B. Hommel & W. Prinz (Eds.), *Theoretical issues in stimulus—response compatibility* (pp. 281–320). Amsterdam, The Netherlands: North—Holland.

Hommel, B. (2007). Feature integration across perception and action: Event files affect response choice. *Psychological Research, 71,* 42–63.

Hommel, B. (2010). Grounding attention in action control: The intentional control of selection. In B. J. Bruya (Eds.), *Effortless attention: A new perspective in the cognitive science of attention and action* (pp. 121–140). Cambridge, MA: MIT Press.

Hommel, B. (2012). Convergent and divergent operations in cognitive search. In P. M. Todd, T. T. Hills, & T. W. Robbins (Eds.), *Cognitive search: Evolution, algorithms, and the brain. Strüngmann Forum Reports,* Vol. 9 (pp. 215–230). Cambridge, MA: MIT Press.

Hommel, B., Colzato, L. S., & van den Wildenberg, W. P. M. (2009). How social are task representations. *Psychological Science, 20,* 794–798.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24,* 849–878.

James, W. (1890). *The principles of psychology* (vol. 2). New York: Dover Publications.

Kiernan, D., Ray, M., & Welsh, T. N. (2012). Inverting the joint Simon effect by intention. *Psychonomic Bulletin & Review, 19,* 914–920.

Knoblich, G., & Sebanz, N. (2006). The social nature of perception and action. *Current Directions in Psychological Science, 15,* 99–104.

Kornblum, S., Hasbroucq, T., & Osman, A. (1990). Dimensional overlap: Cognitive basis for stimulus–response compatibility—a model and taxonomy. *Psychological Review, 97,* 253–270.

Kuhbandner, C., Pekrun, R., & Maier, M. A. (2010). The role of positive and negative affect in the "mirroring" of other persons' actions. *Cognition & Emotion, 24,* 1182–1190.

Langton, S. R. H., Watt, R. J., & Bruce, V. (2000). Do the eyes have it? Cues to the direction of social attention. *Trends in Cognitive Science, 4,* 50–59.

Liepelt, R., & Prinz, W. (2011). How two share two tasks: Evidence of a social psychological refractory period effect. *Experimental Brain Research, 211,* 387–396.

Liepelt, R., Stenzel, A., & Lappe, M. (2012). Specifying social cognitive processes with a social dual-task paradigm. *Frontiers in Human Neuroscience, 6,* 86.

Liepelt, R., Wenke, D., & Fischer, R. (2012). Effects of feature integration in a hands-crossed version of the social Simon paradigm. *Psychological Research, 76,* 1–5.

Liepelt, R., Wenke, D., Fischer, R., & Prinz, W. (2011). Trial-to-trial sequential dependencies in a social and non-social Simon task. *Psychological Research, 75,* 366–375.

Logan, G. D., & Sadler, D. D. (1996). A computational analysis of the apprehension of spatial relations. In P. Bloom, M. A. Peterson, L. Nadel, & M. F. Garrett (Eds.), *Language and space* (pp. 493–529). Cambridge, MA: MIT Press.

Lorch, E. P., Anderson, D. R., & Well, A. D. (1984). The effects of irrelevant stimuli on speeded classification: Reduction of interference due to habituation. *Journal of Experimental Psychology: Human Perception and Performance, 10,* 850–864.

Maylor, E. A., & Hockey, R. (1985). Inhibitory component of externally controlled covert orienting in visual space. *Journal of Experimental Psychology: Human Perception and Performance, 11,* 777–787.

Memelink, J., & Hommel, B. (in press). Intentional weighting: A basic principle in cognitive control. *Psychological Research*.

Miller, J. (1991). The flanker compatibility effect as a function of visual angle, attentional focus, visual transients, and perceptual load: A search for boundary conditions. *Perception & Psychophysics, 49,* 270–288.

Miller, J. E., Carlson, L. A., & Hill, P. L. (2011). Selecting a reference object. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 840–850.

Müller, B. C. N., Brass, M., Kühn, S., Tsai, C. C., Nieuwboer, W., Dijksterhuis, A., & van Baaren, R. B. (2011). When Pinocchio acts like a human, a wooden hand becomes embodied. Action co-representation for non-biological agents. *Neuropsychologia, 49,* 1373–1377.

Näätänen, R. (1992). *Attention and brain function*. Hillsdale, NJ: Erlbaum.

Nicoletti, R., & Umiltà, C. (1989). Splitting visual space with attention. *Journal of Experimental Psychology: Human Perception and Performance, 15,* 164–169.

Nicoletti, R., & Umiltà, C. (1994). Attention shifts produce spatial stimulus codes. *Psychological Research, 56,* 144–150.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9,* 97–113.

Olson, D. R. (1970). Language and thought: Aspects of a cognitive theory of semantics. *Psychological Review, 77,* 257–273.

Posner, M. I., & Cohen, Y. (1984). Components of visual orienting. In H. Bouma & D. G. Bouwhuis (Eds.), *Attention and performance X: control of language processes* (pp. 531–556). Hillsdale, NJ: Erlbaum.

Prinz, W. (1987). Ideo-motor action. In H. Heuer & A. F. Sanders (Eds.), *Perspectives on perception and action* (pp. 47–76). Hillsdale: Erlbaum.

Ridderinkhof, K. R. (2002). Activation and suppression in conflict tasks: Empirical clarification through distributional analyses. In W. Prinz & B. Hommel (Eds.), *Common mechanisms in perception and action. Attention & performance, vol. XIX* (pp. 494–519). Oxford: Oxford University Press.

Roepstorff, A., & Frith, C. (2004). What's at the top in the top-down control of action? Script-sharing and 'top-top' control of action in cognitive experiments. *Psychological Research, 68,* 189–198.

Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: Bodies and minds moving together. *Trends in Cognitive Science, 10,* 70–76.

Sebanz, N., & Knoblich, G. (2009). Prediction in joint action: What, when, and where. *Topics in Cognitive Science, 1,* 353–367.

Sebanz, N., Knoblich, G., & Prinz, W. (2003). Representing others' actions: Just like one's own? *Cognition, 88,* B11–B21.

Sebanz, N., Knoblich, G., & Prinz, W. (2005). How two share a task: Co-representing stimulus–response mappings. *Journal of Experimental Psychology: Human Perception and Performance, 31,* 1234–1246.

Shin, Y. K., Proctor, R. W., & Capaldi, E. J. (2010). A review of contemporary ideomotor theory. *Psychological Bulletin, 136,* 943–974.

Simon, J. R., Hinrichs, J. V., & Craft, J. L. (1970). Auditory S–R compatibility: Reaction time as a function of ear–hand correspondence and ear-response-location correspondence. *Journal of Experimental Psychology, 86,* 97–102.

Simon, J. R., & Rudell, A. P. (1967). Auditory S–R compatibility: The effect of an irrelevant cue on information processing. *Journal of Applied Psychology, 51,* 300–304.

Stenzel, A., Chinellato, E., Tirado Bou, M. A., del Pobil, Á. P., Lappe, M., & Liepelt, R. (2012). When humanoid robots become human-like interaction partners: Co-representation of robotic actions. *Journal of Experimental Psychology: Human Perception and Performance, 38,* 1073–1077.

Stock, A., & Stock, C. (2004). A short history of ideo-motor action. *Psychological Research, 68,* 176–188.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology, 12,* 97–136.

Tsai, C. C., & Brass, M. (2007). Does the human motor system simulate Pinocchio's actions? Coacting with a human hand versus a wooden hand in a dyadic interaction. *Psychological Science, 18,* 1058–1062.

Tsai, C. C., Kuo, W. J., Hung, D. L., & Tzeng, O. J. (2008). Action co-representation is tuned to other humans. *Journal of Cognitive Neuroscience, 20,* 2015–2024.

Tsai, C. C., Kuo, W. J., Jing, J. T., Hung, D. L., & Tzeng, O. J. (2006). A common coding framework in self–other interaction: Evidence from joint action task. *Experimental Brain Research, 175,* 353–362.

Tsai, J. C. C., Knoblich, G., & Sebanz, N. (2011). On the inclusion of externally controlled actions in action planning. *Journal of Experimental Psychology: Human Perception and Performance, 37,* 1407–1419.
van Steenbergen, H. (2007). *Neural integration of actions and their auditory effects: An fMRI-study*. Unpublished Master Thesis. Leiden University.
Vlainic, E., Liepelt, R., Colzato, L. S., Prinz, W., & Hommel, B. (2010). The virtual co-actor: The social Simon effect does not rely on online feedback from the other. *Frontiers in Psychology, 1,* 208.
Welsh, T. N. (2009). When 1 + 1 = 1: The unification of independent actors revealed through joint Simon effects in crossed and uncrossed effector conditions. *Human Movement Science, 28,* 727–737.
Welsh, T. N., Elliott, D., Anson, J. G., Dhillon, V., Weeks, D. J., Lyons, J. L., & Chua, R. (2005). Does Joe influence Fred's action? Inhibition of return across different nervous systems. *Neuroscience Letters, 385,* 99–104.
Welsh, T. N., Lyons, J., Weeks, D. J., Anson, J. G., Chua, R., Mendoza, J., & Elliott, D. (2007). Within- and between-nervous-system inhibition of return: Observation is as good as performance. *Psychonomic Bulletin & Review, 14,* 950–956.
Wenke, D., Gaschler, R., & Nattkemper, D. (2007). Instruction-induced feature-binding. *Psychological Research, 71,* 92–106.
Zajonc, R. B. (1965). Social facilitation. *Science, 149,* 269–274.
Zhang, J., & Kornblum, S. (1997). Distributional analysis and De Jong, Liang, and Lauber's (1994) dual-process model of the Simon effect. *Journal of Experimental Psychology: Human Perception and Performance, 23,* 1543–1551.

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Correction to Choi and Gordon (2013)

In the article "Coordination of Word Recognition and Oculomotor Control During Reading: The Role of Implicit Lexical Decisions," by Wonil Choi and Peter C. Gordon (*Journal of Experimental Psychology: Human Perception and Performance*, 2013, Vol. 39, No. 4, pp. 1032–1046), the graphs in Figures 1 and 2 are reversed. The online versions of this article have been corrected.

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