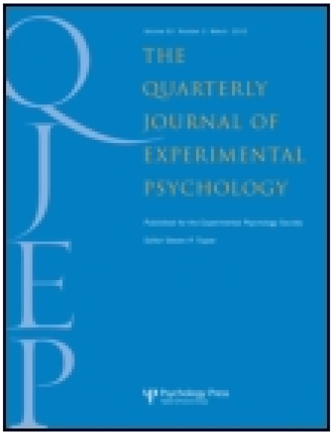

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Modulation of the affordance effect through transfer of learning

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Rapid communication
Modulation of the affordance effect through transfer of learning

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Consistent evidence shows that practising with spatially incompatible stimulus–response trials modulates performance on following tasks requiring the solution of cognitive conflict such as the Simon and Stroop tasks. In the present study we assessed whether a spatially incompatible practice can modulate another effect that is thought to be due to a conflict between two response alternatives, the affordance effect. To this end, we requested participants to categorize pictures of common objects on the basis of their upright or inverted orientation. A group of participants performed the categorization task alone, while the other two groups performed the categorization task after practising with a spatial compatibility task with either a compatible or an incompatible mapping. Results showed that the spatially incompatible practice eliminated the affordance effect. These results indicate that the conflict at the basis of the affordance effect is not unavoidable but it rather permeable to modulations affecting the response selection stage. Indeed the "emit the alternative spatial response" rule acquired during the spatially incompatible task can transfer to and modulate how the subsequent affordance task is performed.

Keywords: Cognitive conflict; Affordance effect; Transfer of learning; Spatial stimulus–response compatibility.

Human performance is characterized by the presence of habitual responses that are automatically triggered by environmental features. Cognitive conflict tasks allow researchers to study the interference and facilitation influences on performance deriving from the automatic activation of habitual responses. In these tasks, performance in a congruent condition (i.e., when the automatically triggered response corresponds to the response required by task instructions) is compared with performance in an incongruent condition (i.e., when the automatically triggered response does not correspond to the response required by task instructions). Reaction times (RTs) and the number of errors are usually lower in the congruent than in the incongruent conditions. Even if explanations differ depending on the particular task used, on the whole there is large agreement that performance is better in the congruent condition because the automatically triggered response could be executed without further cognitive processing. Differently, in the incongruent condition, the automatically activated response should be inhibited, thus increasing RTs and the number of errors.

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A task that is widely used to study cognitive conflict is the Simon task. In this task, participants are required to respond to a nonspatial feature (e.g., colour) of stimuli appearing on the left or on the right of a central fixation cross by pressing one of two lateralized response keys (e.g., Simon & Rudell, 1967; see Proctor & Vu, 2006; Rubichi, Vu, Nicoletti, & Proctor, 2006, for reviews). Although stimulus location is irrelevant for performing the task, results consistently show that it affects performance with faster and more accurate responses when stimulus and response locations spatially correspond (corresponding trials) than when they do not correspond (noncorresponding trials). The difference in performance between corresponding and noncorresponding responses, known as the Simon effect, is attributed to the automatic preactivation of the response that spatially corresponds to stimulus location (e.g., De Jong, Liang, & Lauber, 1994). In corresponding trials, this automatically activated response is the same as the one indicated by the relevant stimulus feature, therefore no competition between response codes arises. In noncorresponding trials, on the contrary, the automatically activated response and the response activated on the basis of the relevant stimulus feature are different, and the incorrect response needs to be aborted thus causing a slowing of response time and an increased number of errors.

Recently, it has been suggested that the conflict between response alternatives at the basis of the Simon effect is not unavoidable. More precisely, the Simon effect disappears or even reverses if, before performing the Simon task, participants are required to perform a spatial compatibility task, in which stimulus location is the relevant dimension, with an incompatible mapping between stimulus and response—that is, a task in which they are instructed to respond on the basis of stimulus location by emitting the contralateral response (e.g., Iani, Rubichi, Gherri, & Nicoletti, 2009; Proctor & Lu, 1999). The elimination or reversal of the effect is thought to occur because the short-term associations between stimulus and response locations, defined to perform the location-relevant trials, affect performance even when location is no longer relevant—that is, during performance of the Simon trials.

It should be noted that such an account predicts that this effect should occur only if the practice and transfer tasks belong to the same domain—that is, the spatial domain in the case of the Simon task. In contrast to this prediction, Marini, Iani, Nicoletti, and Rubichi (2011) reported a transfer-of-learning effect when participants performed a spatially incompatible practice before performing a bimanual colour Stroop task (Stroop, 1935), in which participants were presented with the name of one of two colours printed in coloured ink and were instructed to identify the ink colour by pressing one of two lateralized keys. When this task is performed alone, responses are typically faster and more accurate when the colour name matches the ink colour (i.e., congruent condition) than when they do not match (i.e., incongruent condition). Marini et al. (2011) reported that after a 600-trial practice with a spatially incompatible mapping, the colour Stroop effect disappeared.

In Marini et al.'s (2011) study, stimuli in the practice and transfer tasks did not share any irrelevant spatial dimension since stimuli in the practice task were white lateralized squares while stimuli in the transfer task were colour words presented centrally. However both tasks required bimanual responses (i.e., a right or a left key-press) whose spatial dimension was task-relevant in the practice task and task-irrelevant in the transfer task. This evidence led the authors to suggest that during practice participants learnt to emit the response alternative to the one automatically activated and that such a rule transferred into the following task. To test this hypothesis, in a follow-up experiment participants performed a spatial compatibility task that required manual responses (i.e., left and right key-presses) with either a compatible or an incompatible mapping and then transferred to a colour Stroop task that required vocal responses. Congruent with the hypothesis they advanced, they found no transfer-of-learning effect. Hence, they argued that crucial for the occurrence of transfer-of-learning effects is the similarity (dimensional overlap) between response features of the practice and transfer tasks—that is, both tasks should require bimanual left/right responses. Crucially, this account predicts modulations in other tasks characterized by a conflict between the response required by task instructions and the automatically activated response.

Another example of a task that requires participants to solve cognitive conflict by suppressing the automatically triggered response is the task originally described by Tucker and Ellis (1998) in which participants were required to make button-press responses with the left or right hand to the vertical orientation (upright or inverted) of a centrally presented graspable object. The authors observed that responses were faster when the graspable part corresponded spatially with the required response. More precisely, if participants were required to respond with the right hand to upright objects and with the left hand to inverted objects, response times were faster when the graspable part of the upright object was on the right (i.e., corresponding trial) than when it was on the left (i.e., noncorresponding trial). The advantage for corresponding trials (from now on, affordance effect) has been interpreted as an indication that the location of the object's graspable part automatically activates a motor programme. It should be noted that according to some authors, location coding at the basis of the Simon effect may be responsible for affordance effects as well (e.g., Cho & Proctor, 2010). There are, however, several studies suggesting that the two effects may be independent (e.g., Riggio et al., 2008; Symes, Ellis, & Tucker, 2005). One important difference between Simon and affordance effects is that the automatic activation of the response corresponding to stimulus position, responsible for the emergence of the Simon effect, occurs any time there is dimensional overlap between stimulus and response spatial features (Kornblum, Hasbroucq, & Osman, 1990), and it occurs irrespectively of task instructions. Differently, there is evidence that affordance effects emerge if the task implies processing of shape and meaning (e.g., Pellicano, Iani, Borghi, Rubichi, & Nicoletti, 2010).

The aim of the present study is twofold. First we aimed at assessing whether, similarly to the Simon and Stroop effects, the conflict at the basis of the affordance effect can be modulated by prior practice with a spatially incompatible mapping. The finding of a modulation would indicate that this conflict is not unavoidable. Second, we aimed at testing the generalizability of the "emit the alternative spatial response" rule proposed by Marini et al. (2011). This would indicate that the response selection rule acquired in the spatial compatibility task can be transferred to the affordance task and affect the response selection stage, thus eliminating the conflict between two conflicting response alternatives. To these aims, as in Tucker and Ellis's (1998) study, we required participants to categorize common objects by pressing two lateralized keys. Compared to the Simon and Stroop effects, the affordance effect sometimes is not observed (e.g., Bub & Masson, 2010). Even when observed, its size tends to be relatively small, especially when button-press responses are required (e.g., Iani, Baroni, Pellicano, & Nicoletti, 2011; Symes, Tucker, Ellis, Vainio, & Ottoboni, 2008). We used the relative weakness of the effect to test whether a transfer of learning could occur only in the case of practice with an incompatible mapping, as occurs with other conflict tasks (e.g., Iani et al., 2009; Marini et al., 2011), or whether practising with a compatible mapping could boost the effect. Indeed, as regards the Simon effect, there are studies showing that, although a spatially compatible practice does not affect the standard Simon effect, either it can lead to the emergence of a Simon effect in a condition in which, without practice, it should not have been present, as occurs with the vertical Simon effect in two-dimensional tasks (Rubichi, Gherri, Nicoletti, & Umiltà, 2005), or it can increase its magnitude when the effect observed before practice is weak, as occurs when stimuli and responses are orthogonal (e.g., Bae, Cho, & Proctor, 2009). Given these considerations, in the present study we asked participants to perform an affordance task either alone (no-practice condition) or after performing a spatial compatibility task with either a compatible (compatible-practice condition) or an incompatible (incompatible-practice condition) stimulus–response (S–R) mapping.

EXPERIMENTAL STUDY

Method

Participants

Sixty undergraduate students (37 females; mean age = 22 years) participated in the experiment. All reported normal or corrected-to-normal vision and were naïve as to the purpose of the experiment. Twenty performed only the affordance task (no-practice condition); 20 practised on a spatially compatible task with a compatible S–R mapping and then transferred to the affordance task (compatible-practice condition); the remaining 20 practised on a spatially compatible task with an incompatible S–R mapping and then transferred to the affordance task (incompatible-practice condition).

Apparatus and stimuli

Participants sat in front of a 17″ CRT monitor (75 Hz) controlled by a PC computer, at a viewing distance of about 57 cm. Stimuli presentation and response collection were controlled using E-Prime Version 1.1.

Stimuli in the spatial compatibility task (practice task) were 2° × 2° black squares, which appeared 5° to the left or to the right of a central fixation cross (1° × 1°). Stimuli in the affordance task (transfer task) were black-and-white pictures of the following objects: door handle, computer mouse, spray cleaner, cup, gun, saw, and fry pan. The stimuli were between 6.17° and 21.64° wide and between 6.11° and 13.97° tall and were presented in the centre of the screen. In both tasks, responses were emitted by pressing the keys "x" and "." of a standard Italian keyboard with the left or right index finger, respectively.

Design and procedure

Participants in the no-practice condition performed only the affordance task, while participants in the compatible- and incompatible-practice conditions performed the spatial compatibility task and, after a 5-min rest, the affordance task.

In the spatial compatibility task (practice task), a trial began with the presentation of the fixation cross that was followed, after 500 ms, by the stimulus, which was visible for 1 s or until a response was made. The task was composed of 600 trials, divided into three blocks of 200 trials. In half of the trials, the stimulus appeared on the left, while in the remaining half it appeared on the right. In the compatible-practice condition, participants were required to press the left key ("x") when the stimulus appeared on the left and the right key (".") when the stimulus appeared on the right. In the incompatible-practice condition, participants were required to press the left key when the stimulus was on the right and the left key when the stimulus was on the left. Visual feedback about speed and accuracy was provided for 500 ms in the centre of the display. The intertrial interval was 1 s.

In the affordance task (transfer task), a trial began with the presentation of the fixation cross for 500 ms, followed by the presentation of the target stimulus in the centre of the screen. The stimulus remained on the screen until a response was given, but no longer than 1 second. The task was composed of 192 trials. In half of the trials, the stimulus was presented in an upright position, while in the other half it was presented in an inverted position. For each position, the stimuli were equally rotated to have the handle or the part grasped when using the object oriented towards the right-hand side and towards the left-hand side. Half of the participants were instructed to categorize the object by pressing the "x" key when the stimulus was in the upright position and the "." key when the stimulus was in the inverted position; the other half received the opposite mapping. No feedback was provided. The intertrial interval was 1500 ms.

Results and discussion

Practice task (spatial compatibility task)

Correct mean RTs were analysed using an independent two-sample t-test. RTs were significantly longer in the incompatible-practice ($M = 399$ ms) than in the compatible-practice ($M = 348$ ms) condition, $t(38) = 3.95$, $p < .001$. Errors were very few (less than 3%) and were not further analysed.

Transfer task (affordance task)

Correct mean RTs and arcsine-transformed error rates were entered into two separate repeated measure analyses of variance (ANOVAs) with condition (no practice, compatible-practice, and incompatible-practice conditions) as between-participants factor, and affordance correspondence (i.e., handle–response correspondence; corresponding vs. noncorresponding) as within-participant factor.

RTs in the three experimental conditions did not differ (no-practice: $M = 638$ ms; compatible-practice: $M = 611$ ms; incompatible-practice: $M = 619$ ms) as indicated by the nonsignificant effect of condition, $F(2, 57) = 0.88$, $p = .42$, $\eta_p^2 = .03$. Participants were faster in corresponding ($M = 616$ ms) than in noncorresponding ($M = 629$ ms) trials, as indicated by the main effect of affordance correspondence, $F(1, 57) = 15.33$, $p < .001$, $\eta_p^2 = .21$. More important, there was a significant interaction between condition and affordance correspondence, $F(2, 57) = 4.81$, $p < .001$, $\eta_p^2 = .14$ (see Figure 1).

Separate analyses by condition, which were performed with Bonferroni corrected *t*-test, showed that affordance correspondence was significant for the compatible-mapping condition, $t(19) = -3.52$, $p < .005$, with corresponding trials being 24 ms faster than noncorresponding trials, and for the no-practice condition, $t(19) = -2.83$, $p < .005$, with corresponding trials being 14 ms faster than noncorresponding trials. In the incompatible mapping condition, RTs in corresponding and noncorresponding trials did not differ, $t(19) = 0.05$, $p > .1$.

A further post hoc analysis was carried out on affordance correspondence with condition as between-subjects factor. No difference appeared significant among the three experimental conditions in either the analysis of the corresponding trials or the analysis of the noncorresponding trials, $F(2, 57) = 0.88$, $\eta_p^2 = .03$, $p > .1$; $F(2, 57) = 1.15$, $\eta_p^2 = .04$, $p > .1$, respectively. All Bonferroni corrected *t*-tests were not significant (*t*s > 0.1)

As regards errors, the analysis revealed a main effect of condition, $F(2, 57) = 4.39$, $p < .05$. Errors were 6.5% in the no-practice condition, 10.4% in the compatible-practice condition, and 5.9% in the incompatible-practice condition. Post hoc analysis showed that the only significant difference was between the compatible- and incompatible-practice conditions. Errors were higher in corresponding ($M = 6.5\%$) than in noncorresponding ($M = 8.6\%$) trials, $F(1, 57) = 17.10$, $p < .05$. The interaction between condition and affordance did not reach significance, $F < 1$.

The results of the present experiment are consistent with those of previous studies showing that a spatially incompatible practice can eliminate the conflict at the basis of the Simon and of the colour Stroop effects. Importantly, they extend these results in showing that a spatially incompatible practice can also eliminate the conflict at the basis of the affordance effect, while a spatially compatible practice has no influence on it.

GENERAL DISCUSSION

Previous studies showed that the conflict at the basis of the Simon effect can be eliminated if the Simon task is performed after practice on a spatial compatibility task with an incompatible mapping between stimuli and responses (e.g., Proctor & Lu, 1999). This transfer-of-learning effect has been attributed to the short-term, task-defined associations between stimulus and response locations created for the spatial compatibility task remaining active and influencing performance in the following Simon task. With extensive practice, however, the incompatible practice seems to lead to the acquisition of a general response-selection rule, which is automatically extended to subsequent tasks even when practice and transfer tasks differ in nature. Specifically, Marini et al. (2011) found transfer of learning from a 600-trial spatial compatibility task with an incompatible mapping to a colour Stroop task. Importantly, the transfer of learning effect occurred only when both practice and transfer tasks required a bimanual response. To account for these results, the authors suggested that during practice, participants acquired an "emit the alternative spatial response" rule that is

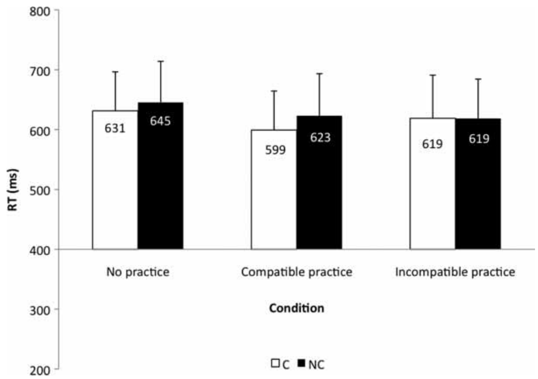

Figure 1. *Mean reaction times (and standard deviations) in ms as a function of experimental condition (no practice, compatible practice, and incompatible practice conditions, respectively) and affordance correspondence (corresponding vs. noncorresponding). RT = reaction time; C = corresponding; NC = noncorresponding.*

transferred to a subsequent conflict task if responses in the transfer task are bimanual too.

In the present study, we assessed whether a spatially incompatible practice can modulate performance in another task characterized by a conflict between response alternatives, the affordance task. To this end, we asked participants to categorize the vertical orientation of common household objects (affordance task; Tucker & Ellis, 1998). The task could be performed alone or after performing a 600-trial spatial compatibility task with either a compatible or an incompatible mapping. We found a significant affordance effect (i.e., faster responses when the location of the graspable part of the object corresponded with the location of a key-press response) when the affordance task was performed alone and when it was preceded by a compatible practice. The effect was, however, eliminated when the task was preceded by a spatially incompatible practice.

This result suggests that, similarly to what occurs with the Simon and colour Stroop tasks, a 600-trial spatial incompatible practice can lead to the acquisition of a general "emit the alternative spatial response" rule that transfers to a subsequent task in which responses can be discriminated by spatial location. We also found that, even though the effect evident after a spatially compatible practice was numerically larger than the effect evident when the task was performed alone, the two values did not statistically differ. Hence, similarly to what occurs with the Simon and colour Stroop tasks, a 600-trial compatible practice seems to leave the affordance effect unaffected.

To note, it is still debated whether the affordance effect is due to a specific motor activation that facilitates responses with the effector most suited to interact with the object (e.g., Tucker & Ellis, 1998) or to the activation of more abstract spatial codes that facilitates all lateralized responses corresponding with the object's affordance (e.g., Phillips & Ward, 2002) or rather, as suggested by Cho and Proctor (2010), to spatial coding of the location of the object's graspable part. Recent data, however, seem to suggest that, similarly to the Simon effect, the affordance effect emerges at the response selection stage (Iani et al., 2011). Although the present study was not aimed at directly testing these different hypotheses, our results allow us to draw some conclusions on the nature of the conflict at the basis of the affordance effect. Indeed they show that this conflict, whether it is caused by the activation of motor (a reach and grasp) representation or by the activation of more abstract spatial codes, is not unavoidable since it can be modulated by prior practice with an incompatible S–R mapping. As suggested by Marini et al. (2011), it is plausible to believe that practice with the incompatible mapping leads to the acquisition of a response selection strategy that affects the way subsequent tasks involving response conflict are performed. The present results indicate that this strategy is automatically transferred to the affordance task and contrasts the activation of the response corresponding with the object's affordance.

To conclude, the results of the present study extend those of previous investigations on transfer-of-learning effects by showing that a 600-trial spatially incompatible practice can eliminate the conflict at the basis of the affordance effect. They also support the results of recent studies showing that the conflict at the basis of the affordance and Simon effect may share some similarities (e.g., Iani et al., 2011; McBride, Sumner, & Husain, 2012). Future investigations should be aimed at assessing whether the modulation observed in the present study occurs even when the affordance task does not require a key-press response in order to directly investigate the nature of the response activated on the basis of the action-related irrelevant stimulus feature responsible for the affordance effect.

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