Simon-like and functional affordance effects with tools: The effects of object perceptual discrimination and object action state

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Abstract

In the present study two separate stimulus-response compatibility effects (functional affordance and Simon-like effects) were investigated with centrally presented pictures of an object tool (a torch) characterized by a structural separation between the graspable portion and the goal-directed portion. In Experiment 1, participants were required to decide whether the torch was red or blue, while in Experiment 2 they were required to decide whether the torch was upright or inverted.

Our results showed that with the same stimulus two types of compatibility effect emerged: one based on the direction signalled by the goal-directed portion of the tool (a Simon-like effect as observed in Experiment 1), the other based on the actions associated with an object (a functional affordance effect as observed in Experiment 2). Both effects emerged independently of the person's intention to act on the stimulus, but depended on the stimulus properties which were processed in order to perform the task.

INTRODUCTION

In the past few years there has been an increasing number of studies showing that the perception of objects can influence our motor behaviours even when interaction with these objects is not required, hence supporting the view that perception and action are closely linked. For instance, it has been demonstrated that the appearance of an object automatically activates a series of actions which are compatible with some of the object's visual properties such as its location, its size and the orientation of eventual graspable parts.

In a well-known experiment by Tucker and Ellis (1998), participants were shown photographs of graspable objects, presented upright or inverted with a leftward- or rightward-oriented handle. Their task was to press a left key for upright and a right key for inverted objects while ignoring their handle orientation. Results showed that responses were faster when the handle orientation corresponded with the side of the responding hand. This effect has been attributed to an affordance for action, that is, the perception of an object results in the potentiation of those actions that can typically be made towards it (e.g., reach-to-grasp movements)[1] (see also, Ellis & Tucker, 2000; Phillips & Ward, 2002; Tucker & Ellis, 2004). Notably, the orientation of the object's graspable part elicited the activation of a reach-to-grasp response specifically directed to interact with the object according to its conventional use. For this reason, and following the distinction proposed by Bub, Masson, and Cree (2008), we will refer to these effects as "functional affordance effects" (see General Discussion for the distinction between functional and volumetric affordances).

Several studies showed that responses can be influenced by object location too. It is well-known that performance is faster and more accurate when stimulus and response

[1] It should be noted that Tucker and Ellis's use of the term affordance departs from Gibson's use (1979). Indeed, according to Gibson, affordances for action are detected directly, without the need for intervening processes. In contrast, according to Tucker and Ellis (1998), "the actions afforded by a visual object are intrinsic to its representation". (cf. p. 844).

locations correspond than when they do not, even when stimulus location is task irrelevant. The advantage for corresponding over non-corresponding responses, known as the Simon effect (Simon & Rudell, 1967), is a clear indication that stimulus location automatically primes a corresponding spatial response (for a review see Proctor & Vu, 2006). In corresponding trials the activated response is the same as that indicated by the relevant stimulus feature and it can be emitted in a fast and accurate way. In contrast, in non-corresponding trials the automatically activated spatial response and the response activated by the relevant stimulus feature are different, thus the automatic response has to be aborted causing a slowing of response time and an increased number of errors.

Recent studies showed that functional affordance effects and the Simon effect can coexist (e.g., Iani, Baroni, Pellicano, & Nicoletti, in press; Riggio, Iani, Gherri, Benatti, Rubichi, & Nicoletti, 2008; Symes, Ellis, and Tucker, 2005). For instance, by simultaneously manipulating the visual location of objects and the position of their graspable parts, Symes, et al. (2005) found that separate spatial codes were formed for an object's location and for the orientation of its graspable part which produced distinct compatibility effects. These results were taken as an indication that affordance effects and the Simon effect are independent.

The idea that Simon and affordance effects are distinct is however not widely accepted. Indeed, while according to Michaels (1988, 1993) the Simon effect, and spatial-stimulus correspondence effects in general, are based on the detection of affordances, some authors have claimed that location coding at the base of the Simon effect may be responsible for affordance effects as well (e.g., Anderson, Yamagishi, & Karavia, 2002; Cho & Proctor, in press).

In our view, Simon and functional affordance effects differ in at least two important ways. On one hand, the Simon effect is independent of reach and grasp representations.

Indeed, the automatic activation of the response corresponding to stimulus position occurs anytime there is dimensional overlap (i.e., similarity) between stimulus and response spatial features (Kornblum, Hasbroucq, & Osman, 1990), and it occurs irrespectively of task instruction. On the other hand, even though there is some controversial evidence (Vainio, Ellis, & Tucker, 2007), some studies (e.g., Loach, Frischen, Bruce, & Tsotsos, 2008; Tipper, Paul, & Hayes, 2006) have shown that affordance effects do not emerge when the task implies simple perceptual processing of the stimuli, as occurs in colour discrimination tasks, whereas they are evident within tasks implying processing of shape and meaning. In other words, the Simon effect seems to emerge irrespectively of the level of processing required by the task, whereas affordance effects do not always arise when the task requires superficial processing.

It is worth noting that, until now, the coexistence of Simon and affordance effects has been investigated by presenting stimuli to the left or to the right of fixation with a graspable part oriented either to the left or to the right. We believe that certain stimuli may potentially allow for the occurrence of both Simon and affordance effects even when presented centrally. There are indeed many objects that do not only have a graspable part which is congruent with a left-hand or right-hand grasp but also a goal-directed portion, that is the portion that is involved in executing a function, which is spatially defined. For example, a teapot can be grasped from its handle in order to pour tea through its spout. If such an object is horizontally displayed with the handle oriented to the left, two opposite spatial codes could be derived from such an object: a left code which derives from the orientation of the handle and is consistent with a reach-to-grasp action of the left hand, and a right code which derives from the orientation of the spout (the goal-directed portion of the object) and is compatible with the action of pouring tea into a cup located on the right. Other examples are represented by the hammer, the screwdriver and the electric torch. Thus, accessing the identity and the proper use of an object implies the coding of its graspable portion, but must also imply the coding of its goal-directed portion. Consequently, centrally presented object could convey a directional meaning, similarly to what occurs with centrally presented stimuli such as pointing arrows, spatial words, and eyes gazing to the left or to the right (e.g., Ansorge, 2003; Masaki, Takasawa, & Yamazaki, 2000; Pellicano, Lugli, Baroni, & Nicoletti, 2009; Ricciardelli, Bonfiglioli, Iani, Rubichi, & Nicoletti, 2007), and could generate Simon-like effects which are distinct from the effects generated on the basis of their handle orientation.

The aim of the present study was to verify whether a tool characterized by a structural separation between the graspable portion and the goal-directed portion could activate, besides the specific reach-to-grasp action towards the handle (generating a functional affordance effect), a response which was consistent with the location of its goal-directed portion (generating a Simon-like effect). The emergence of a Simon effect instead of a functional affordance effect was expected to depend on the task. This would indicate that the two effects are due to different mechanisms.

Indeed, Tipper et al. (2006) observed that when participants analyzed the shape of the object stimuli, handle-to-hand affordance effects were observed, whereas, when participants analyzed colour in the same object stimuli no effects were observed. Thus, a task implying processing of a stimulus property which is less related to grasping is supposed to better allow for the coding of its own goal direction (producing a Simon-like effect) to prevail over the coding of its handle orientation (producing a functional affordance effect), if a clear distinction between the handle and the goal-directed portion is provided. To avoid any confound or overlap between the two possible codes which are expected to generate functional affordance and Simon effects, we used a torch as tool stimulus. In such a stimulus the graspable and the functional parts are structurally separated.

We ran two experiments in which participants were shown a torch presented at the centre of the screen with the handle oriented to the left or to the right. In Experiment 1, participants were required to respond according to the torch colour (red or blue), while in Experiment 2 they were required to decide whether the object was upright or inverted. If the occurrence of the two effects was task-dependent, a Simon-like effect relative to the goal-directed portion of the torch was expected to emerge in Experiment 1. Differently, in Experiment 2 the task requirements were supposed to reinstate the activation of actions related to object grasping, hence a functional affordance effect relative to the orientation of the torch handle was expected to emerge.

Furthermore, we manipulated the functional state of the object. An object state is active when it is executing its function and passive when it is not operating (Tipper et al., 2006). The functional state of the stimuli was manipulated by depicting the torch as switched-on (active state) and switched-off (passive state). The active state of the object tool illustrates how its own functional action is produced. As a consequence, this cueing of the object function is expected to facilitate the simulation of its use (e.g., Decety & Grèzes, 2006; Jeannerod, 2007; Gallese, 2009; Gallese & Goldman, 1998). Thus, we expected to find a stronger functional affordance when the torch was switched-on than when it was switched-off.

EXPERIMENT 1

In the present experiment we assessed whether a Simon-like effect relative to the goal-directed portion of a tool occurs when the task requires a colour discrimination. To this aim, participants were required to respond with a left or right response key to the colour of a torch presented in the centre of the screen. The occurrence of a Simon-like effect, instead of a functional affordance effect, was supposed to be favoured by two experimental manipulations. First, we eliminated the overlap between the graspable and the goal-directed portions of the object stimulus by choosing a tool for which these parts were located at the two opposite ends. Second, we employed a colour discrimination task, that is, we chose an object property whose discrimination was reported to be less related to the activation of reach-to-grasp actions. If only a goal-oriented coding takes place or if it significantly prevails over the handle-orientation coding, responses corresponding to the orientation of the goal-directed part of the torch should be faster than non-corresponding responses.

Furthermore, stimuli could be presented in either an active state (switched-on), or in a passive state (switched-off). This manipulation was introduced to assess whether cueing the function of the object prompts the coding of the handle orientation, even when the task does not require the processing of action-related stimulus properties. If this is true, a functional affordance effect should emerge in the switched-on condition, while a Simon-like effect should emerge in the switched-off condition.

Method

Participants

A total of 20 undergraduate students (7 females; mean age= 22.9 years) participated. All of them reported having normal or corrected-to-normal visual acuity and normal colour vision. They were naive about the purpose of the experiment.

Apparatus, stimuli and procedure

The experiment took place in a dimly lit and noiseless room. The participant sat facing a 17” cathode-ray tube screen (1024 x 768 resolution) driven by a 700 MHz PC with his/her head positioned in an adjustable head-and-chin rest. Stimulus presentation, response timing, and data collection were controlled by the E-Prime v1.1 software (see Stahl, 2006).

The pictures of two sample stimuli were printed out and shown before the start of the experiment to familiarise the participants with the tool stimuli. All stimuli were displayed on a white background, from a viewing distance of 58 cm. A black fixation cross (4 x 4 mm) was presented at the centre of the screen before and after stimulus appearance. The stimuli were pictures of horizontally displaced red or blue electric torches (see Figure 1). In one block (200 trials) the torches were depicted as switched-on, that is with a beam of light coming from the bulb, whereas in the other block (200 trials) they were switched-off (with no beam depicted). The colour of the beam and of the torch body were the same. The switched-on torch pictures were 17.5 cm wide and 6 cm high while the switched-off torch pictures were 14 cm wide and 6 cm high. Stimuli could be presented in 8 different configurations: two colours (red vs. blue) X two horizontal orientations (handle on the left and torch pointing to the right vs. handle on the right and torch pointing to the left) X two functional states (“active” when the torch was switched-on vs. “passive” when the torch was switched-off).

(Figure 1 about here)

Participants were instructed to respond to the colour of the torch, while ignoring its horizontal orientation and functional state. Responses were emitted by pressing either the left or the right key (“a” and “l” key) on the computer keyboard with the left or right index finger, respectively. Half the participants responded to the red torch with the left key and to the blue torch with the right key, while the other half experienced the opposite mapping. Thus, the orientation of the handle could correspond to the location of the responding hand (i.e., handle-to-response position corresponding pairings) or not correspond (i.e., handle-to-response position non-corresponding pairings).

The order of the active- and passive-state blocks was counterbalanced across participants, and each block was preceded by 16 training trials.

Results and Discussion

Mean correct reaction times (RT) and arcsine-transformed error proportions were submitted to two identical repeated-measures analyses of variance (ANOVAs) with *Handle-response correspondence* (handle-to-response position corresponding vs. non-corresponding pairings) and *Functional state* (active vs. passive) as within-subject factors. The respective data are displayed in Figure 2 (left panel).

For RTs, the main effect of *Handle-response correspondence* was significant, $F(1,19) = 8.68$, $p < .01$, with faster RTs for non-corresponding than for corresponding trials (401 vs. 411 ms). Stated differently, RTs were faster when the response position corresponded to the goal-directed portion of the torch compared to when they did not correspond. Neither the main effect of *Functional state* (406 vs. 406 ms for active and passive stimuli), $F(1,19) < 1$, nor the interaction between *Handle-response correspondence* and *Functional state*, $F(1,19) < 1$, reached statistical significance. The analysis on error data showed no significant main effects or interaction.

(Figure 2 about here)

The results confirmed our hypothesis: when the task required participants to pay attention to a stimulus property that is not linked to grasping (such as colour), the goal-oriented coding of the stimulus prevailed significantly over the coding of its handle orientation, thus producing a Simon-like effect. This effect was evident irrespectively of the functional state of the stimuli (switched-on vs. switched-off). Hence it seems that the cueing of the object function is not sufficient to activate the simulation of its use.

EXPERIMENT 2

Experiment 2 investigated whether the same stimulus used in Experiment 1 leads to the emergence of a functional affordance effect when the task requires the subject to process an action-related object property. To this aim, participants were required to decide whether the stimulus was upright or inverted. This task requires a close analysis of the object shape to access memories of its normal orientation and has been demonstrated to produce functional affordance effects (e.g., Tucker & Ellis, 1998). Furthermore, when the stimulus is in the active-state condition, that is when the torch is switched-on and its functional meaning is clearly displayed, the simulation of the tool use should be facilitated. Thus, we expected to find a stronger functional affordance effect in the active-state than in the passive-state condition.

Method

Participants

A total of 28 new undergraduate students (16 females; mean age= 23.8 years) participated. They were selected as in Experiment 1.

Apparatus, stimuli and procedure

The apparatus, stimuli and procedure were the same as for Experiment 1, except for the following: torches were black and presented in an upright or 180° vertically rotated (upside-down) view (see Figure 3). Thus, stimuli were presented in 8 different configurations: two vertical orientations (upright vs. inverted) X two horizontal orientations (handle on the left and torch pointing to the right vs. handle on the right and torch pointing to the left) X two functional states (active vs. passive).

(Figure 3 about here)

Participants were instructed to respond to the vertical orientation (upright vs. inverted) of the stimuli while ignoring the horizontal orientation and functional state. Half the subjects responded to the upright stimuli with the left key and to the inverted stimuli with the right key, while the other half experienced the opposite mapping. As in Experiment 1, the orientation of the handle could correspond to the location of the responding hand or not correspond.

Results and Discussion

Reaction times and errors were analyzed as in Experiment 1. The respective data are displayed in Figure 2 (right panel).

For RTs, there were significant main effects of *Handle-response correspondence*, $F(1,27) = 11.20$, $p < .01$, with faster RTs for corresponding (425 ms) than for non-corresponding trials (430 ms), and *Functional state*, $F(1,27) = 4.73$, $p < .05$, with slower responses for active (432 ms) than for passive stimuli (423 ms). The two effects interacted significantly, $F(1,27) = 6.02$, $p < .05$. Post-hoc t-tests revealed that the correspondence effect was present with active stimuli (427 vs. 437 ms), $t(27) = -4.60$, $p < .001$, while it was absent with passive stimuli (423 vs. 424 ms), $t(27) = -0.47$, $p = .64$.

For errors, there was a main effect of *Handle-response correspondence*, $F(1,27) = 10.56$, $p < .01$, with a higher number of errors in non-corresponding than in corresponding trials (2.9% vs. 1.9%). The interaction between *Handle-response correspondence* and *Functional state* was significant, $F(1,27) = 11.14$, $p < .01$. T-tests showed that the number of errors was higher in non-corresponding (3.7%) compared to corresponding (1.4%) trials with active stimuli, $t(27) = -3.84$, $p < .01$, while no difference was evident with passive stimuli (2% vs. 2.4%), $t(27) = 0.94$, $p = .354$.

When the vertical orientation was the task-relevant property of the stimulus, a functional affordance effect was observed for both RTs and errors, thus suggesting that when the task required the processing of an action-related stimulus property, the activated response was congruent with the orientation of the object handle and not, as in Experiment 1, with the orientation of the goal-directed portion. Interestingly, the effect was evident only in the active-state condition (10 ms and 2.3%), while it was absent in the passive-state condition (1 ms and -0.4%). Thus, the perception of a functionally active object was critical for the activation of a response that was congruent with the orientation of the handle.

It is worth noting that RTs in Experiment 2 appeared to be longer than those in Experiment 1. One could therefore argue that in Experiment 2 attention was initially drawn to the goal-directed part of the torch and then re-oriented to the graspable portion. Hence, the Simon-like effect emerging as a function of the first attention shift to the goal oriented portion of the stimulus could have been replaced by a functional affordance effect emerging as a function of the re-orienting to the graspable portion of the stimulus.

To exclude this possibility, we ran a combined analysis of Experiments 1 and 2 with *Handle-response correspondence* and *Functional state* as within-subject factors and *Experiment* as a between-subjects factor. The main effect of Experiment did not reach statistical significance, $F(1,46) = 2.01$, $p = .16$, indicating that the RTs in Experiment 1 (406 ms) did not differ from those in Experiment 2 (428 ms).

To further exclude a time-course account of the functional affordance effect observed in Experiment 2, we assessed the changes in the effect size across the RT distribution by means of a distributional analysis (Ratcliff, 1979). For each condition, RTs for handle-response corresponding and non-corresponding trials were rank ordered and divided into five bins. Mean RTs for each bin were then submitted to a repeated-measure ANOVA with *Bin* (from bin 1 to bin 5), *Handle-response correspondence* and *Functional state* as within-subject factors.

If attention was initially drawn to the goal-directed part of the torch and then re-oriented to the graspable portion, a Simon-like effect (relative to the goal-directed portion of the object) should be evident for faster RTs, while a functional affordance effect (relative to the graspable portion of the object) should be evident for longer RTs. Crucially, neither the *Bin* x *Handle-response correspondence* interaction, $F(4,108) < 1$, nor the *Bin* x *Handle-response correspondence* x *Functional State* interaction, $F(4,108) < 1.62$, $p<.16$, reached significance providing clear evidence that in the active state condition the functional affordance effect was already significant at the fastest bin (i.e., bin 1) and remained constant in size until the slowest bin (i.e., bin 5) (see Figure 4).

The results of these two analyses are inconsistent with a time-course account of the correspondence effect observed in Experiment 2. On the contrary, they clearly support the view that colour processing selectively activated a response relative to the orientation of the goal-directed portion (Experiment 1), while vertical orientation processing of the object selectively activated a response relative to the orientation of the object handle (Experiment 2).

(Figure 4 about here)

GENERAL DISCUSSION

The present study was aimed at verifying whether a tool characterized by a structural separation between the graspable portion (the handle) and the goal-directed portion (which executes the proper function of the tool) can activate, besides the specific reach-to-grasp action towards the handle (functional affordance effect), a spatial response which is consistent with the location of its goal-directed portion (Simon-like effect). In addition, it aimed to test whether the activated response depends on the type of required task.

Our results showed that with the same stimulus two types of compatibility effect can emerge: one based on the direction signalled by the goal-directed portion of the tool (a Simon-like effect as observed in Experiment 1), the other based on the actions associated with an object (a functional affordance effect as observed in Experiment 2). Both effects emerged independently of the person’s intention to act on the stimulus, but depended on the stimulus properties which needed to be processed in order to perform the task.

In Experiment 1, where a colour discrimination was required, a significant Simon-like effect emerged with faster responses when the goal-directed portion of the tool corresponded to the response position than when it did not. Conversely, in Experiment 2, where a decision about the object vertical orientation was required, a significant functional affordance effect emerged, with faster and more accurate performance when the orientation of the handle corresponded to the response position.

The presence of a Simon-like effect in Experiment 1 is a novel finding compared to previous results which show no correspondence effects with colour discrimination tasks (Tipper et al., 2006). This finding demonstrates that an alternative coding of the object stimulus is possible as a function of the orientation in space of its goal-directed portion. In the present study, tools allowed for the occurrence of a Simon-like effect even when their location in space was not manipulated and they were presented centrally. Similarly to arrows, gazing eyes and spatial words, tools are able to “indicate a direction” which is consistent with the direction towards which their function is performed. However, this spatial coding emerged significantly when participants had to process a property unrelated to grasping, and the goal-directed and graspable portions were clearly separated.

The presence of a functional affordance effect in Experiment 2 and its absence in Experiment 1 are consistent with the view that handle orientation affords spatially consistent motor responses only if the task requires processing of the object shape. Crucially, increased attention to the structural properties of the stimuli in Experiment 2 was a necessary but not sufficient condition for the functional affordance effect to emerge: also the proper function of the object tools needed to be highlighted. In fact, only the functionally active tools induced their spatial coding as a function of the handle orientation and the activation of corresponding response codes, whereas no effect was produced with functionally passive tools. These findings show that visually presented tools can activate an internal simulation, as suggested by the embodied simulation hypothesis (e.g., Decety & Grezès, 2006; Gallese, 2009; Gallese & Goldman, 1998; Jeannerod, 2007). As claimed by Jeannerod (2007), simulating consists in the offline recruitment of the neural networks involved in specific operations such as perceiving and acting. In this case, however, this activation is quite selective, as it implies a simulation of the interaction with the torch for a specific aim: to use it properly. Indeed, the torch activated the response which was congruent with its proper use only when its functional meaning was made very salient. This result can be explained by referring to the distinction between functional and volumetric gestures proposed by Bub et al. (2008). Neuropsychological studies do indeed provide support for two different ways of interacting with objects (Buxbaum, Sirigu, Schwartz, & Klatzky, 2003; Jeannerod, Decety, & Michel, 1994), which have been termed by Bub et al. (2008) as *volumetric* and *functional* gestures. Volumetric gestures are associated with the overall shape and weight properties of objects and concern the hand posture used to grasp an object to lift or move it, rather than to use it for its defined purpose. Functional gestures, on the other hand, involve specific manipulation of objects in accordance with their proper conventional use.

Along this line, it is plausible that when the functional meaning of the tool was not explicit (i.e., in the passive-state condition), concomitant activation of functional gestures and of multiple and (probably) conflicting volumetric gestures took place thus preventing any significant motor activation from influencing performance (Bub et al., 2008). On the other hand, when the functional meaning of the tool was highlighted (i.e., in the active-state condition), the functional response prevailed over volumetric gestures, thus producing a significant functional affordance effect.

The fact that previous studies showed activation of affordances when the items were not displayed in their active state might be due to the kind of instructions given to participants. Consider for example the effects of automatic activation found by Tucker and Ellis (1998). At least for a subset of objects, the authors asked participants to consider the object function; namely, for objects such as a knife or saw, participants were told that upright or inverted was defined with regard to the object's normal use. This instruction might have been generalized for all the items, so that the mere vision of the object suggested grasp-to-use actions. On the contrary, in our study participants were not encouraged to consider the object function so that the effect emerged only when this information was visually explicit, that is, when the torch was switched-on (active state) but not when it was switched-off (passive state).

On a more general level, the results of the present study may have interesting implications for the investigation of the neural bases of affordances, as well as for the literature on how tools are represented in the brain (e.g., Bach, Peelen & Tipper, in press; Blangero, Menz, McNamara, & Binkofski, 2009; Creem-Regehr & Lee, 2005; Johnson-Frey, 2003; Kellenbach, Brett & Patterson, 2003; Martin, 2007). As to the neural bases of affordances, recent increasing evidence suggests that action (grasping) and function information can be sub-served by two different neural pathways (Young, 2006; see also Borghi & Riggio, 2009, for a discussion on this issue). Namely, the dorsal stream can be divided into two different systems: a dorsal-dorsal system specialized for grasping and a dorsal-ventral system specialized for object function (Rizzolatti & Matelli, 2003). We might speculate that, in normal conditions, the specificity of tools would consist in activating not only the system for manipulation and grasping but the system for object function as well. In this respect, our results are particularly insightful: in Experiment 2 we found clear evidence that both systems, the system for grasping and the system for function, were concurrently activated, as there was a functional affordance effect when the torch was switched-on. These results are in keeping with the idea that hand actions do not operate in isolation but are *''embodied in a broader system for producing action which involves other areas, including those from the ventral system''* (Jeannerod, 1997, p. 72).

To conclude, the results of the present study suggest that object tools with distinct graspable and goal-directed portions can be coded as a function of their goal-directed end and thus interpreted as “pointing to a direction” in a way that is similar to arrow symbols. This coding appears to be separate from the coding of handle orientation and occurs if simple perceptual processing is performed, as for the colour discrimination task. These results also suggest that affordances do not appear to be automatic but, rather, seem to depend on the extent to which the task requires detailed processing of shape. Furthermore, they are selectively activated if the functional meaning of tools is made very salient. In these cases, functional affordance effects are activated which consist of motor simulations of the appropriate grasp-to-use action directed towards the handle. It is worth noting that our results suggest that these simulations influence motor performance even in simple, button-press choice reaction time tasks in which the involvement of the effectors is minimal compared to the more complex reach-to-grasp movements for which functional affordances have been originally displayed.

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Figure 1: Pictures of the torch stimuli used in Experiment 1. Panel A represents the red stimuli (dark grey in the figure), panel B represents the blue stimuli (light grey in the figure). Half the stimuli were presented in a passive state (i.e., switched-off; A1 and B1), while the other half were presented in an active state (i.e., switched-on; A2 and B2). Stimuli also varied in horizontal orientation (i.e., handle on the left vs. handle on the right; not shown in the figure).

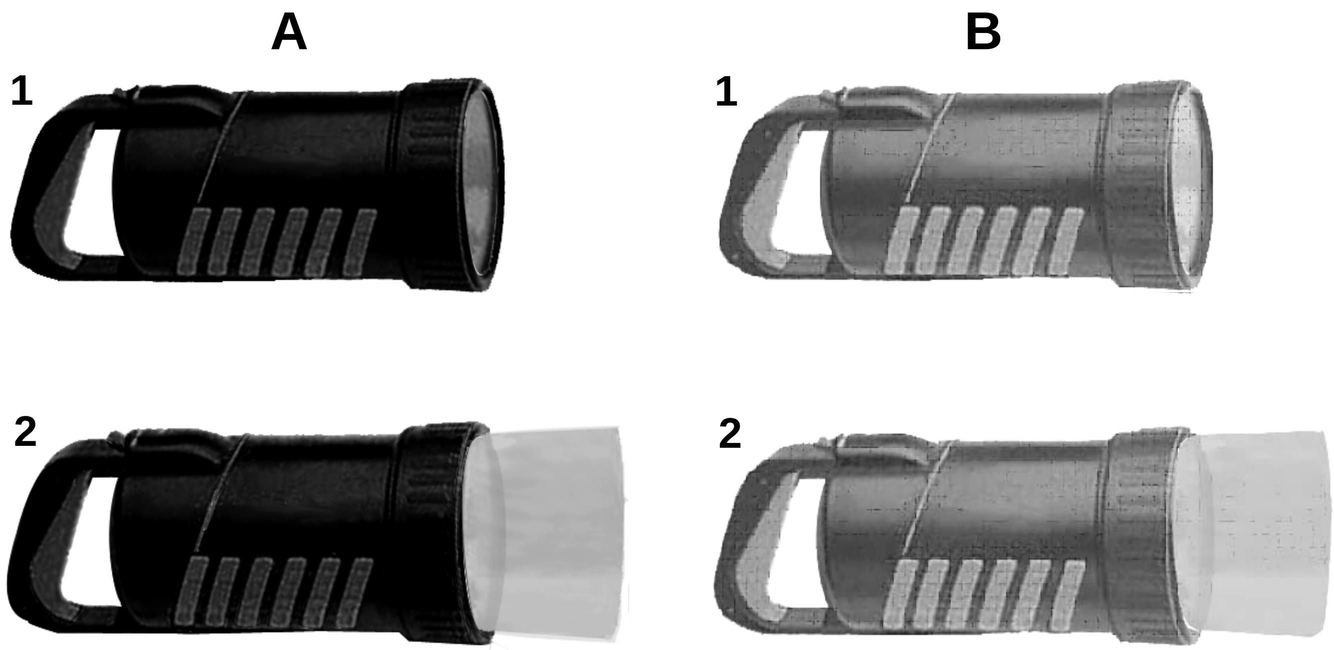

Figure 2: Handle-response correspondence effect (handle orientation-to-response position corresponding vs. non-corresponding pairings) in the active- and passive-state conditions for mean reaction times (RT) and error percentages. In Experiment 1, the negative effect denotes a goal-oriented coding of the tool that produced a Simon-like effect. In Experiment 2, the positive effect indicates a handle-orientation coding that produced a functional affordance effect.

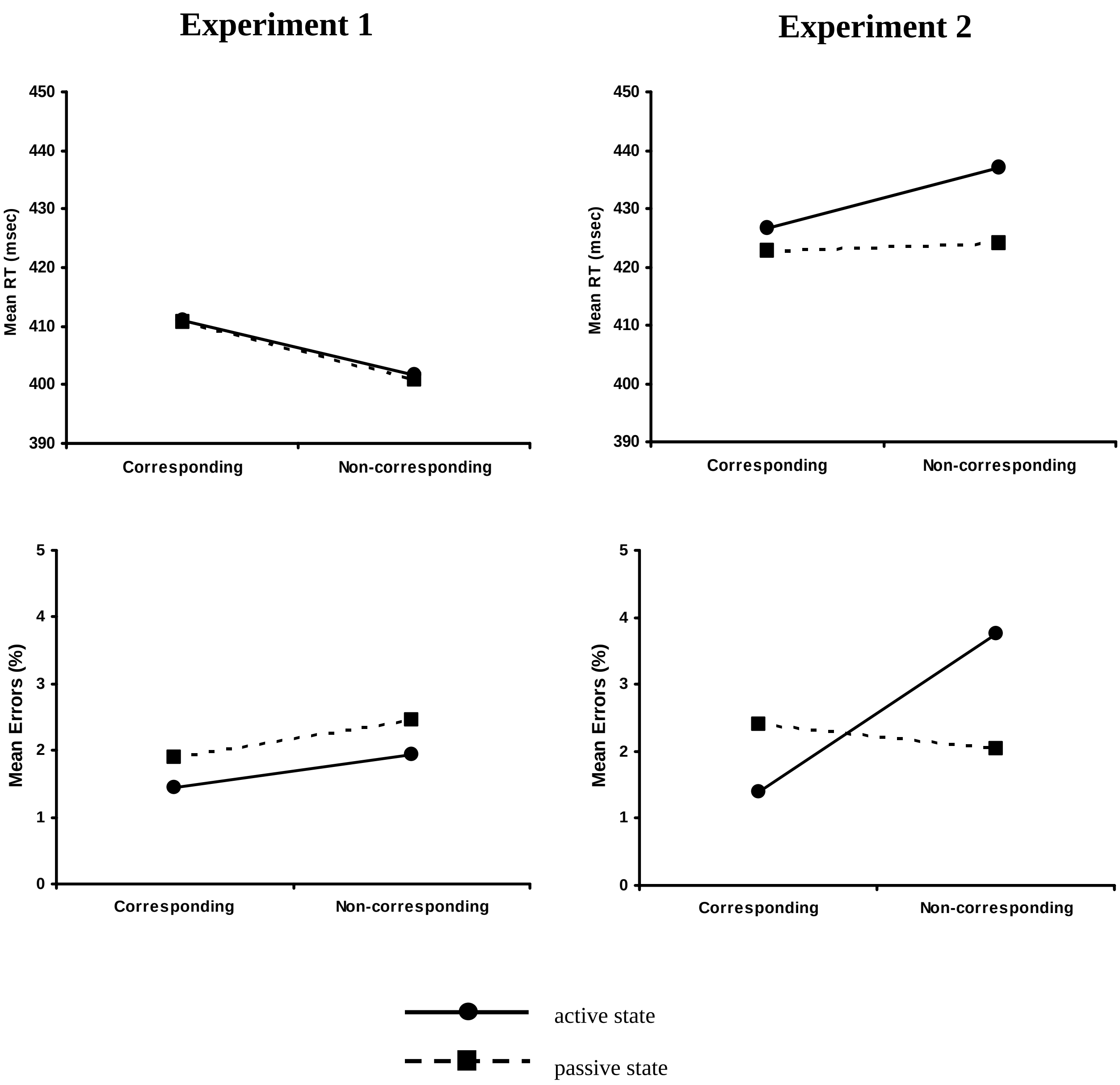

Figure 3. Pictures of the torch stimuli used in Experiment 2. Panel A represents the upright stimuli, while panel B shows the inverted stimuli. Half the stimuli were displayed in a passive state (i.e., switched-off; A1 and B1), while the other half were displayed in an active state (i.e., switched-on; A2 and B2). Stimuli also varied in horizontal orientation (i.e., handle on the left vs. handle on the right; not shown in the figure).

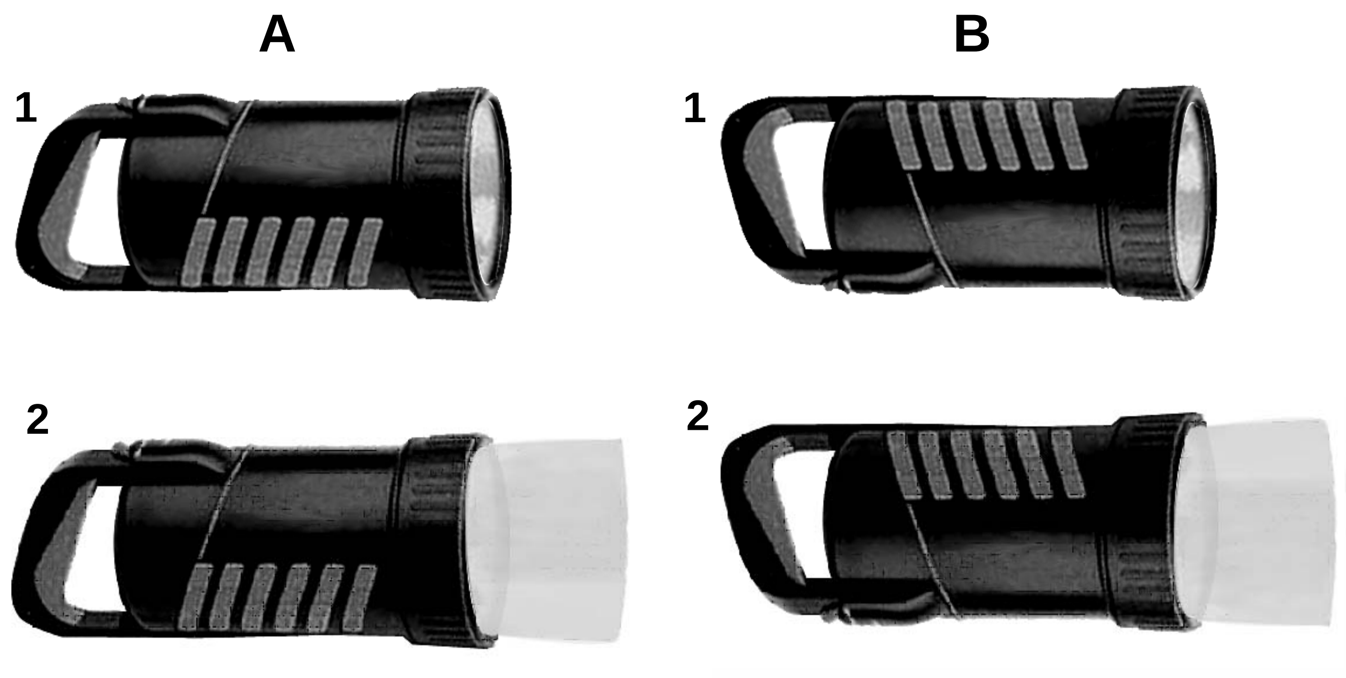

Figure 4: Mean reaction times (RTs) for the active- and passive-state conditions of Experiment 2 as a function of handle-response correspondence and bin.