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Dissociating Simon and affordance compatibility effects: Silhouettes and photographs

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ABSTRACT

When a graspable object's handle is oriented to the same side as the response hand, responses are quicker and more accurate than when it is oriented to the opposite side. This effect has been attributed to the affordance of the object's handle (Tucker & Ellis, 1998). Recent findings suggest this effect results instead from an abstract spatial response code (i.e., Simon effect; Cho & Proctor, 2010). However, the stimuli used in these previous studies differ in the amount of object and environmental depth information they contain, which may be critical to conveying an affordance. This information could explain these disparate findings as well as dissociate Simon and affordance compatibility effects. Four experiments demonstrate that the Simon effect results from the absence of this information, as in a silhouette, and the affordance effect results from its presence, as in a photograph. A fifth experiment confirmed that modifying information associated with the affordance, rather than the modification itself, produced the effects observed in the previous experiments. These findings support the following: (a) the internal details of an object and environmental depth can dissociate Simon and affordance compatibility effects, (b) this information is necessary to convey the object's graspable affordance, and (c) the outer shape of the object is not sufficient to elicit an affordance effect. These findings are discussed in relation to the theory of embodied cognition.

1. Introduction

Studies in which viewers are presented with images of a graspable object (e.g., frying pan) with its handle oriented to the same side of as the response hand demonstrate that the orientation of its handle influences response times (RT) and percentage of errors (PE). This is interpreted as evidence of an automatic potentiation of action associated with the grasping affordance because responses are not made to the object's handle, but instead made to imperative stimuli unrelated to the handle's orientation (e.g., Ellis & Tucker, 2000; Tucker & Ellis, 1998). These findings, referred to as stimulus–response compatibility effects (Alluisi & Warm, 1990) and hereinafter as *compatibility effects*, are due to an overlap between stimulus and response dimensions. Objects, such as those with graspable handles that allow for specific motor interactions, known as affordances (Gibson, 1979), have been proposed to produce compatibility effects due to their propensity to prime specific object-relevant motor responses (Michaels, 1988; Michaels, 1993; Tucker & Ellis, 1998). This *affordance effect* has not only been interpreted as resulting from a specific motor behavior afforded by the graspable component (Tucker & Ellis, 1998), but also from an abstract motor behavior (Phillips & Ward, 2002), as well as from attention being directed toward the graspable component (Anderson, Yamagishi, & Karavia, 2002). Cho and Proctor (2010) have put forth another explanation, the Simon effect (Simon, 1969; Simon & Rudell, 1967), for which they

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argue the affordance effect is instead due to the dimensional overlap between stimulus (i.e., salient object property) and response spatial codes.

An affordance effect resulting from images of graspable objects was first demonstrated by Tucker and Ellis (1998). In Experiment 1, participants pressed buttons with their left and right index fingers (between-hand responses) in response to the vertical orientation (i.e., upright/inverted) of graspable objects. The orientation of the handle (45° to the left/right of midline) also varied, but was irrelevant to the task. The response fingers were separated by 30 cm to avoid ambiguity as to which hand is in the optimal position to respond to the handle orientations. They found when the handle was oriented to the same side as the response hand (compatible trial), RTs were significantly faster and PEs significantly smaller than when the handle was oriented to the opposite side (incompatible trial). To eliminate the possibility that this compatibility effect was due to the Simon effect (Simon, 1969; Simon & Rudell, 1967), they repeated the task in Experiment 2 with participants instead providing responses using the right hand index and middle fingers on the same right side location as Experiment 1 (within-hand responses). They argued that if the handle's affordance had produced the effect in Experiment 1 then a compatibility effect should not be obtained when responses were unimanual, because the handle's orientation was only compatible with a right hand response for half of the trials. In contrast, if a compatibility effect was obtained with unimanual responses then the findings of Experiment 1 must be a result of the Simon effect. No support for the Simon effect hypothesis was found, but it should be noted that a significant compatibility effect was obtained when the RT medians were analyzed. Tucker and Ellis concluded that the affordance provided by the handle's orientation automatically potentiates the relevant motor response (i.e., reach and grasp movement) which in turn influences the speed and accuracy of the response task.

Subsequent research has found that depth information plays a critical role in eliciting the affordance effect (Symes, Ellis, & Tucker, 2007, Experiment 4). In Experiment 4, Symes et al. presented images of a centered cylinder rotated ±45° from the vertical midline. In one condition, the cylinder was presented in the frontal plane so that neither of its ends appeared to be oriented toward the observer. In another condition the cylinder was oriented in depth so that its lower end appeared to be closer. An affordance effect was only obtained when the cylinder was oriented in depth. Depth information was provided by external details, outer shape, and internal details, shading and contour lines, as well as environmental depth cues, texture gradient and shading, all of which served to indicate the cylinder's proximal end. Environmental depth has also been found to play a role in producing an affordance effect for an approach response (i.e., pushing a joystick) to a distal stimulus in an array (Stins & Michaels, 1997, Experiment 2). Considering the critical role depth plays in eliciting an affordance effect, stimuli should depict the affording component as oriented toward the observer and within the observer's peripersonal space (Costantini, Ambrosini, Tieri, Sinigaglia, & Committeri, 2010).

Another important factor in the production of Simon and affordance compatibility effects is the object's horizontal location (Iani, Baroni, Pellicano, & Nicoletti, 2011, Experiment 2; Symes, Ellis, & Tucker, 2005, Experiment 1). In one study, the object's left/right location was found to interact with the handle's left/right orientation resulting in a subtractive compatibility effect (Iani et al., 2011, Experiment 2). In another study, Simon and affordance compatibility effects were not found to interact, but nevertheless produce distinct effects that result in an additive compatibility effect (Symes et al., 2005, Experiment 1). Aside from the dissimilarity between these findings, they suggest that manipulating horizontal location influences the affordance compatibility effect, and research on affordance effects should therefore control for horizontal location.

The notion that bimanual responses can produce an affordance effect has been challenged by a demonstration that the same effect is obtained with foot responses, suggesting it is due to an abstract spatial response code (Phillips & Ward, 2002). However, Symes et al. (2005) found the pattern of results derived from hand and foot responses are somewhat distinct in that the latter, unlike the former, did not yield a significant compatibility effect due to the handle's orientation. In addition, they found foot responses do not give rise to the Stroop-like effect that was obtained with hand responses due to the interaction between handle orientation and object location. Another challenge to the validity of the affordance effect is the finding that it results from attention being directed to a salient component of an object, such as a handle (Anderson et al., 2002). However, it is difficult to reconcile this with Pappas and Mack's (2008) finding that attention is not necessary for the generation of an affordance effect by using the attentional blink task (Raymond et al., 1992; Shapiro, 1994), as well as Riggio et al.'s (2008) demonstration that the affordance effect is nevertheless obtained in the presence of a concurrent attention capturing event (i.e., offset of a non-target stimulus; see also Symes et al., 2007, Experiment 5).

Cho and Proctor (2010) recently presented evidence that Tucker and Ellis' (1998) findings are not due to an affordance, but rather due to the spatial compatibility of the handle's relative location, essentially a Simon effect. In their study (Experiments 2a and 3), a frying pan was presented with its handle oriented to the left or right sides, and participants responded to the object's vertical orientation. Robust compatibility effects were obtained for between- and within-hand responses. Of importance was their failure to find a significant difference in RTs and PEs between the response modes. Since a compatibility effect was obtained using within-hand responses, this effect was not due to the handle's affordance, but instead due to an abstract spatial response code resulting in the Simon effect. Additionally, they obtained similar compatibility effects when the affordance information was eliminated, by presenting a disembodied version of the handle (Experiment 2b) and a dotted line (Experiment 2c). Their experiments clearly provide strong evidence for the Simon effect. However, there are important differences between their experiments (Experiments 2a and 3) and those of Tucker and Ellis.