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Is that graspable? Let your right hand be the judge

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ABSTRACT

A right-hand preference for visually-guided grasping has been shown on numerous accounts. Grasping an object requires the integration of both visual and motor components of visuomotor processing. It has been suggested that the left hemisphere plays an integral role in visuomotor functions. The present study serves to investigate whether the visual processing of graspable objects, without any actual reaching or grasping movements, yields a right-hand (left-hemisphere) advantage. Further, we aim to address whether such an advantage is automatically evoked by motor affordances. Two groups of right-handed participants were asked to categorize objects presented on a computer monitor by responding on a keypad. The first group was asked to categorize visual stimuli as graspable (e.g. apple) or non-graspable (e.g. car). A second group categorized the same stimuli but as nature-made (e.g. apple) or man-made (e.g. car). Reaction times were measured in response to the visually presented stimuli. Results showed a right-hand advantage for graspable objects only when participants were asked to respond to the graspable/non-graspable categorization. When participants were asked to categorize objects as nature-made or man-made, a right-hand advantage for graspable objects did not emerge. The results suggest that motor affordances may not always be automatic and might require conscious representations that are appropriate for object interaction.

1. Introduction

Behavioral studies have demonstrated that humans generally prefer to use their right hand for grasping. Using unimanual and bimanual tasks, an overall right-hand preference in the majority of right-handed individuals has been shown for picking up various types of objects: geometric 3D shapes (Gabbard, Tapia, & Helbig, 2003), cards (Bishop, Ross, Daniels, & Bright, 1996; Calvert & Bishop, 1998; Carlier, Doyen, & Lamard, 2006), toys (Bryden & Roy, 2006; Sacrey, Karl, & Whishaw, 2012), tools (Mamolo, Roy, Bryden, & Rohr, 2004; Mamolo, Roy, Bryden, & Rohr, 2005; Mamolo, Roy, Rohr, & Bryden, 2006), and blocks (Gonzalez, Whitwell, Morrissey, Ganel, & Goodale, 2007; Stone, Bryant, & Gonzalez, 2013), for example. This preference extends beyond handedness as several of these studies have also found similar results in subgroups of left-handed individuals (Gonzalez & Goodale, 2009; Gonzalez et al., 2007; Stone et al., 2013). In addition, psychophysical studies have shown that in both left- and right-handers, right hand reach-to-grasp movements are less susceptible to the influence of visual illusions and visual context (Adam, Müskens, Hoonhorst, Pratt, & Fischer, 2010; Gonzalez, Ganel, & Goodale, 2006) when compared to those performed by the left hand. For instance, when participants were asked to grasp an object embedded in the Ebbinghaus or Ponzo illusion, the grip apertures of the right hand were accurately scaled to the real size of the object. Grip apertures of the left hand, however, reflected a perceived (illusory) state rather than the actual size of the target (Gonzalez et al., 2006). In harmony with the aforementioned behavioral studies, functional studies examining right-handers have shown a left-hemisphere dominance for motor behavior (Civardi, Cavalli, Naldi, Varrasi, & Cantello, 2000; Volkmann, Schnitzler, Witte, & Freund, 1998). Together these results suggest that the left hemisphere, which controls the right hand, plays a special role in the control of visually-guided grasping.

But what aspects of visuomotor processing are more specialized to the left hemisphere? Visually-guided actions like reaching and grasping require the integration of visual and motor information. Is there a left-hemisphere advantage in the processing of visual information relevant to grasping? This was the question addressed in the current investigation. Behavioral and neuroimaging research has shown that the visual representation of an object not only includes a description of its visual properties but also encodes actions relevant to that object (Ellis & Tucker, 2000; Gibson, 1979; Grèzes & Decety, 2002; Grèzes, Tucker, Armony, Ellis, &

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Passingham, 2003; Tucker & Ellis, 1998). In other words, the viewing of manipulable objects has been shown to potentiate motor affordances of possible actions toward those objects. For instance, a cup handle might afford grasping and a door knob might afford turning. In a classic experiment investigating motor affordances, Tucker and Ellis (1998) presented participants with photographs of graspable objects. The objects were presented in two horizontal orientations (one compatible with a right-hand grasp, and the other with a left-hand grasp) and two vertical orientations (upright or inverted). Participants were asked to make keypad responses as quickly and accurately as possible according to whether an object was upright or inverted. The results showed a 'stimulus response compatibility (SRC) effect'; when an object's horizontal orientation was compatible with the hand of response (handle oriented to the right when responding with the right hand and viceversa for the left hand), participants responded quicker even though the object's horizontal orientation was irrelevant to the task at hand (as participants were responding to the vertical orientation). This result led the authors to suggest that the perception of an object induces a range of object-action associations irrespective of the viewer's intention. Extensive behavioral data have shown similar results in that the perception of an object automatically elicits motor affordances (Ellis & Tucker, 2000; Grèzes et al., 2003; Phillips & Ward, 2002; Tucker & Ellis, 1998, 2001).

To this day, a focus on motor affordances continues to remain in the spotlight of empirical research. By far and large, the SRC effect has been shown to play a prevailing role in the actualization of motor affordances and has been ascribed to automatic mapping of compatible stimulus-response coding (Kornblum, Hasbroucq, & Osman, 1990). For example, studies have shown that participants respond more accurately and rapidly when the spatial location of a response is congruent with the spatial location of a stimulus, even though the location of the stimulus is *irrelevant* to the task at hand (i.e. the Simon effect (Simon, 1969; Simon & Rudell, 1967)). Three main accounts underlying the manifestation of task-unrelated motor affordance effects have been put forth: (1) specific motor coding, (2) abstract motor coding and (3) attention-directing coding (Symes, Ellis, & Tucker, 2005). Firstly, the notion of specific motor coding holds that there will be facilitation toward the hand of response that is most suited to perform an action. As demonstrated in Tucker and Ellis' (1998) experiment, handle orientation of a graspable object will trigger a quicker response when there is congruency between hand of response and the direction of an object's handle. However, in the past decade or so, the seemingly one-dimensional view of specific motor coding strictly linked to a right- or left-hand facilitation has been challenged. Research has shown that a spatial corresponding scheme may even be evoked from abstract motor codes (Phillips & Ward, 2002; Symes et al., 2005). More specifically, Phillips and Ward (2002) observed that it is not just the response 'hand' that is preferentially activated in SRC designs, but that when participants are asked to make speeded responses with their foot or crossed arms, the effector closest to the visually presented object will gain an advantage. Lastly, in regard to attention-directing coding, it has been proposed that the affordance effect may emerge as a result of the asymmetry of an object. The asymmetrical attribute may lead a viewer's attention toward the part of an object that carries salient features, thus generating an automatic attentional bias response code (Anderson, Yamagishi, & Karavia, 2002; Cho & Proctor, 2010). Phillips and Ward (2002) bring to light that salient features of objects may play an active role in both specific motor coding and abstract motor coding.

In the present study, a simple keypad response experimental design was used in order to investigate whether motor affordances would be evoked in two separate experimental conditions. The purpose of this study served to address: (1) if the observation of graspable objects elicits motor representations that favor a left hemisphere/right hand system (e.g. faster reaction times for the right hand when viewing graspable objects); and (2) whether affordances for graspable objects are automatic (i.e. if they exist independent of the viewer's intention). The novelty of the experimental design resided in that, in general, spatial compatibility influences were avoided. Importantly, for the graspable objects, the majority of stimuli were chosen based on their limited explicit grasping cues in order to steer clear of attentional bias or a SRC effect. More specifically, limited explicit grasping cues refer to objects that do not direct attention to a particular asymmetrical feature within the graspable stimuli. The vast majority of objects used in this study were symmetrical in shape (particularly the nature-made stimuli) and were presented in a wide range of orientations, providing little indication of an effector dependent grasping code. Thus, graspable objects that carried salient grasping features were limited. For the very few objects with handles for example, orientation was counterbalanced between stimuli (e.g. frying pan with handle oriented to the right vs. a coffee pot with handle oriented to the left). Furthermore, all visual stimuli were presented in the centre of a computer monitor in order to remove any influence of response location compatibility.

For the two experiments, pictures of common graspable (e.g. flower) and non-graspable (e.g. boat) objects were presented on a computer screen. In Experiment 1, participants were asked to use their right or left hand to make keypad responses according to whether the object was graspable or non-graspable. We hypothesized that if the left hemisphere specialization for grasping stems from an advantage in processing the visual properties of objects that afford manual interaction, we would expect faster reaction times for the right hand when identifying graspable objects. In a following experiment (Experiment 2) a new set of participants were presented with the exact same stimuli as in Experiment 1 but were asked to categorize objects according to their nature, explicitly, whether an object was nature-made (e.g. flower) or man-made (e.g. boat). The purpose of Experiment 2 served to examine whether task-unrelated motor affordances for graspable objects would be evoked. If the hypothesis put forth in Experiment 1 is confirmed, then Experiment 2 will allow for a further investigation into whether a right-hand advantage exists for graspable objects independent of the viewer's intention. If motor affordances do not require conscious action representations, then faster reaction times would be expected for graspable objects with the right hand regardless of categorization (i.e. nature-made/man-made).

2. Experiment 1: Graspable/Non-graspable categorization

2.1. Methods

2.1.1. Participants

Twenty-one self-reported right-handed individuals and one self-reported left-handed individual took part in the study, ranging between the ages of 16-35. The majority of the participants (eighteen) were from the University of Lethbridge and received course credit for their participation. Four additional participants were recruited from a local high school and came in to the University for testing. Subjects were naïve to the purpose of the study. The study was approved by the local ethics committee and all participants provided written informed consent before commencing.

2.1.2. Material and methods

2.1.2.1. Handedness questionnaire. A modified version of the Edinburgh (Oldfield, 1971) and Waterloo (Brown, Roy, Rohr, & Bryden, 2006) handedness questionnaire was given to all participants (see Stone et al., 2013 for a full version of the questionnaire)