# Tracking the compatibility effect of hand grip and stimulus size

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## 1. Introduction

Grasping, traditionally investigated in motor control literature (e.g., Oztop & Arbib, 2002), has became an usual topic for those visuo-motor transformations studies that, building on the notion of *affordance*, have shown objects observation/processing as able to activate adequate motor responses. For example, Tucker & Ellis (2001) required to categorize (artificial/natural) objects differing in size (big/small) with grasping responses (power/precision) over a customized device. The results showed a compatibility effect between object size and response grip. Tucker & Ellis (2004) also showed that object names are able to exert analogous effects, suggesting *affordance-based compatibility effects* as supported by long-term associations between objects and actions. Recently, influence on affordance activation by visual contexts determined by the presence of a hand in manipulative/functional interaction with a tool and a passive object (e.g., Borghi et al., 2012; Natraj et al., 2013) has been observed; in the same direction, Kalenine et al. (2013) presented conflict-objects in complex visual contexts, observing a compatibility of manual response (precision/power grip) and object state (active/passive) driven by the visual scene where the conflict-object was embedded.

No study so far has investigated how the compatibility/incompatibility of object information and hand posture develops during explicit movements. This work is aimed at unfolding when the possible conflict of hand posture and object size come into play and how it modulates the trajectory of reaching movements to the target-object, by presenting along with it a distractor-object compatible/incompatible in size.

This study required participants to respond using a mouse to investigate static hand postures often performed to interact with objects (we hold screws, apples etc.), providing an ecological validation of the affordance effect. In fact, as a continuous measure particularly useful to reveal the fine-grained effect of conflicting cognitive processes, the mouse trajectory informs about the influence of congruent/conflicting information over response selection (Barca & Pezzulo, 2012; Freeman & Ambady, 2010).

Our prediction is a compatibility effect between the grip on the mouse and the grip elicited by the target-object; reciprocally, the degree of uncertainty expressed by the trajectory should be higher when mouse and distractor are size-compatible.

## 2. Experiment 1

## 2.1 Method

24 students (9 males; age = 21.25 (2.88)) performed a semantic categorization task on 16 visual objects (8 natural objects and 8 artifacts; within each category 4 objects afforded a power and 4 a precision grip), see Fig. 1.

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Insert Figure 1 about here
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Participants began each trial clicking the START button, then the cue-word ARTIFICIAL/NATURAL appeared, followed by the stimuli in the left/right-top corners. Participants had to decide which among the two stimuli matched the cue-word (see Fig. 2). Stimuli were presented in two blocks of 128 trials each; in one participants used the big mouse (length 11 cm x width 6 cm x height 3.5 cm), in the other the small (7 x 3.5 x 2.2 cm).

MouseTracker software[1] recorded the continuous stream x-y coordinates of participants' hand movements: precise characterizations of temporal and spatial dynamics of the trajectories were available to be analyzed.

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## 2.2. Results

The *Area Under the Curve* (AUC) measures the attraction of the movement toward the distractor item, indexing the indecision during the choice.

The data were entered into a 2 x 2 x 2 x 2 within subjects ANOVA, with the factors Response Device (big/small), Target Type (artifact/natural), Target Dimension (big/small), Distractor Dimension (big/small). Interaction effects were evaluated with Newman-Keuls post-hoc test ($p$ <.05). Only the results relevant for our theoretical conclusion are reported.

The interaction Response Device x Target Dimension was significant ($F$(2, 46) = 11.06, $MSe$ = 0.04411, $p$ <.01 - Big mouse: Big target-object $M$ = 0.29, Small target-object $M$ = 0.37; Newman-Keuls $p$ < .05. Small mouse: Big target-object $M$ = 0.45, Small target-object $M$ = 0.38; Newman-Keuls $p$ <.05), see Fig. 3, Fig. 4 - Graph a.

[1] http://www.dartmouth.edu/~freemanlab/mousetracker/dl.htm)

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Insert Figure 3 about here
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The interaction Response Device x Distractor Dimension was significant ($F(2, 46) = 8.73$, $MSe = 0.03408$, $p < .01$ - Big mouse: Big distractor $M = 0.36$, Small distractor $M = 0.29$; Newman-Keuls $p < .05$. Small mouse: Big distractor $M = 0.44$, Small distractor $M = 0.40$; Newman-Keuls $p = .07$), see Fig. 4 - Graph b.

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2.3. Discussion of Experiment 1

The results confirmed that the trajectories were more direct, revealing less uncertainty in the decisional process, when the dimension of the mouse and the object size matched. A reciprocal effect was observed for distractor objects, even if it was somewhat weaker,. To our knowledge, this is the first evidence of compatibility effect between object size and static hand posture with a kinematic measure.

The effects obtained raise the issue of whether our effects depend on online computation, or whether they depend on information stored in memory. To investigate this issue, we performed a second experiment in which we presented the names of the objects instead of the images; this allowed us to determine to what extent the effects were due to information stored in memory.

3. Experiment 2

3.1. Method

Twenty-four under graduated students (12 males; age = 22.37 (3.19)) performed the same task of Experiment 1, but on the objects' names.

3.2. Results

The ANOVA on AUC showed the interaction Target Dimension x Distractor Dimension ($F(2, 46) = 4.57$, $MSe = 0.02833$, $p < .05$ - Big target-object: Big distractor $M = 0.48$, Small distractor $M = 0.39$; Newman-Keuls $p < .01$. Small target-object: Big distractor $M = 0.42$, Small distractor $M = 0.41$), see Fig. 5 - Graph a.

The interaction between Response Device x Target Type x Target Dimension was significant ( $F(3, 92) = 4.87$, $MSe = 0.06818$, $p < .05$ - Mouse big / Artifact: Big target-object $M = 0.37$, Small target-object $M = 0.34$; Natural: Big target-object $M = 0.29$, Small target-object $M = 0.33$; Mouse small / Artifact: Big target-object $M = 0.53$, Small target-object $M = 0.59$, Natural: Big target-object $M = 0.54$, Small target-object $M = 0.43$), with differences concerning especially the small target when using the small mouse, whereas the natural items were lower in AUC than the artifacts (Newman-Keuls $p < .05$) (see Fig. 5 - Graph b).

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Insert Figure 5 about here
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### 3.3. Discussion of Experiment 2

In Experiment 2 the compatibility between hand posture and implied dimension of the stimulus was not observed. At first sight, its absence seems problematic for embodied accounts, according to which words are grounded in perception, action and emotion systems (e.g., Barsalou, 2008). However, the Response Device x Target Type x Target Dimension interaction showed evidence of motor information activation with words. This presence of the effect suggests that words elicit modal information as part of an embodied reenactment of associated sensorimotor experiences, but this simulation is not so fine-grained as the one formed during object processing.

## 4. Conclusion

The reported evidence supports the embodied cognition view: object observation activated a fine-grained motor simulation preparing specific kinds of grip. Evidence of motor information activation was found with words too, but we failed to replicate the compatibility effect previously observed with objects.

Experiment 2's results can be read in terms of theories of reuse/motor exploitation: if language recruits structures and mechanisms characterizing the motor system, it also modifies them and builds on them (Anderson, 2010; Pezzulo & Castelfranchi, 2009; Gallese, 2008). For example, it seems that language recruits only some kinds of affordances linked to stable characteristics of objects/actions (see Borghi, 2012; Flumini, 2014).

In general, our results indicate that, while the compatibility between postures and visual objects occurs online, motor information on object size is processed offline and influences language comprehension as well.

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WORD COUNT: 1575 (main text and bibliography)

# FIGURES

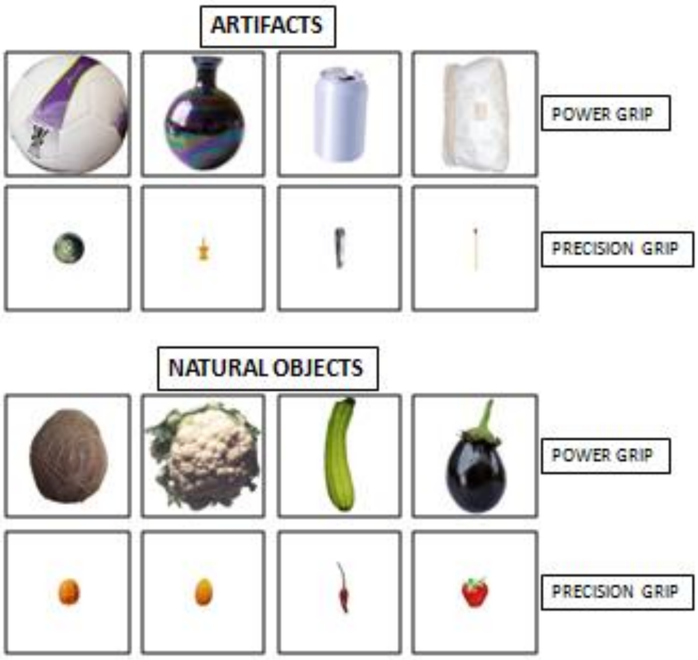


**Fig. 1.** Sample stimuli used in the experiment

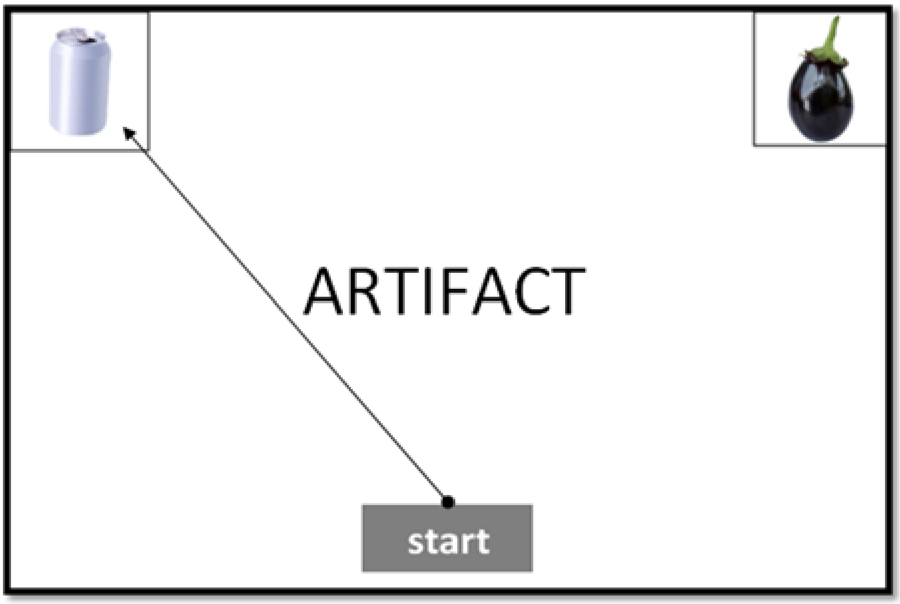


**Fig. 2.** Example of an experimental trial

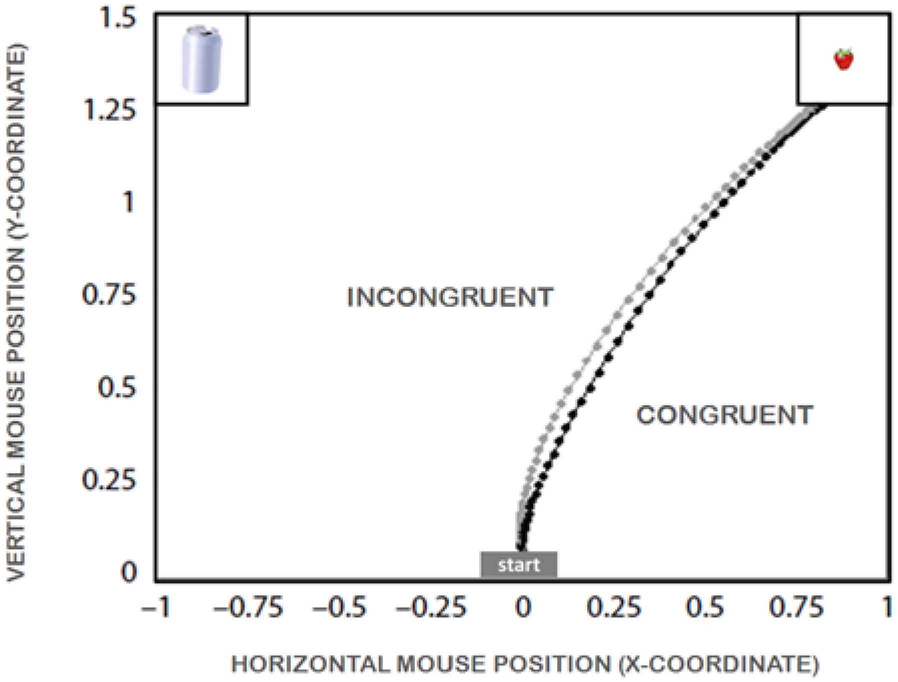


**Fig. 3.** Experiment 1, congruent (black line) vs. incongruent (grey line) trials, plot of the mean trajectories

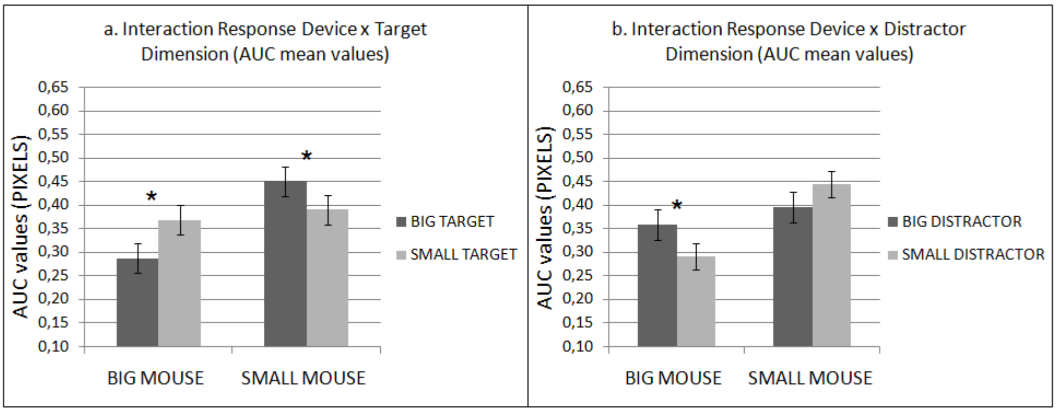


**Fig. 4.** Experiment 1, all the results

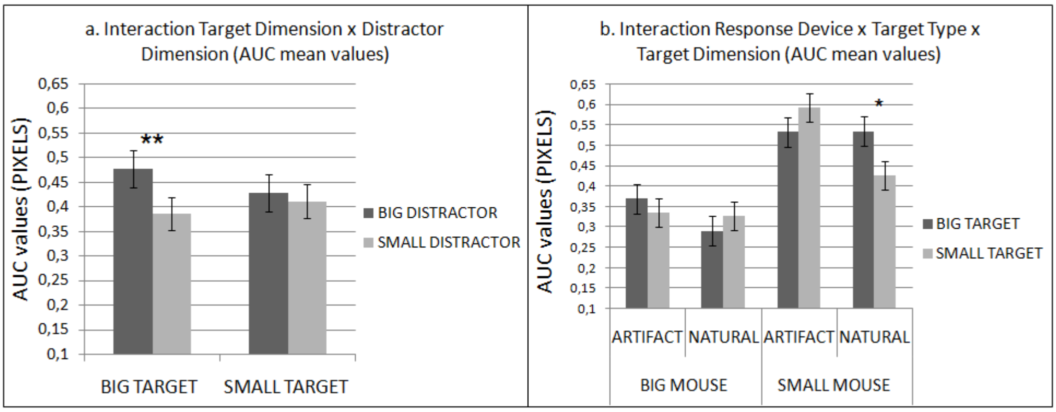


**Fig. 5.** Experiment 2, all the results