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Objects and their nouns in peripersonal space

Francesca Ferri[a,*], Lucia Riggio[a], Vittorio Gallese[a,b], Marcello Costantini[c,d,**]

[a] Dipartimento di Neuroscienze, Sezione di Fisiologia, Università di Parma, 39 Via Volturno, 43100 Parma, Italy
[b] IIT Brain Center for Social and Motor Cognition, 39 Via Volturno, 43100 Parma, Italy
[c] Laboratory of Neuropsychology and Cognitive Neuroscience, Department of Neuroscience and Imaging, University G. d'Annunzio, Chieti, Italy
[d] Institute for Advanced Biomedical Technologies – ITAB, Foundation University G. d'Annunzio, Chieti, Italy

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ABSTRACT

In this study we investigated whether objects and their name evoke the activation of the same motor programs. In the first experiment participants had to make speeded responses based on the category of an object. They had to signal whether an object, presented visually, either within or outside their reachable space, was natural or manufactured, by making reach-to-precision or reach-to-power grasp responses. We found a compatibility effect between the response required by task, and the grip evoked by the object, for reachable space only. Nevertheless, this finding holds for artefacts and not for natural objects. In the second experiment, participants had to make reach-to-precision or reach-to-power grasp responses when deciding whether an object, presented either within or outside their reachable space, was congruent with a previously displayed word. In this case we found a compatibility effect between the response required by task and the grip evoked by the object's name, however this effect was not limited by participants' reaching range. Our data suggest that objects and objects' name likely correspond to different motor representations. That is, while the former seem to house both stable (i.e., shape and size) and temporary (i.e., orientation and distance with respect to the perceiver) action-relevant information, the latter seem to house only stable action-relevant information.

1. Introduction

Neuroimaging and behavioural studies have demonstrated that visual perception of objects recruits sensory-motor resources. Such a recruitment has been considered as evidence that objects are represented in terms of the action they elicit (Gallese, 2000; Grafton, Fadiga, Arbib, & Rizzolatti, 1997; Grezes, Tucker, Armony, Ellis, & Passingham, 2003). Behaviourally this would imply that observing an object would lead to the selection of the movements aimed at skillfully acting upon it (e.g., Bub & Masson, 2010; Costantini, Ambrosini, Tieri, Sinigaglia, & Committeri, 2010; Ellis & Tucker, 2000; Tucker & Ellis, 1998, 2001, 2004). This selection has been demonstrated by means of the compatibility effect, that is, a decrease of reaction times when participants execute a motor act congruent with that suggested by the observed object. For instance, an apple would evoke a whole hand prehension while a cherry would evoke a precision grip. Such motor activations have been referred to as *micro-affordances* by Ellis and Tucker (2000). In their terminology *micro-affordances* are action-relevant object properties whose representation is in part constituted by the partial activation of the motor patterns required to interact with them. However, in order to skillfully interact with an object it is required that it falls within the reaching space of the agent. That is, the object should be near enough to be reached and grasped. This idea is supported by fMRI data showing that reach related areas, in parietal cortex are more responsive to real objects when they are within reach as compared to out of reach (Gallivan, Cavina-Pratesi, & Culham, 2009). Following this line of reasoning, it might be hypothesized that the activation of movements aimed at grasping an object should be stronger when it is located within the reaching space of the agent. This hypothesis was not confirmed in a previous study by Tucker and Ellis (2001). In their study, participants had to signal whether an object, located at a distance of 15 or 200 cm, was natural or manufactured, by producing precision or power grip responses, but notably, without any effective reaching movement. In fact, the response device was constantly held by participants' hands during the experiment. Their results showed a compatibility effect between the response produced by participants and the type of grip required by the object, regardless of their spatial relation. It is likely that the lack of any interaction between the action evoked by the object and its location might be due to the fact that a mere grip movement does not require the spatial localization of the object (Jeannerod, Arbib, Rizzolatti, & Sakata, 1995). Indeed, space localization is critical for reaching only, in a

* Corresponding author at: Dipartimento di Neuroscienze – Sezione di Fisiologia, Università di Parma Via Volturno 39, I-43100 Parma, Italy. Tel.: +39 0521 903963.
** Corresponding author at: Department of Neuroscience and Imaging, University of Chieti, Via dei Vestini 33, 66100 Chieti, Italy. Tel.: +39 0871 3556945; fax: +39 0871 3556930.
E-mail addresses: francesca.ferri@nemo.unipr.it (F. Ferri), marcello.costantini@unich.it (M. Costantini).

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reach-to-grasp sequence: its successful execution relies on the processing of the spatial relationship between the object to be reached and the body-effector performing the movement (Rizzolatti & Sinigaglia, 2008).

Thus, the aim of the first experiment presented in this study was to reveal whether the lack of the reaching component in Tucker and Ellis's study might account for the failure to find an interaction between the action evoked by visually presented objects and the spatial relation between the agent and the objects. In the first experiment participants had to make speeded responses based on the category of an object. Participants had to signal whether an object, presented either within or outside their reachable space, was natural or manufactured by making reach-to-precision or reach-to-power grasp responses.

Certainly, reachability does matter when participants are presented with real objects, where an actual interaction is possible, or at least, might be simulated. But, what happens when participants are presented with an objects' name? Previous studies have shown that the compatibility effect occurs even in this case (Bub, Masson, & Cree, 2008; Glover, Rosenbaum, Graham, & Dixon, 2004; Tucker & Ellis, 2004), suggesting that an object's name, as well as real objects, is able to evoke a suitable motor program. Nevertheless, names are conceptual representations of objects, thus it can be hypothesized that the motor program they are related to should

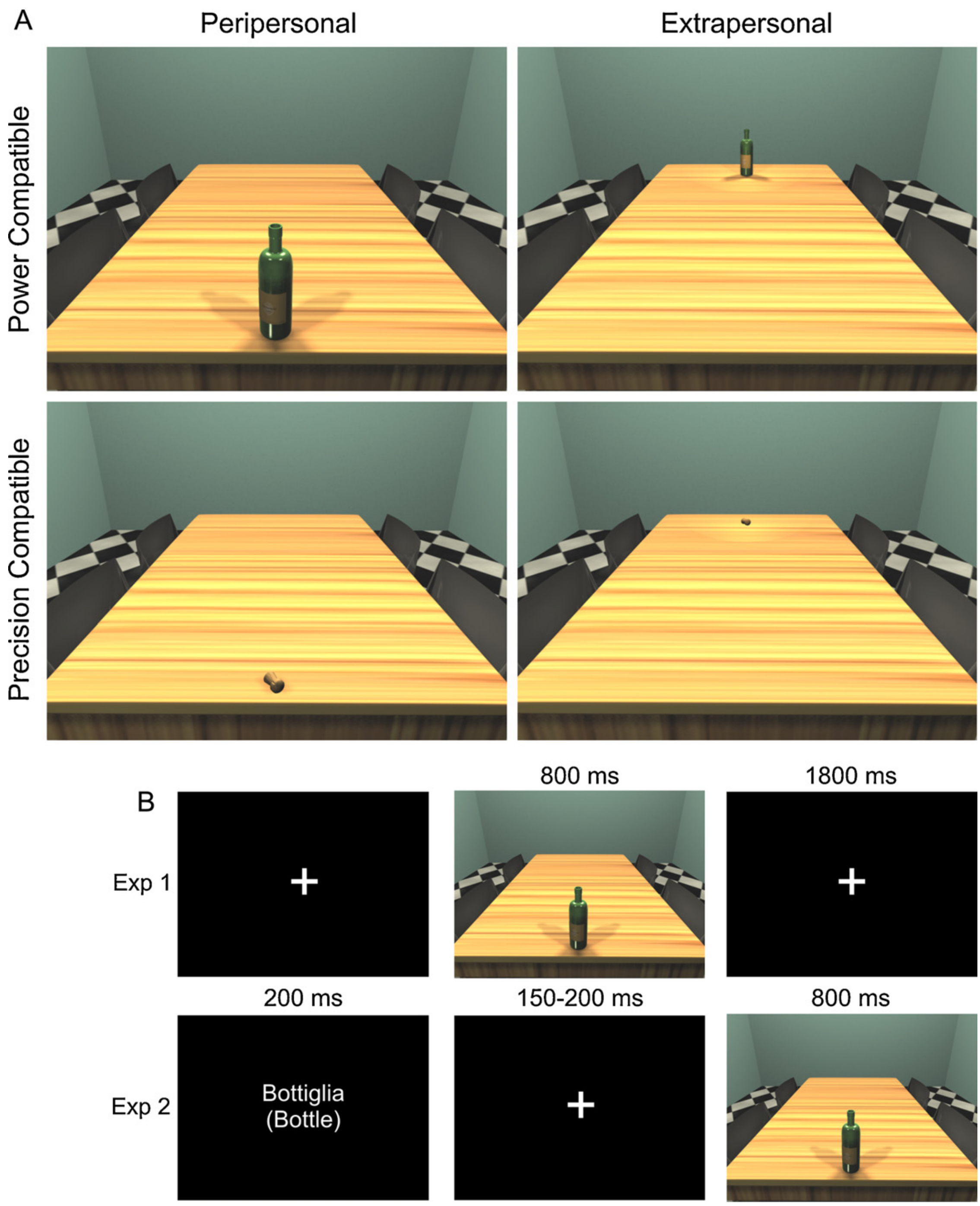

Fig. 1. Exemplar stimuli for Experiments 1 and 2 (panel A). Panel B depicts an exemplar trial from Experiment 1 (upper row) and Experiment 2 (lower row).

somehow be different from that evoked by the visual presentation of physical objects.

To test this hypothesis we ran a second experiment in which participants had to make reach-to-precision or reach-to-power grasp responses when deciding whether an object, presented either within or outside their reachable space, was congruent with a previously displayed word.

Recently, Borghi and Riggio (2009) proposed a distinction between what they have called stable and temporary action-relevant object properties. The former are related to features like shape and size, determining the type of grip with which the object is typically grasped, while the latter are related to temporary aspects, like orientation and position, which change depending on the way an object is presented with respect to the observer. If a difference does exist between the actions evoked by an object's name and those evoked by a visually presented object, it may lie in the fact that an object's name only recruits stable action-relevant object information while physical objects demand the encoding of both stable and temporary action-relevant object properties.

2. Experiment 1

2.1. Method

2.1.1. Participants

20 healthy participants (8 males, mean age 24 years) took part in the experiment. All participants had normal or corrected-to-normal visual acuity, and were right-handed according to self report. Informed consent was given before participation. Participants were naive as to the purpose of the experiment.

2.1.2. Materials

The experimental stimuli were red/cyan anaglyph stereo pictures depicting a 3D room in which there was a table with an object placed on top of it. Anaglyph images are useful to provide a stereoscopic 3D effect. Images are made up of two color layers, superimposed, but offset with respect to each other to produce a depth effect. The experimental stimuli were twenty-eight common objects listed in Appendix A. Fourteen were natural objects and fourteen were manufactured. The stimuli were inserted in a 1024 × 768 pixels matrix when presented in both the peripersonal/reachable and the extrapersonal/non-reachable space. Such dimensions allowed to reliably discriminate the objects both in near and far locations. Within each category half of the objects were small and would normally be grasped with a precision grip, and half were large and would normally be grasped with a power grip. Images were created by means of 3D Studio Max™ and StereoPhoto Maker. Using red/cyan anaglyph stereo pictures allowed us to present the objects either within the peripersonal/reachable (50 cm) or extrapersonal/non-reachable (170 cm) space of participants (See Fig. 1, panel A).

2.1.3. Procedure

Participants sat in front of a computer screen at a distance of approximately 57 cm, wearing anaglyph 3D glasses. Each trial consisted of the presentation of a visual stimulus for 800 ms followed by a fixation cross lasting 1800 ms (see Fig. 1, panel B). Each trial began with the participant resting the right hand, with the fingers in pinch position, on a response button. Half of participants were instructed to produce a power grasp if the object was manufactured and a precision grip if the object was natural, while the other half had the opposite response assignment. Responses were made by lifting the fingers from the response button and then making the appropriate grasping movement toward a device fixed at approximately 30 cm from the response button. This allowed us to measure liftoff time (i.e., the time between onset of the visual stimulus and initial hand movement). The device was a plastic object consisting of two segments: a larger cylinder (diameter: 6 cm; height: 14 cm) at the bottom and a much smaller cylinder (diameter: 1.5 cm; height: 4 cm) attached on top of it, thus, the lower part was graspable with a whole hand prehension while the upper part was graspable with a precision grip. The accuracy of each response was visually checked by one of the experimenters, sitting next to the participants, but out of their sight.

The presentation of the stimuli and the recording of participants' responses were controlled by E-prime software. Accuracy was visually checked by one of the experimenters. Each object was presented three times in both peripersonal and extrapersonal space resulting in 42 trials per object class, for a total of 168 trials, lasting approximately 7 min.

2.2. Results

Trials in which participants failed to respond (0.5%) were excluded from the analysis of response times (RTs). The mean RTs were calculated for each condition; responses more than 2 standard deviations from the individual mean were treated as outliers (3%). Data were entered in a three-way ANOVA with Object Class (manufactured vs. natural), Compatibility (compatible vs. incompatible) between the response required and the grip evoked by the object, and object location (reachable vs. non-reachable). Whenever appropriate, post hoc analyses were performed with the Newman–Keuls method. An alpha level of 0.05 was always used.

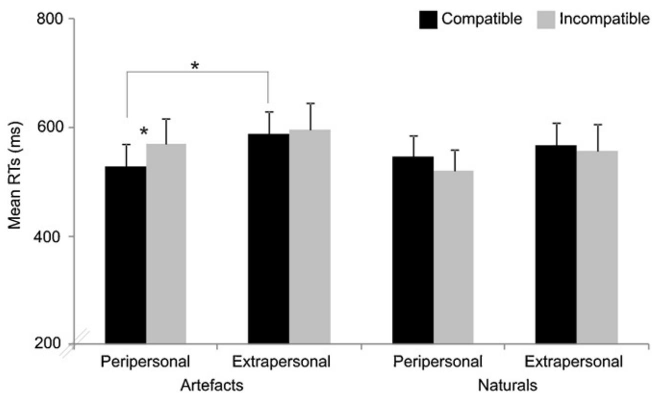

Fig. 2. Mean RTs and error rates for Experiment 1 by category (artefacts or natural), object location (peripersonal or extrapersonal) and compatibility (compatible or incompatible).

The analysis revealed a significant main effect of object class ($F_{(1,19)} = 13.48$; $p < 0.01$) with faster RTs to natural ($M = 547$ ms; SD = 182 ms) compared to manufactured objects ($M = 570$ ms; SD = 199 ms).

The ANOVA also revealed a significant main effect of Object Location ($F_{(1,19)} = 31.8$; $p < 0.001$) with faster RTs to objects located within the reachable space ($M = 541$ ms; SD = 180 ms) compared to those in the non-reachable space ($M = 576$ ms; SD = 200 ms). The interaction between object class and compatibility was also significant ($F_{(1,19)} = 4.27$; $p < 0.05$). Post hoc analyses revealed faster RTs to compatible trials ($M = 558$ ms; SD = 186 ms) compared to incompatible trials ($M = 582$ ms; SD = 213 ms, $p < 0.05$) for manufactured objects only.

The most important result, however, was the significant three-way interaction ($F_{(1,19)} = 4.19$; $p = 0.05$). This interaction is illustrated in Fig. 2 and shows faster RTs to compatible reachable trials ($M = 528$ ms; SD = 185 ms) compared to compatible non-reachable trials ($M = 587$ ms; SD = 196 ms; $p < 0.01$), for manufactured objects only. Moreover, it shows faster RTs to compatible reachable trials ($M = 528$ ms; SD = 185 ms) compared to incompatible reachable trials ($M = 569$ ms; SD = 211 ms; $p < 0.05$), for manufactured objects only. No other effects were significant.

3. Experiment 2

In the first experiment we found a compatibility effect for manufactured confined to participants' reaching space. This finding suggests that action-related information associated with visually presented objects are spatially-constrained, that is, they are evoked provided that the object is actually reachable by the perceiver. In this second experiment we aimed at investigating whether objects' names are also able to evoke action-related information and, if this is the case, whether such information is spatially constrained.

3.1. Method

3.1.1. Participants

20 healthy participants (11 males, mean age 23 years) took part in the experiment. All participants had normal or corrected-to-normal visual acuity, and were right-handed according to self report. They were naive as to the purpose of the experiment and gave their informed consent prior to participation.

3.1.2. Materials

The experimental stimuli were images and words. Images consisted of red/cyan anaglyph stereo pictures depicting a 3D room in which there was a table with an object placed on top of it. Fourteen common manufactured objects were used (see Appendix A). Half of the objects were small and would normally be grasped with a precision grip while half were large and would normally be grasped with a power grip. Images were created by means of 3D Studio Max™ and StereoPhoto Maker. Using red/cyan anaglyph stereo pictures allowed us to present the objects either within the peripersonal/reachable (50 cm) or extrapersonal/non-reachable (170 cm) space of participants (see Fig. 1, panel A). Word stimuli consisted of the name of the presented objects (see Appendix A).

3.1.3. Procedure

Participants sat in front of a computer screen at a distance of approximately 57 cm, wearing anaglyph 3D glasses. Each trial consisted of the presentation of an object name shown at the center of the screen (fixation point) for 200 ms followed, after a delay of 150 or 200 ms, by an object presented on the vertical meridian of

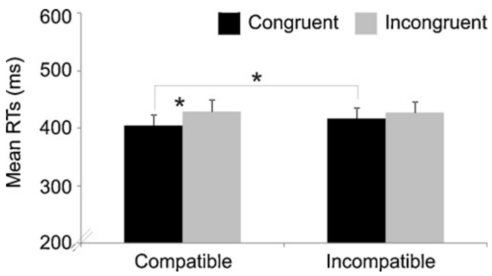

Fig. 3. Mean RTs and error rates for Experiment 2 by compatibility (compatible or incompatible) and congruency (congruent or incongruent).

the screen (in the peripersonal or the extrapersonal space; see Section 2.1.2 for Experiment 1) and lasting 800 ms (see Fig. 1, panel B). Each trial began with the participant resting the right hand, with the fingers in pinch position, on a response button. Half of the participants were instructed to produce a power grasp if the object was the same as that indicated by the word, and a precision grip if the object was different from that represented by the word, while the other half of participants had the opposite response assignment. Responses were made by lifting the fingers from the response button and then making the appropriate grasping movement toward a device fixed at approximately 30 cm from the response button. The accuracy of each response was visually checked by one of the experimenters, sitting next to the participants, but out of their sight. During the inter-trial interval, a white fixation cross was presented for 1000 ms. Each object was presented four times in both the peripersonal and the extrapersonal space preceded by an object name which could represent the same object (e.g., hammer/hammer; congruent), a different object evoking a different grip (e.g., hammer/tea spoon; incongruent) or a different object, but evoking the same grip (hammer/frying pan; partially incongruent). Each subject completed 28 congruent trials, 14 partially incongruent and 14 incongruent trials in the peripersonal and extrapersonal space for a total of 224 trials.

3.2. Results

Trials in which participants failed to respond (1%) were excluded from the analysis of response times (RTs). The mean RTs were calculated for each condition; responses more than 2 standard deviations from the individual mean were treated as outliers (4%).

Data analysis was performed in two steps. First we investigated the effect of the level of incongruence, namely, partially incongruent (hammer/frying pan; different object, but evoking the same grip) and incongruent trials (e.g., hammer/tea spoon; different object also evoking a different grip), on RTs. We analyzed data in this way because the number of trials was different in the congruent, partially incongruent and incongruent conditions. Indeed, each participant provided us with 28, 14 and 14 trials per condition, respectively. This apparently unbalanced number of trials per condition was done in order not to bias participants toward one of the two responses.

The factors were: object location (peripersonal vs. extrapersonal), compatibility (compatible vs. incompatible) between the response required and the grip evoked by the word, and type of incongruence between the object's name and the presented object (partially incongruent vs. incongruent). The ANOVA revealed a significant main effect of object location only ($F_{(1,19)} = 8.3$; $p < 0.01$) with faster RTs to objects located within reachable space ($M = 419$ ms; SD = 83 ms) compared to those in non-reachable space ($M = 437$ ms; SD = 94 ms).

As partially incongruent trials did not differ from incongruent trials, in the second analysis these values were collapsed. Data were entered in a three-way ANOVA with location of the object (peripersonal vs. extrapersonal), compatibility (compatible vs. incompatible) between the response required and the grip evoked by the word, and congruency (congruent vs. incongruent) between the presented object and the object's name.

The ANOVA revealed a significant main effect of object location ($F_{(1,19)} = 11.6$; $p < 0.01$) with faster RTs to objects located within reachable space ($M = 412$ ms; SD = 80 ms) compared to those in non-reachable space ($M = 427$ ms; SD = 85 ms).

The ANOVA also revealed a significant main effect of congruency ($F_{(1,19)} = 20.2$; $p < 0.01$) with faster RTs to congruent ($M = 411$ ms; SD = 83 ms) compared to incongruent trials ($M = 428$ ms; SD = 94 ms). The interaction compatibility by congruency was also significant ($F_{(1,19)} = 4.5$; $p < 0.05$). Post hoc analyses revealed faster RTs to congruent ($M = 405$ ms; SD = 85 ms) compared to incongruent trials ($M = 430$ ms; SD = 91 ms; $p < 0.001$) only when the required response and the grip evoked by the word were the same (compatible condition, Fig. 3). This was true both when the stimuli were presented in peripersonal ($M = 397$ ms; SD = 83 ms vs. $M = 417$ ms; SD = 86 ms, $p < 0.05$) and in extrapersonal space ($M = 413$ ms; SD = 94 ms vs. $M = 442$ ms; SD = 94 ms, $p < 0.05$). Finally, when trials were congruent, participants responded faster to compatible ($M = 405$ ms; SD = 85 ms) as compared to incompatible trials ($M = 418$ ms; SD = 87 ms; $p < 0.05$).

4. Discussion

The aim of this study was two-fold. First, it aimed at investigating whether activation of gestures associated with visually presented objects is modulated by their location in space, that is, their being positioned within or outside the perceivers' reachability. Second, it aimed at investigating whether action-related information evoked by visually presented objects is different from that evoked by the objects' names. Regarding the first question we found that action related information is spatially constrained, that is, it is activated provided that objects fall within the reaching range of the perceiver. Regarding the second question we found that the action related information, activated by an object's name, is not spatially constrained. The two results will be discussed in turn.

To date only two studies have investigated the relationship between the representation of action-relevant information and space for objects (Costantini et al., 2010; Tucker & Ellis, 2001). While Tucker and Ellis failed to find any interaction, the study by Costantini and colleagues did. In the earlier study (Tucker & Ellis, 2001) participants were asked to signal whether an object was natural or manufactured by grasping a response device with a precision grip or with a whole hand prehension. In different blocks objects could be located at a distance of 15 or 200 cm from participants. The categorization task was accomplished without any effective reaching movement, as the response device was always held by the participants and they had only to change their grip. Conversely, in Costantini et al.'s study (2010) participants had to replicate a reach to grasp movement as soon as a task irrelevant go-signal (i.e., a handled mug placed on a table) appeared. The mug could be placed either within the operational (i.e., near and reachable) or non-operational (i.e., far and non-reachable) space of participants. Furthermore, the handle of the mug suggested a motor act which could be compatible or incompatible with the action to be executed. The two experiments differ in three main aspects. First, in the former study the size of the object (that is the type of grip it elicited) was the relevant pragmatic feature, while in the latter it was the orientation of the handle (that is the selected effector). Second, the former study employed a categorization task while in the latter the object was task irrelevant. Third, in the former study the task was accomplished without any effective reaching movement, while in the latter a reaching movement was required. Previously (Costantini et al., 2010) we hypothesized that the lack of any interaction between spatial representation and action-relevant information in the earlier study might be due to the type of responses required of participants, that is, to respond by performing a grasping movement without having to reach the response device since it was held continually during the experiment.

There is much evidence that, although reaching and grasping movements are strictly intertwined, their planning and execution depend on different and segregated neural processes (Cavina-Pratesi et al., 2010; Jeannerod et al., 1995; Jeannerod, 1988). Indeed, grasping an object with the hand requires the transformation of the visual features of the object into the appropriate shaping of the fingers as well as the control of the execution the movements. For example, some neuropsychological patients are able to accurately reach a mug, but then fail to pre-shape the hand appropriately for grasping the handle (Binkofski et al., 1998), while other patients reach to an incorrect location even though they can form a proper grip under some circumstances. Spatial localization is critical for reaching only for which successful planning and execution depends on the processing of the spatial relationship between the object to be reached and the body parts involved in the reaching movements (Rizzolatti & Sinigaglia, 2008). Thus, it is likely that the effective reach-to-grasp motor task in the latter study was able to reveal the interaction between handle orientation and space. We employed the very same categorization task as Tucker and Ellis and we found that participants exhibited the compatibility effect only when the target object was located within their reachable space, showing that the experimental task is irrelevant while the actual execution of a reach-to grasp movement is mandatory for spatial modulation. Nevertheless, this finding holds only for artefacts and not for natural objects.

This dissociation between artefacts and natural objects is important for at least two reasons. First, it rules out the possibility that faster responses in the categorization task for reachable trials was due to higher visual salience of near objects compared to far objects (see also ter Horst, van Lier, & Steenbergen, 2011; Yang & Beilock, 2011). Second, it is fully in line with the proposal that while artefacts activate manipulation as well as functional information (Borghi et al., 2007; Costantini, Ambrosini, Scorolli, & Borghi, 2011; Vainio, Symes, Ellis, Tucker, & Ottoboni, 2008), natural objects do not. Also, at the behavioural level it has been shown that in categorization tasks artefacts are responded to more slowly than natural objects (Anelli, Nicoletti, & Borghi, 2010; Gerlach, 2009). Such increases in reaction time have been explained as being due to the recruitment of motor resources while processing artefacts.

In fact artefacts and natural objects differ on a number of factors. First and foremost, artefacts are intrinsically related to their function while natural objects are not. This idea is corroborated by the well-known phenomenon of functional fixedness (Duncker, 1945). This phenomenon refers to a cognitive bias that limits a person to using an object only in the way it is traditionally used. On the other hand, natural objects are not so clear on these aspects. On the same vein, representations of natural objects are thought to depend largely on perceptual features, whereas artefacts may depend more on functional information (Farah & McClelland, 1991; Warrington & McCarthy, 1987). Fruits such as oranges and apples differ in their color, but they are both food to be eaten. In contrast, artefacts are primarily differentiated by their functional properties. For instance, the fact that mugs are used for drinking distinguishes them from other tableware (e.g., plates) more than their perceptual properties. Mugs with varied features (e.g., with or without a handle) are still classified as mugs based on their use as drinking vessels (Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997). It should be noted here that some artefacts may belong to the special class of objects, namely tools. Indeed, though artefacts and tools have exemplars in common, they do not perfectly correspond. As the aim of this study was to investigate the spatially constrained activation of action relevant objects features we did not take into account such distinction.

As stated in Section 1, Borghi and Riggio (2009) made a distinction between stable and temporary action-relevant object properties. The former have been proposed to be related to the knowledge of how to grasp an object (computing its shape and size), which can be incorporated into an object representation and stored in memory; while the latter is related to the way the object is presented with respect to the observer (e.g., its orientation and position in space).

Before going on with the discussion we should make clear that the knowledge we are referring to does not pertain to the object itself, rather to the object–action association, named by Tucker and Ellis (2004) object–action knowledge.

Imagine the situation in which you have to cut a piece of bread. In this case you need both to localize the knife in space and to preshape your hand to accurately grasp the hilt of the knife. Following this functional distinction, it can be hypothesized that stable and temporary action-relevant object properties could be subserved by different neural circuits. The results of our first experiment suggest that visually presented objects activate both stable and temporary action-relevant object properties.

A lot of evidence has shown that an object and its name are almost indistinguishable in their ability to evoke motor programs (Bub et al., 2008; Glover et al., 2004; Tucker & Ellis, 2004). Such similarity is in line with the embodied theory of language perception (Barsalou, 1999; Gallese & Lakoff, 2005; Zwaan & Taylor, 2006) positing that language processing, especially action-related sentences, recruits the same neural networks activated when we perform the action referred to. This evidence recalls a central issue in cognitive neuroscience, that is, whether there are different representations associated with different input modalities (Paivio, 1971, 1986; Warrington & Shallice, 1984) or, a convergence onto the same set of representations from different input modalities (e.g., Caramazza, Hillis, Rapp, & Romani, 1990; Lambon Ralph, Graham, Patterson, & Hodges, 1999; Rapp, Hillis, & Caramazza, 1993). The paradigm used in our second experiment does not allow us to enter directly into this debate; at the same time it suggests a partially different representation for visual objects and nouns. Indeed, while we found a compatibility effect, in terms of grip, between the response required to the participants and the action evoked by the object, we failed to find any modulation of such effect with respect to spatial position of the object primed by the word. This result is particularly intriguing because it suggests a dissociation between the motor representations evoked by object names from those evoked by visually presented objects.

Returning to the distinction between stable and temporary action-relevant object information (Borghi & Riggio, 2009), the results of our second experiment suggest that an object's name activates only the former which by definition is insensitive to the location of the object in space. This evidence is particularly relevant if one considers that peripersonal space is specifically and transiently built up in a body-related way, thanks to the processes of sensory-motor integration. Indeed, the body is not represented as a mere object in space but is a subject/agent of spatial structuring: "When we say that an object is huge or tiny, nearby or far away, it is often without any comparison, even implicit, with any other object, or even with the size and objective position of our own body, but merely in relation to a certain 'scope' of our gestures" (Merleau-Ponty, 1962 [1945], p. 310–311).

Our results are in line with a recent study by Yoon, Humphreys, and Riddoch (2010). They examined the effect of pairs of objects, rather than a single object, in an action decision task. Participants were required to verify whether a linguistic term presented just below the image of an object described the way the object is usually used (e.g., if participants were presented with an axe they were requested to respond to the following question: is the object used for chopping?). They positioned pairs of objects (e.g., a nail and a hammer) either in the locations where they would typically be used by right-handed actors (with the "active" member of a pair of objects shown on the right and its passive partner on the left) or in the opposite locations ("active" member on the left, passive on the right). They found an effect of positioning the objects for action on the time taken to decide whether the objects would typically be used together (Yoon et al., 2010, Experiment 1). Interestingly, for the purpose of our study, such an effect was not present when participants, undertaking the same task, were presented with an object name rather than with a visually presented object.

As far as neural activation is concerned, a recent fMRI study concurs. Shinkareva, Malave, Mason, Mitchell, and Just (2011) used neural activation patterns to identify object categories across stimulus formats. Besides finding high commonalities of the neural basis of these two types of object knowledge, i.e., printed word versus visually presented objects, they also found evidence of format-specific neural activation. Their findings indicate that some small but information-laden part of the neural representation of objects is specific to the format of stimulus presentation. These results clearly point to the fact that objects' name and objects, although sharing common representations, are represented in a partially different way.

In summary, we propose that objects and objects' names might house different motor representations. Indeed, while the former seem to embed both stable and temporary action-relevant information, the latter seem to embed mainly stable action-relevant information.

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Appendix A.

Precision compatible		Power compatible	
Manufactured	Natural	Manufactured	Natural
Cork	Blackberry	Bottle	Apple
Dart	Carrot	Frying pan	Aubergine
Dice	Cherry	Hair brush	Banana
Eraser	Chili	Hammer	Cucumber
Pen	Garlic	Mug	Lemon
Pencil	Pachino (small tomato)	Shovel	Pear
Tea spoon	Strawberry	Tea pot	Pumpkin

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