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Temporal dynamics of action contribution to object categorization

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The presentation of a hand grasp facilitates the recognition of subsequent objects when the grasp is coherent with the object to be identified. This outcome is usually explained as the integration of two different processes: descriptive visual processes in ventral visual areas and processes in charge of the computations of action metrics in dorsal visual regions. With the aim to explore the temporal dynamics of this interaction, we conducted an experiment in which participants categorized objects preceded by congruent and incongruent hand grasp gestures under different interstimulus interval (ISI) conditions. Hand grasp gestures and target objects were separated by five different interstimulus intervals (ISI): 0, 250, 500, 1000, and 2000 ms. Results showed significant shorter response times for congruent trials than for incongruent trials for ISI conditions of 250 and 500 ms. However, no effect was found for the other ISIs (0, 1,000 and 2,000). These results suggest that the contribution of automatically driven visuomotor dorsal areas in object recognition is stronger up to 500 ms after prime offset, and that object identification is facilitated by hand gesture primes just inside this time window (250–500 ms).

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When we look at an object the information about its identity is automatically activated. Part of this information involves object function and also the information about how we can interact with it. Behavioural evidence suggests that the presence of objects, we have interacted with in the past, automatically influences our present actions (Morsella, Larson, Zarolia, & Bargh, 2011). This kind of phenomenon has been explained by the spontaneous activation of action-related object information, the so-called *affordances*. The term *affordance* refers to action possibilities that could appear in the environment, including objects (Gibson, 1979). In this study, we focus on the well-known division proposed by Goodale and Milner (1992) between perceptual representation and action-related processing, which are carried out by the ventral and dorsal cortical pathways, respectively. The integration of these two processes underlies object recognition (Rizzolatti & Arbib, 1998). Starting from this premise, our aim in this study is to explore the temporal dynamics of ventral and dorsal integration in an object categorization task. It has been claimed that objects' affordances are processed by the same brain areas that control the motor actions used when interacting with the object (Rizzolatti & Arbib, 1998). Behavioural research has shown that the activation of motor programs can influence the subsequent categorization of different objects.

Employing a grasping gesture as a prime, a number of authors found facilitation in object identification when the gesture was appropriate to handle the object (Borghi et al., 2005; Borghi, Bonfiglioli, Ricciardelli, Rubichi, & Nicoletti, 2007; Grèzes, Tucker, Armony, Ellis, & Passingham, 2003; Vainio, Symes, Ellis, Tucker, & Ottoboni, 2008). This effect, which we will refer to as the "grasp-object facilitation effect", is a form of visuomotor facilitation and suggests a link between motor planning and visual perception (Craighero, Fadiga, Rizzolatti & Umilta, 1998; Craighero, Fadiga, Umilta, & Rizzolatti, 1996; Tucker & Ellis, 1998). By means of the human mirror neuron system (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) the presentation of an image depicting a body action activates brain areas related to the preparation of the observed movement as it would be executed by the observer. If the brain areas in charge of motor planning also process objects' action-related information, as Rizzolatti and Arbib (1998) have suggested, then the presentation of hand grasp actions should influence the subsequent identification of a graspable object.

This grasp-object facilitation effect has also been found using a static grasp gesture as a prime in an object categorization task (Borghi et al., 2005; 2007), and using an animated sequence as the prime (Vainio et al., 2008). In both studies, the use of a congruent prime (i.e., a power grasp –in which the fingers wrap around the object– for a banana) led to a faster categorization of the target object as natural or man made. The grasp-object facilitation effect could be explained as the combination of motor and semantic visual information. However, according to the dual visual stream hypothesis, those two sources of information are processed within different temporal dynamics by the visual system (Goodale & Milner, 1992).

The pathways of visual information in the brain have been classically divided into two cortical streams, named ventral and dorsal (Goodale & Milner, 1992; Ungerleider & Mishkin, 1982). The ventral pathway stores semantic information whereas the dorsal stream provides spatial and interactive information to accomplish the goal of an action (usually with an object). Accordingly, ventral and dorsal processes must integrate information in order to permit the grasp-object facilitation effect to occur. A good amount of research suggests that dorsal areas are also fundamental for semantic coding of objects and actions (Chao & Martin, 2000; Jirak, Menz, Buccino, Borghi & Binkofski, 2010; Pulvermüller, Lutzenberger & Preissl, 1999).

Ventral areas store object information in long-term memory, permitting its recognition over time. Meanwhile, dorsal areas constantly renew visual information in order to allow the rectification of an ongoing action. In the dorsal stream, action-related information is not stored further than in iconic memory (Milner & Goodale, 2008). The influence of dorsal temporal limitations on visuomotor facilitation has been previously reported (Tucker & Ellis, 2001). The authors found that a short stimulus onset asynchrony could disrupt visuomotor facilitation on a manual response resembling a power or a precision grasp when the prime was an object that had to be categorized. However, in further experiments in which participants had to respond after the object's offset, visuomotor facilitation was observed (Derbyshire, Ellis & Tucker, 2006; Tucker & Ellis, 2004). In those studies, participants had to remember the objects until the response was produced. The authors concluded that motor response facilitation does not depend on transient on-line processing associated with the dorsal visual stream.

In the current study, we explore the possibility that a dorsal limitation influences visuomotor effects when the prime is a grasp gesture. Grasp gestures have been shown to be a less robust prime compared to objects. For example, Borghi et al. (2005) had to train participants reproducing grasp primes before finding grasp-object facilitation when prime stimuli were static. It is worth noticing that object primes are more likely to be based on ventral activation since they are semantically richer than grasp gestures, which may rely on action-related activation.

We propose that the binding of motor and semantic information that occurs in the grasp object facilitation effect, is constrained by dorsal temporal dynamics, specifically from 0 to 500 ms, as suggested by a number of different studies (for a review, see Bruno & Franz, 2009).

In order to investigate the time constraints for the binding of semantic and interactive information when a graspable object had to be identified, we carried out two experiments. First, we replicated Vainio et al. (2008) with the aim of confirming the efficiency of the experimental paradigm (experiment 1). Subsequently, in a second experiment (2) we introduced five different interstimulus interval (ISI) conditions. If grasp-object facilitation was not found a few hundred milliseconds after the prime disappeared, that is to say, beyond the bounds of dorsal storage, it would mean that grasp visuomotor facilitation depends on automatic online motor processing in dorsal areas. This would be in agreement with different theories extending the role of motor visual systems as mirror neuron systems (Rizzolatti, Fogassi & Gallesse, 2009), the FARS model (Arbib, 2010; Fagg & Arbib, 1998) or the affordance competition hypothesis (Cisek, 2008).

Based on previous research, we expect that the facilitation effect found in previous studies would occur during the first ISIs (up to 500 ms) and would disappear with increasing inter-stimulus intervals.

Previous studies have reported different patterns of response depending on whether the target objects were natural or man made. Natural objects are usually associated with faster responses (Borghi et al, 2005; Vainio et al., 2008). However, we expect the temporal dynamics of the grasp facilitation effect not to be modulated by object category.

EXPERIMENT 1

In order to be consistent with prior studies of grasp-object compatibility (Vainio et al., 2008), we carried out a first experiment with no interstimulus interval. Our aim here was to check the visuomotor effect in our experimental design and confirm that our hand grasp animations efficiently primed object recognition before introducing the additional interstimulus interval conditions. Stimuli included big and small objects commonly grasped with either a power or a precision grip. Our critical variable was congruency or match between grasp type and object size (match trial: power grasp and banana; mismatch trial: precision grip and a banana). Half of the objects were natural and half were man-made, and participants were instructed to categorize each item as either an artefact or a natural object. Our target object set included four classes of objects: big natural, big man-made, small natural and small man-made. In previous experiments (Vainio et al., 2008) the set of target objects included 16 pictures, four for each class. However, in experiment 2 we used only one stimulus per class due to the introduction of five ISI conditions. Therefore, in experiment 1 one of the main aims was to test the stimuli set in order to detect the more efficient stimulus for each size and category.

METHOD

Participants. Thirteen participants (six men and seven women) aged between 20 and 33 years (*M* = 28.7, *SD* = 4.05) volunteered to participate in the experimental sessions. All of them were psychology students at the Universidad Autónoma de Barcelona and were not aware of the objectives of the study. All of them were right-handed with normal, or corrected-to-normal, vision.

Apparatus. The experiment was run on a Pentium IV computer (800 Mhz). The stimuli were presented on a 19" colour monitor with a screen resolution of 1280 by 1024 pixels and a refresh rate of 100 Hz interlaced

Stimuli. Following Vainio et al. (2008), the stimuli were pictures depicting different objects and six visual animations of different hand grasp gestures.

Objects. The photographs of 16 familiar objects were processed to equalize proportional sizes, brightness and contrast levels and also to arrange them in front of a white background. We selected eight small objects that are graspable with a precision grip, including four natural (e.g., an olive) and four man-made (e.g., a pencil sharpener), and eight large objects that are graspable with a power grasp, with four natural (e.g., a banana) and four man-made (e.g., a bottle).

Hand grasp animations. Six animations were used as primes (Figure 1) varying in the direction of movement and the kind of hand gestures. Three of them were carried out with the left hand and the other three with the right hand. Following the design of Vainio et al. (2008), the animations consisted of the presentation of eight consecutive static images (see Figure 1). The hand grasp gestures represented in the animations were: (a) A precision grip in which the thumb and index finger close to press on a small object; (b) a power grasp with a final image showing a closed fist holding an object; and (c) a third gesture for catch trials that does not resemble any known hand grasp and was constructed merging the two previous ones. The images were processed and arranged in front of a white background and equal in terms of brightness and contrast. The first image of the animation was presented for 400 ms. Each of the intermediate images were presented for 30 ms. The total duration of each animation was 610 ms. The last image of the hand was presented superimposed onto the target object.

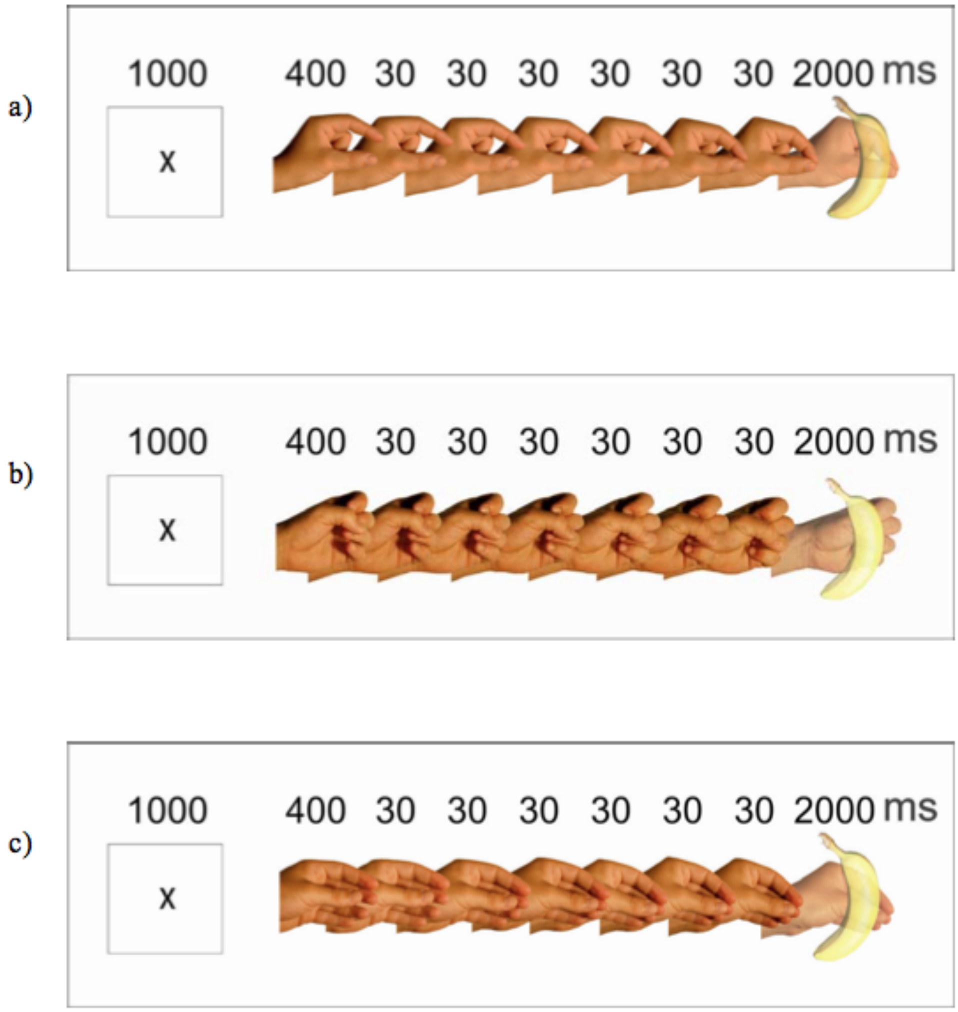

Figure. 1. Illustration of the stimuli employed in Experiment 1. The precision grasp (panel a); the power grasp (panel b); and the"catch" grasp (panel c). Each picture of the hand represents a different frame of the animation. In the last frame the target object appears superimposed with the hand.

Procedure. Participants sat in a dimly lit room 60 cm away from a computer screen. They signed an informed consent, received written instructions and completed a training session of 50 trials. After a short break, valid experimental sessions began. Trials began with a black cross (1° × 1°20') in the centre of the screen (31° × 24°15'). After 1,000 ms, one of the 6 animations was presented. Participants were instructed to indicate whether each item was natural or man-made. In half of the trials, animated primes were presented evolving from the right side to the center of the screen, and in the other half they were presented in the opposite direction (from the left side to the center of the screen). In order to ensure that participants were actively observing the different types of grasp, they were instructed to avoid answering when "the catch trials gesture" was presented. (The task was a go no-go paradigm). The final frame of the animations was one of the 16 target objects that appeared synchronized in time with the last image of the hand grasp animation. The overlapped image of hand grasp and object remained on the screen until participants responded or for 2,000 ms if no response was required (catch trials). The responses were produced on a computer keyboard using only the right hand. Participants indicated their response by pressing the O key for natural objects and the P key for man made objects. Subjects received the same subtle feedback signal every time they made a response, regardless of whether their answer was right or wrong. After that, a new trial began.

Presentations of different combinations of the six gestures (2 directions of movement × 3 types of grasp) and the 16 objects (4 objects × 2 sizes × 2 natures) led to sessions of 96 trials where 32 trials were catch trials. Half of the trials were match trials in which the presented prime and target object were congruent (i.e., power grasp and a banana) and the other half were mismatch trials (i.e., power grasp and an olive). Each participant took part in two of these sessions (total trials = 192). Total experiment duration was about seven minutes.

RESULTS

Three of the 13 subjects were discarded due to more than 10% incorrect answers (including responses to the catch trials, when it was not required). Analyses focused on participants' RTs to the 64 trials in which the prime was either a power grasp or a precision grip (valid trials). RTs for error trials were excluded (4.06%) as were RTs that were above 2 SD from each participant's mean (2.73% of responses).

Differences in RT were examined with a repeated measures 2 × 2 (Match [match, mismatch] × Category [man made, natural]) analysis of variance (ANOVA).

The variable Category was included in order to explore the influence of object category on the match effect.

The interaction effect was not statistically significant, $F(1,9) = 0.002$, $p = .965$, $\eta_p^2 < .001$. The mean RT for man made objects ($M = 549$ ms) was not statistically different from the mean RT for natural objects ($M = 553$), $F(1,9) = 0.169$, $p = .690$, $\eta_p^2 = .018$. As expected, responses to match trials ($M = 535$) were statistically faster than responses to mismatch trials ($M = 567$), $F(1,9) = 11.383$, $p = .008$, $\eta_p^2 = .558$.

In order to discard the possibility of a speed-accuracy trade-off, differences in error rates were analyzed with the same ANOVA model. None of the effects reached statistical significance, all *p*s > .133.

DISCUSSION

Objects were categorized faster when preceded by a congruent grasp type. The difference between match and mismatch trials ($M_{\text{Differences}} = 32$ ms, 95% CI [10 ms, 53 ms]) was similar to the differences found in previous studies (Vainio et al., 2008: about 20 ms; Borghi et al. 2005: about 15 ms). Our preliminary results revealed that the object's motor related information is picked up more easily when the previously presented hand grasp is congruent. As Vainio et al. (2008) showed, the observed grasp action influenced the recognition of the target object. Object category did not influence the observed effect, as has been reported in previous studies (Vainio et al., 2008; Borghi et al., 2005). However, we did not address this discrepancy, given that the focus of the current experiment was the match effect.

The hand grasp animations used as primes proved to be efficient at facilitating the identification of congruent objects. Therefore, we can assume that the stimuli selected for this experiment were appropriate for the purposes of this research.

EXPERIMENT 2

The aim of Experiment 2 was to explore the temporal dynamics of the grasp-object facilitation effect by introducing five ISI conditions. Target objects were presented following five different intervals after animation offset (five ISI conditions: 0, 250, 500, 1,000, and 2,000 ms). The shorter intervals (0, 250, and 500 ms) were chosen to explore the findings of previous studies where no facilitation effect was found after 300 ms (Tucker & Ellis, 2001). We decided to explore up to 500 ms because we know that early activation in dorsal areas and the integration of dorsal and ventral areas occurs around 450 ms (Mahon et al., 2007; Milner & Goodale, 2008). Larger intervals were selected in order to explore the evolution of the effect in working memory.

METHOD

Participants. Twenty five participants took part in the experiment. All of them were students at the Universidad Autónoma de Barcelona, naïve to the purpose of the study. Their participation was voluntary and unpaid. All of them were right-handed with normal or corrected to normal vision and ranged in age from 18 to 30 years old (*M*= 23.4).

Materials. Six animations of action gestures very similar to those employed in experiment 1. The first three frames of the power grasp animation were slightly modified in order to improve dynamicity (Figure 2). Half of the grasp actions were performed with the left hand and the other half with the right hand. As in experiment 1, the grasp gestures represented three types of grasp: (a) a power grasp, (b) a precision grip, and (c) a grasp used for the catch trials.

Due to the introduction of five ISI conditions we had to reduce the number of target objects in order to keep the experimental sessions relatively short. We then identified and selected the objects from each category and size which presented the largest RT differences between congruent and incongruent trials in experiment 1: (1) a natural object graspable with a power grasp (a cucumber), (2) a natural object graspable with a precision grip (an olive), (3) a man made object graspable with a power grasp (a deodorant recipient), and (4) a man made object graspable with a precision grip (a screw).

Procedure. The procedure was very similar to that used in experiment 1. Presentations of different combinations of the six gestures (2 directions of movement × 3 types of grasp) and the 20 types of presentation (5 ISIs × 2 kinds of grasp × 2 kinds of objects) led to 120 different trials. As in experiment 1, half of the trials were match trials –in which grasp gestures and target objects were congruent– and the other half were mismatch trials. These trials defined an experimental session of about 8 minutes. Each subject participated in three experimental sessions after a training session of 50 trials.

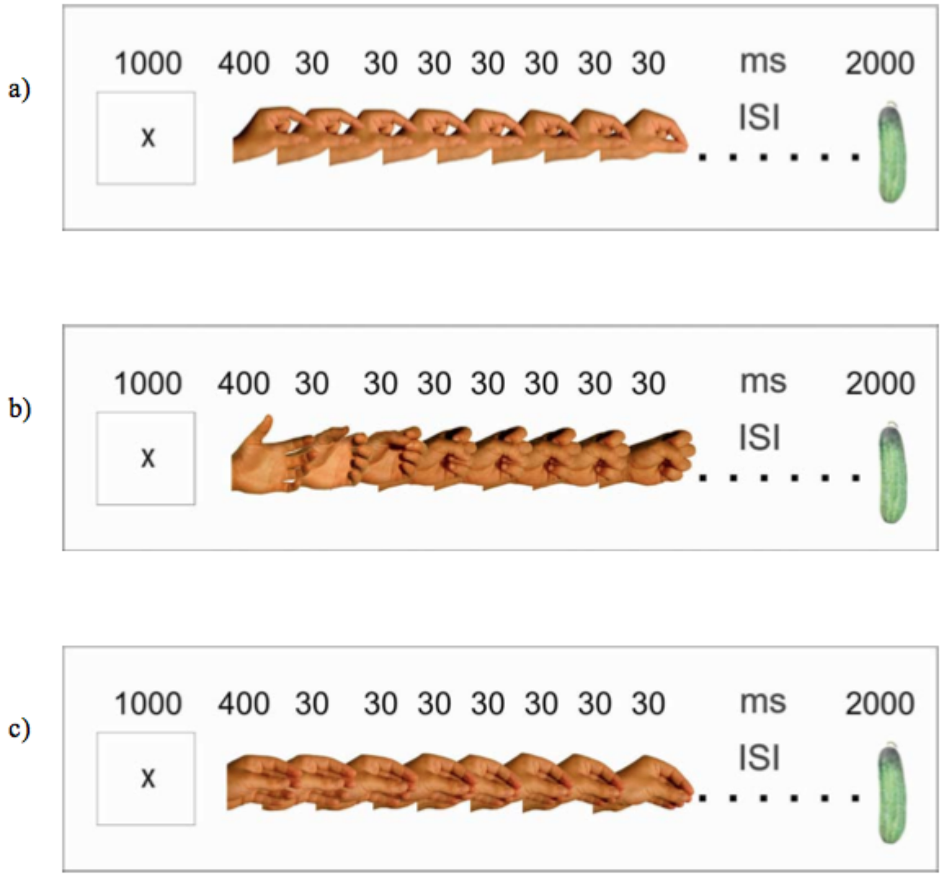

Figure 2. Illustration of the stimuli employed in Experiment 2. The precision grasp (panel a); the power grasp (panel b); and the ‘‘catch” grasp (panel c). Each picture of the hand represents a different frame of the, animation. The target object appears after a variable delay following hand grasp offset.

RESULTS

The data from five subjects were discarded due to the following reasons: One participant reported having ADHD and had significantly higher RTs than the rest of participants and four participants' errors were over 10%. Incorrect answers (4.35 %) and RTs separated above 2 SD (3.94 %) from the participant mean were discarded. Data from 20 participants were used in the final analyses.

The tested ANOVA model was equivalent to that of Experiment 1 with the inclusion of the ISI variable. The second order interaction was not statistically significant, $F(4,76) = 1.514$, $p = .206$, $\eta_p^2 = .074$. Out of the three first order interactions, only the Match × ISI reached significance, $F(4,76) = 5.131$, $p = .001$, $\eta_p^2 = .213$ (the other two *p*s > .270). This interaction was further tested with a simple effects analysis. The congruent trials were statistically faster (critical p value adjusted with Bonferroni correction) than the incongruent trials when the ISI was 250 ms [$M_{\text{Differences}} =$ 32 ms, 95% CI [13 ms, 51 ms], $F(1,19) = 12.159$, $p = .002$, $\eta_p^2 = .390$] and 500 ms [$M_{\text{Differences}} = 23$ ms, 95% CI [7 ms, 39 ms], $F(1,19) = 8.918$, $p = .008$, $\eta_p^2 = .319$]. By contrast, for ISIs of 0 ms [$M_{\text{Differences}} = -6$ ms, 95% CI [–21 ms, 8 ms], $F(1,19) = 0.766$, $p = .392$, $\eta_p^2 = .039$], 1,000 ms [$M_{\text{Differences}} = 2$ ms, 95% CI [–15 ms, 19 ms], $F(1,19) = 0.065$, $p = .801$, $\eta_p^2 = .003$] and 2,000 ms [$M_{\text{Differences}} = 3$ ms, 95% CI [–8 ms, 14 ms], $F(1,19) = 0.417$, $p = .526$, $\eta_p^2 = .021$] RTs did not differ significantly according to match.

All three main effects were statistically significant. Given the significant Match × ISI interaction, the interpretation of the faster responses to congruent trials ($M = 544$ ms) than incongruent trials ($M = 555$ ms) requires considering the effect of the ISI, $F(1,19) = 6.512$, $p = .019$, $\eta_p^2 = .255$. Also the differences between ISI levels require considering the effect of the match effect, $F(4,76) = 19.190$, $p < .001$, $\eta_p^2 = .502$. In this experiment natural objects lead to a statistically significant faster response ($M = 542$ ms) in comparison with man made objects ($M = 557$), $M_{\text{Differences}} =$ 15 ms, 95% CI [4 ms, 27 ms], $F(1,19) = 7.654$, $p = .012$, $\eta_p^2 = .287$.

An ANOVA with the same factors described for RT was carried out for error rate. As in experiment 1, none of the effects reached statistical significance, all *p*s > .126. Therefore, the possibility of a speed-accuracy trade-off can confidently be discarded.

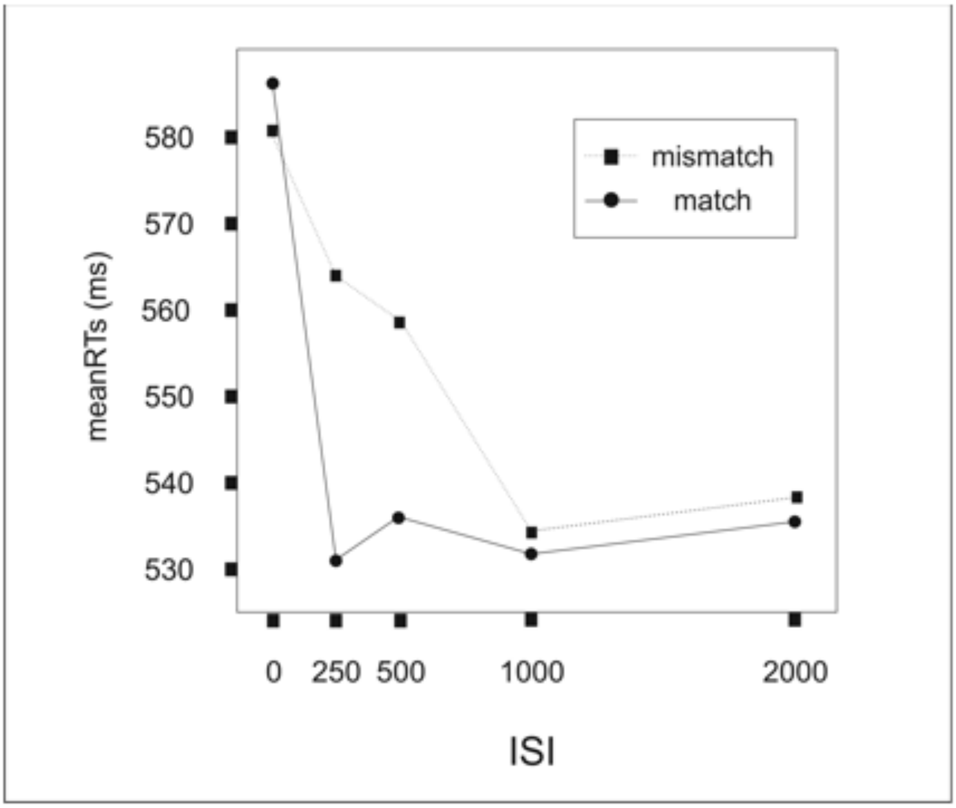

Figure 3. Mean reaction times (ms) for each of the ISI used in experiment 2 and as a function of match between object size and type of grasp.

DISCUSSION

Reaction times were longer for ISI = 0 than for the rest of the ISI conditions. This result suggests that when the stimuli were replaced immediately, participants' responses were delayed. This outcome could be identified as a foreperiod effect (Correa, Lupiáñez, & Tudela, 2006; Näätänen, 1972). Moreover, at ISI = 0 (when an object was immediately preceded by a congruent hand grasp gesture) no facilitation effect was found. At first sight the results for ISI = 0 are not in agreement with our experiment 1 or with Vainio et al. (2008), where facilitation effects were found with no delay between grasp prime and target object. However, there is an important difference in stimuli presentation between the tasks: in our experiment 2, the grasp animation is removed before the object is presented and this was not the case either in experiment 1 or in Vainio et al (2008).

In experiment 2, the replacement of the visual stimulus led to a disruption of the grasp-object facilitation effect found in the other ISI conditions. Interference effects in sensorimotor integration of this kind have been reported in previous behavioural studies (Bub & Masson, 2006; Tucker & Ellis, 2001; Vainio, Hammarén, Hausen, Rekolainen & Riskilä, 2011). According to neurophysiological evidence (Kesysers & Perrett, 2002), when two images are presented in SOA less than 300 ms, groups of visual neurons in the superior temporal sulcus attempt to codify the existence of two different objects, which leads to negative priming. In the ISI = 0 condition of experiment 2, the duration of the last image of each animation was 30 ms, resulting in a very short SOA after the target stimuli onset.

In experiment 1, just as in Vainio et al. (2008), no delay was introduced. In fact, both images –prime and target- remained superimposed and on the screen until participants responded.

In experiment 2, the effect of compatibility between grasp type and object size was limited to ISIs of 250 and 500 ms. As described in figure 4, the effect appeared at 250 ms, remained at 500 ms and became shorter and non significant at longer ISI latencies. This suggests that a time window between approximately 250 and up to 500 ms after prime offset enables the grasp-object facilitation effect.

Responses to natural objects were faster than to man made objects as Borghi et al. (2005) and Vainio et al. (2008) have previously shown. Those authors explained the advantage of natural objects arguing that man made objects elicit more complex motor information due to the functions associated with them. This effect was not found in experiment 1. The lack of category effect in the first experiment could be explained by the smaller size of the employed sample (less statistical power). However we cannot exclude the possibility that this disparity is due to other differences in the experimental design. Further work is needed in order to solve this question. Nevertheless these discrepancies do not alter the overall findings and interpretations of this study. Importantly, in experiment 2 this category effect did not modulate the interaction found between ISI and match.

GENERAL DISCUSSION AND CONCLUSIONS

Our results show the existence of a temporal window for the grasp-object facilitation effect. This period of time where visuomotor facilitation would be stronger occurs near the prime offset, with the exception of the immediate substitution of stimuli (ISI = 0), that seems to lead to an interference effect.

The results found in this study support the view that object affordances are generated by the connection between ventral and dorsal areas. When an object is categorized, ventral semantic information is required, but also motor information related to the way the object is handled is recruited by dorsal visual areas. This might be the reason why the recognition of graspable objects can be facilitated by the use of a congruent hand grasp gesture as a prime. Grasp-object facilitation reflects the automatically driven computation of action metrics that are processed when an object is visually perceived (Borghi et al., 2005; Vainio et al., 2008). This effect was reflected in experiment 2.

In their seminal paper on visuomotor facilitation, Craighero, Bello, Fadiga & Rizzolatti (2002) support an embodied interpretation of the grasp-object facilitation effect. However, the authors recognize that another type of explanation is possible. They concede that the effect found in their experiment can be attributed to the facilitation of specific responses by congruent visual stimuli. These two alternative explanations are not mutually exclusive, but as Craighero et al. (2002) suggest, unless one assumes this link as innate, a more parsimonious explanation is needed. Visuomotor priming appears as the best candidate to explain grasp facilitation in object recognition.

In the same line of reasoning, it is necessary to say that the prime-target facilitation extinction found in our study (after 500 ms) can be explained by other reasons that do not involve dynamics of motor dorsal areas. One could argue that the extinction is caused by a decay in working memory. We believe that what could be understood as working memory in the present case is the flip side of the transient dynamics of dorsal visuomotor areas contributing to object identification. We cannot deny a classic interpretation; however, we think that the working memory hypothesis does not negate an embodied explanation such as ours.

It is worth mentioning that several experiments found visuomotor facilitation employing a remembered object as a prime (Debyshire, Ellis, & Tucker, 2006; Riggio et al, 2008; Tucker & Ellis 2004) or even words depicting objects (Gough et al., 2012). These results show that long-term memory stores motor-related object information, as has been reported in neurophysiological studies (Chao & Martin, 2000; Pulvermüller et al., 1999). However, we believe that grasp primes, due to their poorer semantic information, are more dependent on dorsal transient activation; thus, evoking the sort of temporary interactive activation that can be elicited by visually available objects but not by evoked ones. Recent findings showed that object motor related activation is stronger when objects are seen within the peripersonal space than when they are presented out of reach (Constantini, Ambrosini, Scorolly, & Borghi, 2011; Constantini, Ambosini, Sinigaglia, & Gallese, 2011, Cardelicchio, Sinigaglia, & Constantini, 2011). It has been proposed that object motor activation is stronger when an actual interaction is available (Constantini et al., 2011). We believe that this automatic, visually dependent and transient action-object link is reflected in the temporal pattern found in experiment 2.

In the present study the fact that motor-related activation is reduced in longer interstimulus intervals contributes to the embodied semantics debate. Theories of embodied semantics (see Gomila & Calvo, 2008), supported by neurophysiological evidence (see Jirak et al., 2010), claim that when an object is evoked –remembered or semantically recalled– the information related to the subject's past experience with that object is recruited. According to simulation theory (Barsalou, 1999) or the more recent emulation theory (Grush, 2004), semantic perception is the integration of a stimulus in a code that refers to the experiences of the subject throughout his/her life. The reconstruction of object experience when it is evoked by the subject would require the participation of distributed resources which can be visual, motor, auditory, emotional, and so on. Importantly, this distributed activation will be stronger when the object is seen than when it is remembered or evoked by other means –say, by a word- because the actual perception of an object is enhanced by the online activation of motor visual areas.

In conclusion, our results contribute to our understanding of visuomotor integration and object recognition and suggest that there is a temporal constraint on grasp-object facilitation 500 ms after stimulus offset.

Future work will explore different temporal dynamics regarding the interaction of different kinds of motor actions in object recognition and the processing of different types of interactive information. We recognize that the small number of objects used as targets in experiment 2 can pose as a limitation that may constrain the scope of the present findings. More experiments including a broader set of stimuli will be useful in clarifying this issue. Also, future studies will explore more interstimulus intervals concentred within the temporal window between 0 and 500 ms.

RESUMEN

Dinámica temporal de la contribución de la acción a la identificación de objetos. La presentación de un gesto de agarre facilita el reconocimiento de un objeto presentado a continuación cuando el gesto es coherente con el objeto a identificar. Este efecto se explica habitualmente como el resultado de la integración de dos procesos visuales diferentes: procesos descriptivos asociados a áreas visuales ventrales y procesos a cargo de la computación de las métricas de acción en áreas visuales dorsales. Con el objetivo de explorar la dinámica temporal de esta interacción llevamos a cabo un experimento en el que los participantes categorizaron objetos precedidos por gestos de agarre congruentes y no congruentes luego de distintos intervalos temporales (ISI). Los gestos de agarre y los objetos se presentaron separados por cinco intervalos entre estímulos distintos (ISI): 0, 250, 500, 1,000, y 2,000 ms. Los resultados mostraron respuestas significativamente más cortas para los casos congruentes en las condiciones de ISI de 250 y 500 ms. Sin embargo, no se encontró efecto para las restantes condiciones de ISI (0, 1,000 y 2,000). Estos resultados sugieren que la contribución automática de áreas visuomotoras dorsales para el reconocimiento de objetos es más robusta hasta 500 ms después de la desaparición del estímulo facilitador, y que la identificación de objetos es facilitada por un gesto manual de agarre en el marco de una ventana temporal concreta (250–500 ms).

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