“The object is wonderful or prickly": how different object properties modulate behavior in a joint context

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Abstract

This study investigated whether the interaction with objects could be modulated by the real presence of another person. We used a “joint paradigm” in which participants performed the task while another person was just sitting in front of them (Social condition) or interacting with them (Joint condition). Kinematics measures showed how comprehending sentences referring to objects and to others influenced overt movement.

Keywords: joint action, social context, affordances, action sentences, kinematics, language comprehension, embodied cognition.

Introduction

The ability to coordinate our actions with others has always been a crucial ability for our species. Nevertheless, the main focus of cognitive scientists has been on individual cognition rather than on collaborative activities so far (Sebanz & Knoblich, 2009; Semin & Smith, 2008). However, in the last years several studies have been devoted to the social aspects of cognition. A great impulse to this kind of research came from the discovery of the mirror neuron system (for a review, see Rizzolatti & Craighero, 2004) and also from the development of common coding theories (e.g., Prinz, 1997; Hommel, Musseler, Aschersleben & Prinz, 2001). Indeed, a broad and consistent variety of data showed that humans rely on their own motor system while observing others’ actions and, crucially, also when they predict the outcomes or goals of these actions. Therefore, a large number of studies investigating joint attention, joint action, action coordination, synchronization and task sharing has flourished (Sebanz, Knoblich & Prinz, 2003; Sebanz, Bekkering & Knoblich, 2006). In this framework, the so-called “Social Simon Effect” (SSE) demonstrated that, when a task is split between two participants (i.e. Distributed task), each of them tends to represent the action plans of both agents (e.g., Milanese, Iani & Rubichi, 2010; Sebanz et al., 2003; Tsai, Kuo, Hung & Tzeng, 2008; Vlainic, Liepelt, Colzato, Prinz & Hommel,2010). These findings extended the ones obtained in the standard Simon Effect (i.e. better performance when there is a spatial correspondence between stimuli and responses, even when responses have to be given to a non-spatial stimulus attribute) showing that a spatial compatibility effect also occurs within a social context, i.e. when two participants share the task and they have to perform it together. Conversely, the effect did not occur when each participant was asked to perform part of the task by his/her self, i.e. without the other co-actor. Further studies manipulated the kind of relationship shared by participants in order to investigate how this manipulation influenced the resulting SSE. For instance, Hommel, Colzato & van den Wildenberg (2009) showed that a positive Social Simon Effect was only found when the co-actors were involved in a positive (cooperative) relationship. Moreover, Tsai & Brass (2007) asked participants to perform the Simon task either with a human or non-human being (e.g. a wooden hand) and found the effect only in the former case.

In the current study we focused on how our linguistic representation of everyday objects and interactions is influenced by the presence of another person. Specifically, we tested, through kinematics measures, whether the presence of another person (which could play either an observer or a co-actor role) affected our comprehension of action sentences stimuli and thus the following overt response movements.

Both sentences and responses implied a specific movement direction, i.e. away or towards the body, which thus defined a specific interaction space with respect to the body of the participant and to the body of the other person sitting in front of the participant throughout the experiment. Thus, we introduced a social extension of the so-called “approach-avoidance effect”, a phenomenon that has been well documented in literature. In other words, participants were found to extend their arm when faced with positive words, whereas negative words elicited an arm flexion, as if people simulated to reach for something “good” and to avoid something “bad” (Chen &

Bargh,1999; Freina, Baroni, Borghi & Nicoletti, 2009; van Dantzig et al., 2008). This effect revealed that reading emotive words activates a motor simulation, that is the same systems that are usually activated while interacting with objects (Zwaan, 2004; Borghi & Cimatti, 2010; Jeannerod, 2007; Gallese 2009; Glenberg & Kaschak, 2002). However, the above mentioned studies do not take into account the social context in which objects are perceived. Hence, in a recent study (Lugli, Baroni, Gianelli, Borghi & Nicoletti, under review) we used a modified version of the approach-avoidance paradigm to frame the linguistically described objects within a social context. We faced participants with sentences formed by a descriptive part, referred to an emotively connoted object, and by an action part, composed by an imperative verb implying a motion towards oneself or towards other targets (e.g., "The object is attractive/ugly. Bring it towards you /Give it to another person"). Participants had to judge whether each sentence was sensible by moving the mouse towards or away from their body. Results showed that the performance was modulated both by the connotation of the stimulus (positive/negative), and by the kind of target sentences referred to, indicating that the presence of other targets besides the self influenced performance and movement direction.

In the present study the same paradigm was used but with some crucial manipulations. First, response movements (i.e. moving the mouse away or towards the body) were measured through kinematics recordings, which allowed us to obtain clearer information concerning both the time-course of the effects and the influence of our manipulations on the motion dynamics. Those kinematics recordings were new with respect to the existing approach-avoidance literature, where the main focus was on reaction times (RTs) and movement times (MTs) measures.

Second, we introduced a real social context beside of the one conveyed by sentences presentation. Specifically, participants had to perform the task in presence of another person (i.e. the experimenter sat in front of the participants while they were performing the task). In the so called "social" condition, the experimenter acted as a mere observer. Conversely in the so called "joint" condition, there was an active and shared interaction between the experimenter and the participant during task execution. More precisely, when the participant moved the mouse away from the body, the experimenter re-positioned the mouse in the starting position. It has to be pointed out, though, that such a joint condition was not identical to the task sharing paradigms used for the SSE, since the experimenter only contributed to re-locate the mouse, instead of sharing the experimental task with participants.

The rationale underlying our predictions were as follows. In the Experiment 1 of our previous study (Lugli et al., under review) sentences referred generally to a second person, e.g. "The object is attractive/ ugly. Give it to another person" and participants did not have any clue concerning the characteristics of such "another person". In this study participants read sentences and, on top of that, saw a real person (an experimenter) sitting in front of them. This should help them to instantiate the meaning of the word "another person" and, therefore, it should also affect their performance. In particular we expect to find that the presence of another person would shape both the direction and the dynamics of the participants overt movements. Two different situations might occur: The instantiation of a real other might enhance social courtesy, thus reducing the ego-centric bias typically found for the approach-avoidance effects. In contrast, the presence of an unknown person, and particularly of a person who, by moving and re-locating the mouse, actually reduces participants' action space, might lead them to keep pleasant objects for themselves and to give unpleasant objects to the other person.

Hence, we predict that the presence of a real other would modify the way participants form a simulation while reading action sentences. In particular, the presence of a real other should enhance the link between the linguistic meaning and the motor system. We expect that, in the "joint" condition, participants should be more sensitive to the type of target ("oneself" vs. "another person") as well as to object's characteristics. Specifically, we predict that participants would respond differently to qualitative properties (nice vs. ugly) and to properties pertaining fine grained movements, related to object grasping (smooth vs. prickly).

Presenting two different kinds of object properties, lead us ,to verify whether the presence of a "real" other would influence the way in which objects are represented. When we simulate giving something to an unknown person, do we pay more attention to object properties related to its value (positive vs. negative) or to the way in which the motor interaction can occur, for example to the fact that the object is prickly or smooth to grasp? We predicted that properties related to grasping should be processed slower, thus more accurately, in the "joint" condition compared to the "social" condition, given that the other person is not only present, but collaborates with the participant. Previous studies have provided evidence that, when a precise motor act has to be performed with another person (e.g., feeding), a higher accuracy is required. Interestingly, this higher accuracy can be detected through kinematics parameters (Ferri, Campione, Dalla Volta, Gianelli & Gentilucci, 2010).

Method

Participants Fourteen students (10 females, 4 males) participated in this study. All participants were right-handed, native Italian speakers and reported normal or corrected-to-normal vision. All were naive as to the purpose of the experiment and gave their informed consent to the experiment.

Apparatus and Stimuli The experiment took place in a sound-proof room. The participant sat in front of a 17" cathode-ray tube screen driven by a 1 GHz processor computer, at a viewing distance of 50 cm. Participants were required to hold a mouse on their right hand at a distance of 30 cm from the body (starting position, SP). Away or towards the body movements were performed in a 60 cm long and 10 cm wide course on the table, thus allowing kinematics recording.

Stimulus selection, response timing, and data collection were controlled by the E-Prime v2 software. A black fixation cross (1.87° x 1.87° of visual angle) was presented at the beginning of each trial. The stimuli consisted of sentences written in black ink and presented at the centre of a white screen. Words were written in a 30 point size Courier New font.

Half of the stimuli were composed by sensible sentences (target sentence) and the other half by nonsense sentences (filler). Both sentences were composed by a descriptive and an action part. The descriptive part could refer to a positive or negative object. Each object was positively or negatively connoted by means of two different proprieties, one related to the emotional valence and one related to the grasping proprieties (16 different adjectives in total, 4 qualitative positive (e.g., attractive), 4 qualitative negative (e.g., ugly), 4 grasp-related positive (e.g., smooth) and 4 grasp-related negative (e.g., prickly). The action part was composed of an imperative verb implying a motion towards the self or towards another person and a pronoun referring to the object. An example of the sentence was “The object is attractive/prickly. Bring it to you/Give it to another person”. The order of the descriptive and action part was counterbalanced within subjects.

Filler sentences were not sensible due either to the adjective, i.e. “The object is tanned (/touchy), bring it towards you”, to the verb, i.e. “The object is ugly, walk it to another person”, or to the agent, i.e. “The object is smooth, give it to another person”.

We used a sensibility judgment task, that is participants had to respond by moving the mouse towards/away from their body according to whether the sentence was sensible or not.

Participants were asked to position the right hand on the mouse and to move it towards or away from their body following a vertically-traced course drawn on the tabletop. The movement of the mouse was always followed by the vertical movement of the cursor from the centrally presented sentence and by a congruent motion of the sentence, either towards or away from participant's body (Neumann, Förster & Strack, 2003; Neumann & Strack 2000). The motion of the sentence was simulated by gradually increasing the font size and moving it slightly downwards (towards-the-participant movement) or decreasing the font size and moving it upwards (away-from-the-participant movement).

Procedure Participants initiated each trial by clicking on the fixation cross. Then a sentence appeared and remained on the screen until response or until 4000 milliseconds (ms) had passed. In case of incorrect or delayed responses, the word “ERROR” or “DELAY”, respectively, appeared in red uppercase letters for 1500 ms. After a blank of 500 ms the fixation cross appeared and a next trial was initiated. The experiment was composed of two blocks of 64 trials each. Opposite instructions were given for each block, that is: in block 1, participants had to move the mouse towards or away from the body for sensible sentences and for fillers, respectively. Block 2 had the opposite assignment. The order of the blocks was balanced between subjects.

Data recording and kinematic analysis We recorded response times (RTs) coupled with kinematics recording of the participants’ right hand. This allowed a complete definition of the spatio-temporal evolution of mouse movements, hence giving precise information on when and how motor responses were affected by action sentences. Movements of the participant’s right hand were recorded using the 3D-optoelectronic SMART system (BTS Bioengineering, Milano, Italy). The system consists of four cameras detecting infrared reflecting markers (spheres of 5-mm diameter) at a sampling rate of 120 Hz. Spatial resolution of the system is 0.3 mm. Recorded data were filtered using a linear smoothing low pass filter, i.e. a triangular filter where each value was the weighted mean computed over 5 samples (window duration 33.3 ms). We recorded participants’ movement through a single reflecting marker applied on the wrist of the participant’s right hand. Participants were informed that their movement was recorded and they were asked to perform the movement as naturally as possible and to maintain a constant motion during the experiment.

We analyzed the time course of the wrist marker in order to study the spatio-temporal evolution of the response movement away or towards the body. Together with RTs we decided to focus on the velocity peak, which is a crucial parameter that could be influenced by action sentences both in movement planning and execution.

RT was defined as the time between the click on the fixation cross and the beginning of mouse movement. The start of the movement corresponded to the moment in which the mouse cursor moved 20 pixels from its starting point in a vertical direction.

The peak velocity is the maximum speed reached between the beginning of the movement and the end. In this case the type of movement is characterized by a single peak, occurring normally in the middle of the movement, then around 50-60% of movement time (acceleration phase). This is the main parameter that is determined at the planning stage of the action, so it is very informative as it is most likely to be modulated by the task during the preparation of the action. Combined with the RTs it provides information on how the modulation has evolved, giving us information on how the effect on movement times is determined by the early phases of the movement.

Data analysis The incorrect responses were removed from the analysis (2,5%). We also discarded all the filler sentences. Analyses of errors revealed no evidence of speed-accuracy trade-off, so we focused on RT analyses. RTs that were faster/slower than the overall subject mean minus/plus 2 standard deviations were excluded from the analyses (1,5%).

Mean correct RTs were submitted to a repeated-measures ANOVA with *Object Property* (Grasp-related *vs.* Qualitative), *Target* (Oneself *vs.* Another person), *Object Valence* (Negative *vs.* Positive) and *Movement Direction* (Towards the body *vs.* Away from the body) as within-subjects factors.

The kinematic analysis similarly focused only on the correct responses. Mean values of peak velocity were then submitted to a repeated-measures ANOVA with the same within-subject factors as RTs.

Fisher's LSD post-hoc tests were also conducted on significant interactions.

Results

Response Time

The main effect of *Object Valence*, $F(1,12) = 13.23$, $MSe = 621421$, $p < .001$, was significant. RTs were faster with Positive than with Negative objects (1764 and 1779 ms, respectively).

The interaction between the *Condition* and *Target* was significant, $F(1,12) = 4.82$, $MSe = 87713$, $p < .05$.The post hoc test showed that when the sentences referred to the act of giving an object to Another person target, participants were faster in the Social condition than in the Joint one, $p < .05$.

Furthermore, the interaction between the *Object Property* and *Movement Direction* was almost significant, $F(1,12) = 4.7$, $MSe = 32716$, $p = .051$. Grasp-related properties yielded faster RTs when combined with movements Towards the body, while Qualitative properties yielded faster RTs for Away from the body movements.

Lastly, the *Object Property* x *Target* x *Object Valence* interaction was significant, $F(1,12) = 10.84$, $MSe = 103496$, $p < .05$. When objects were described with Grasp-related proprieties, the post-hoc test showed that the Oneself target was faster with Positive objects than with Negative ones ($p< .01$). With regard to Qualitative properties, the Oneself target resulted to be faster than the Another person one when objects were positively connoted ($p<.01$).

Kinematics analysis: Peak Velocity

The two experimental conditions did not significantly differ, but it is worth noting that the Joint condition produced higher velocity peaks ($M = 447$) as compared to the Social one ($M = 308$).

A main effect of *Object Property* was present. Specifically, Grasp-related properties produced slower velocity peaks, $F(1,12)=13.43$, $MSe = 34800$, $p<. 01$. This suggested that movement planning was more likely to be affected by motor properties, such as the Grasp-related ones, when a social dimension is directly evoked. In addition, the overall interference effect produced by social aspects is different in the two conditions. This was shown by the significant *Condition* X *Object Property* interaction, $F(1,12)=12.4$, $MSe = 32100$, $p< .01$. In the Social condition, no significant difference was present between Grasp-related properties and Qualitative ones. On the contrary, the Joint condition yielded significant differences ($p< .01$) with slower peaks for grasping. This result suggested that in the Joint condition a more fine-grained distinction between Qualitative and Grasping properties emerged.

Crucially, the *Object Property* x *Target interaction* was close to significance, $F(1,12)=4,39$; $MSe = 4509$, $p = .06$. What was critical was how *Object Property* differently interacted with the Self-Other distinction. Namely, while Qualitative properties induced higher velocity peaks for the Oneself target, Grasp-related properties induced higher velocity peaks for the Another person one.

The *Target* factor also interacted with the *Object Valence* one, $F(1,12)=12.95$, $MSe = 9951$, $p <. 01$. A reverse pattern was present for the Positive and Negative valence. As shown by the post-hoc tests, when Positive objects were presented the Another person target produced slower peaks with respect to the Oneself one ($p< .05$). The reverse was true for the Negative objects, since the peaks were slower for the Oneself target than for the Another person one ($p<. 05$). This confirmed and qualified the tendency to attract Positive objects and to reject Negative ones.

The significant interaction *Condition* X *Target* X *Object Valence*, $F(1,12)=6.96$; $Mse=5353$, $p< .05$, gave us further evidence in favor of a stronger modulation of peak velocities in the Joint condition. Indeed, in the Joint condition the Oneself-Positive objects combination yielded faster responses than the Oneself-Negative objects one ($p< .01$) . The reverse was true as well: the Another person-Negative objects combination was faster than Another person-Positive objects one ($p< .05$). In addition, the Oneself-Positive object combination produced faster velocity peaks than the Another person-Positive one ($p< .05$) Finally, the Another person-Negative objects combination was faster than the Oneself-Negative object one ($p< .01$).

Finally, the interaction *Condition* X *Target* X *Object Valence* X *Movement Direction*, $F(1,12)=5.43$, $MSe = 8588$, $p< .05$, revealed how the previous effects interacted with movement direction. In particular, post-hoc tests showed that movements were slower overall in the Social condition and specifically for movements Towards the body. Interestingly, the Social condition did not show significant modulations. On the contrary, a clear modulation was present for the Joint condition. Specifically, participants had faster Away from the body movements, when the sentence referred to the Oneself target than to the Another person one ($p < .05$). A reverse pattern was detected for Negative Objects: Participants were faster in executing Away from the body movements when sentences referred to Another person target that to the Oneself one. Away fromt the body movements resulted, then, as particularly sensitive to Object Valence. Interestingly, the Oneself-away movements combination was faster with Positive Objects than with Negative ones, whereas Another person-away movements combination was faster with Negative objects (*ps* <.05). These results suggested that in the Joint condition the tendency to attract Positive objects and to reject Negative ones was particularly marked for movements away from the body (see Fig. 1).

General Discussion

Our findings suggest that the presence of a real person facilitates the instantiation of the simulated "another person" mentioned in the sentences. The presence of a real other influences and modifies the performance particularly when the other is interacting with the participant (co-actor), as the differences between the Social and the Joint condition in the analyses of RTs and velocity peak indicated. Overall, we found clear evidence that the presence of a real person, and particularly of a co-actor, led to a change in the salience of object proprieties and to more marked distinction between valuable and motor properties.

The real presence of another person led to reframe the way in which the two participants in the simulated linguistic interaction (the self and the other) are conceived, and the way in which the relationships between the two mentioned agents and the object properties are represented. In the current experiment, and particularly in the Joint condition, participants are more sensitive to how the self-other distinction is modulated both by objects Qualitative properties and by more fine grained aspects pertaining the motor interaction, as those related to Grasping properties. Specifically, the interaction on RTs between the *Object Property*, *Movement* and *Target* factors reveals that Qualitative properties are faster than the Grasp-related ones, particularly in towards the body movements.

In addition, participants are faster to attract positive objects when they are described with Qualitative Properties.

The presence of a real other seems to induce participants to take into account the factors that can influence their motor interaction with another person. Specifically, the presence of an observer or a co-actor lead participants to pay attention to aspects related to object grasping. This is particularly true in the Joint condition. This is confirmed also by the interaction in RTs between *Condition* and *Target*, showing that in the Joint condition participants were slower than in the Social condition, when processing sentences mentioning another person. A further confirmation of the enhanced attention to properties influencing motor interaction with others is given by results on peak velocity, showing that in the Joint condition Grasping properties have slower peaks compared to Qualitative properties.

The presence of another person, and particularly of a co-actor, leads participants to be more precise, yielding lower velocity peaks specifically for Grasping properties. If we consider objects described through Qualitative properties, instead, the pattern of results shows that the presence of Another person enhances the tendency to attract nice objects and reject ugly ones. This is revealed in response times by the *Object Property*, *Target* and *Object Valence* interaction and in peak velocity by the 4-way *Condition* x *Target* x *Object Valence* x *Movement Direction* interaction. Noteworthy, only the velocity peaks of away movements are significantly modulated in the Joint condition.

It is worth noting that the presence of an unknown other does not reduce the ego-centric bias typically highlighted by the approach-avoidance effects, enhancing the social courtesy. In contrast, the presence of an unknown person, and particularly of a person who, by moving and re-locating the mouse, actually reduces participants' action space, renders more marked the tendency to keep pleasant objects for the self and to give unpleasant objects to the other.

Finally, and crucially for us, the presence of a co-actor modifies the way in which objects are conceptualized. When another person is present, and particularly in the Joint condition, participants seem to ascribe more relevance to valuable objects. They are attracted by positive objects very fast, as if the presence of another person they don't know would represent a menace, particularly if the other person is allowed to enter in their action space. This result has implications for literature on object representation and affordances, as it suggests that even the mere presence of other people might lead us to represent objects differently (Becchio, Sartori, Bulgheroni & Castiello, 2008). Further studies are necessary, in order to investigate more in depth how different kinds of social context influence the way we respond to objects' affordances.

Figures

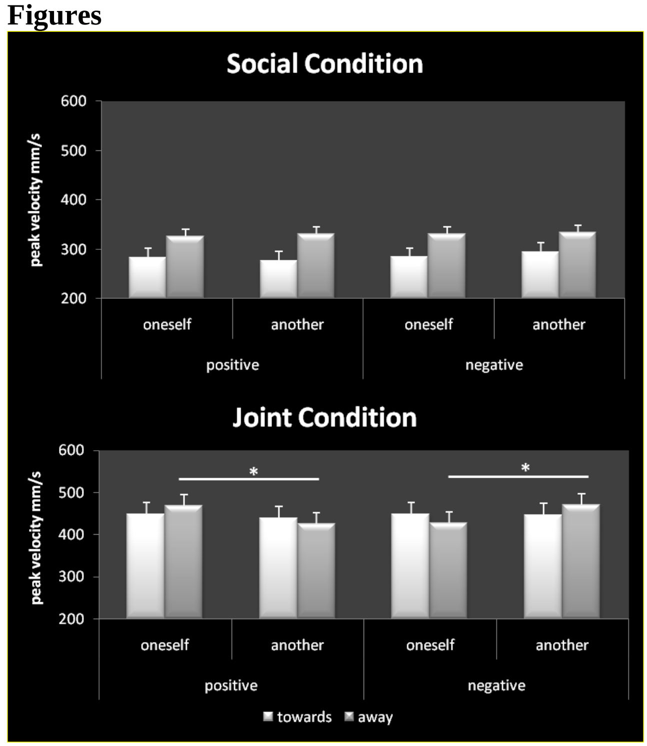

Figure 1: Mean Peak Velocity for the Social and Joint conditions. Significant comparisons are indicated with * ($p<.05$) and ** ($p<.01$), bars are SE.

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