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Running head: EMOTIVE CONCEPT-NOUNS

Emotive Concept-Nouns and Motor Responses: Attraction or Repulsion?

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Abstract

We carried out three experiments aimed at testing whether the compatibility effect between a word's emotional connotation and arm movement direction found by Chen and Bargh (1999) is affected by hand posture. Participants responded by pressing two buttons: one placed near their body, the other far away. In Experiment 1, they classified words as positive or negative by hitting the response button with their hand open. RTs were shorter when pressing the "far" button for positive words and the "near" button for negative words, as if they "simulated" reaching for something "good" and avoiding something "bad". In Experiment 2 and 3 participants responded while holding a tennis-ball in their hand. RTs were shorter when pressing the "near" button for positive words and the "far" button for negative words, as if they "simulated" drawing something "good" near themselves and pushing the "bad" thing away. Results are discussed within the framework of theories on concept grounding in emotion and action systems.

Introduction

In recent years the "embodied cognition" approach has gradually been overtaking the traditional cognitive view in which the mind is seen as a device for manipulating arbitrary symbols. The new position, according to which our cognitive system is grounded in sensory-motor processes, is emerging in all fields that relate to cognitive sciences, for example philosophy (Clark, 1997; Prinz, 2002), neurosciences (Berthoz, 1997; Pulvermüller, 2003; Rizzolatti & Arbib, 1998) and experimental psychology (Barsalou, 1999; Elsner & Hommel, 2001; Glenberg, 1997). In addition, many computational models based on an embodied approach have been proposed (e.g. Elman, Bates, Johnson, Karmiloff-Smith, Parisi & Plunkett, 1996; Nolfi & Floreano, 2000).

According to the embodied theory, concepts consist of the reactivation of the same neural activation pattern that is present when we perceive and/or interact with the objects or entities they refer to (Barsalou, 1999; Borghi, 2005; Gallese & Lakoff, 2005; Glenberg, 1997). In the same way, according to the embodied view, understanding language implies forming a mental "simulation" of what is linguistically described. This simulation is thought to entail the recruitment of the same neurons that are activated when actually acting or perceiving the situation, action, emotion, object or entity described by language (Barsalou, 1999; Gallese & Lakoff, 2005; Gibbs, 2003; Glenberg, 1997; MacWhinney, 1999; Zwaan, 2004).

In the last decade a large body of evidence has been gathered in support of the simulation theory of language comprehension. Recent studies on sentence comprehension show that people form a sensorimotor simulation of the situation described by a sentence by internally reproducing the action or situation described (Buccino, Riggio, Melli, Binkofski, Gallese & Rizzolatti, 2005; Glenberg & Kaschak, 2002; Zwaan & Taylor, 2006; see also Klatzky, McCloskey, Doherty & Pellegrino, 1987; Klatzky, Pellegrino, McCloskey & Doherty, 1989). Results obtained with different methods have clearly shown that language comprehension implies the activation of the motor system, and therefore these results support the simulation theory. However, it is still a matter of debate whether this simulation is necessary for comprehension, or whether it is due to motor imagery. In addition, the results leave a question open as to the extent to which this simulation is detailed.

Recent evidence suggests that this simulation is quite accurate. For example, behavioural and TMS studies have shown that the comprehension of sentences referring to actions performed with different effectors (hands, feet, mouth) differentially influences a participant’s response with the hand (keyboard), with the foot (pedal) and with the mouth (microphone) (Buccino et al., 2005; Scorolli & Borghi, 2007). The sensitivity to the effectors reveals that the simulation run during the comprehension of an action sentence is rather detailed, and that, apart from the goals, it also takes into account the means involved in a motor action. In addition, other studies indicate that the simulation activated while processing a sentence that refers to an object’s movement contains directional information. For example, participants were faster in responding that *Close the drawer* made sense when moving away from the body rather than when moving towards it, whereas the opposite was true in responding to a sentence like *Open the drawer* (Borreggine & Kaschak, 2006; Glenberg & Kaschak, 2002). The same sensitivity to directional aspects (upwards/downwards) was obtained when participants were required to decide whether nouns such as “foot” and “head” referred to parts of an object or entity such as a horse (Borghi, Glenberg & Kaschak, 2004).

Along the same line, other evidence shows that the motor system and the evaluation of emotional terms are strictly interwoven. For example, learning the meaning of a word while we are performing a specific movement can cause us to evaluate that word in a positive or negative manner. Cacioppo, Priester and Berntson (1993) demonstrated the effect of arm movement on the attitude people have towards Chinese ideograms they did not know. When they made an approach movement - i.e. they were required to pull their arm towards their body in order to respond - they tended to provide a better evaluation of the ideograms than when they performed a movement of repulsion - i.e. they extended their arms away from their body in order to respond.

In a Chen and Bargh's study (1999), authors showed participants words with a positive/negative emotive valence, such as "love" and "hate". The task was to respond to the word's emotive valence by pulling or pushing a lever towards or away from their body. Reaction times (RTs) were quicker when there was congruence between the performed arm movement and the word valence, i.e. when participants had to pull something near to their body for positive words and to push something away for negative words. The same result was obtained when participants were not required to provide an evaluation but were only asked to react to words appearing on the computer screen by pushing or pulling the lever. Similar results were found with a noun generation task. Participants were required to write the names of famous people and then to make an evaluation performing a movement that could be of approach or avoidance (Forster & Strack, 1997). Results showed that people tended to produce names of famous people they liked or disliked congruently with the movement they made.

Even though the reported evidence suggests that during sentence comprehension we activate simulations, and that we also recruit the motor system during the evaluation of emotional terms, the extent to which these simulations are specific is still a matter of debate. In our work we sought to investigate the degree of specificity involved in these simulations. Namely, we aimed to understand whether reading words that have a different meaning and a positive vs. negative emotional connotation differentially activate the motor system. More specifically, our hypothesis is that if reading a positive or negative word activates a simulation of the object/entity it refers to, then this simulation should affect the motor response.

As we reported before, it has been demonstrated that positive stimuli tend to facilitate approach movements, whereas negative stimuli facilitate avoidance movements. Different accounts have been proposed of these effects. According to the specific muscle activation account, they are due to an association of extension movements with negative stimuli and of flexion movements with positive ones (Cacioppo et al., 1993). In line with this view, Tops and de Jong (2006) asked participants to respond to positive and negative words by pressing a response button with one hand while holding a tennis ball in their other hand or while keeping it empty and wide open. Their findings show that contracting the forearm flexors (i.e. holding the tennis ball) facilitated categorization of pleasant but not of unpleasant words in comparison with contracting the forearm tensors (i.e. stretching the fingers). However their experiment does not deal with approach / avoidance movements: the hand is kept steady while performing the task. Their main concern is the psychological effect of contracting vs. stretching specific muscles, while in our experiments we wanted to test if the meaning assigned to a specific movement can change according to hand posture.

A second account, that is the distance-regulation one, explains the results on the basis of the distance between the subject and the evaluated stimulus (Schneirla, 1959). A third proposal, the evaluative coding view, attributes instead these effects to a correspondence relation between evaluative stimuli and responses on a cognitive, representational level rather than on the motor level. The embodied framework we adopt in this paper is in line with the evaluative approach as it takes into account the flexible role played by context (Eder & Rothermund, 2008). However, it differs from it as it explains the effects on the basis of the re-enactment of previous affective motor responses. For this reason, in this paper we consider how stimuli with the same valence are modulated not only by the directional movements but also by the hand posture used to respond to the stimuli. Our concern regards in fact the level of detail of the simulation and its interaction with the response movement. In particular, the question is whether hand posture can influence the meaning of such movement. Responses given with an open hand could induce people to simulate the action of reaching a positive object and avoiding a negative one. When reading positive words, participants should be quicker in moving the hand towards the stimulus. On the contrary, when reading negative words, they should be faster in bringing the hand back near their body. Responses performed while holding an object in the hand could be coded in an opposite manner inducing people to simulate the action of pushing away negative objects and attracting positive ones. This was the case in Chen and Bargh's (1999) experiments, in which participants responded while holding a long lever.

We hypothesized that if we found this pattern of results, it would show that the simulation run during word comprehension is very detailed. Specifically, the results would suggest that this simulation is sensitive not only to the effector involved and to directional aspects, but also to the specific posture of the hand (clench-closed hand vs. palm-open hand; see Klatzky et al., 1987; Klatzky et al., 1989). Furthermore, we would demonstrate that the response movements are not interpreted as approach or avoidance in an unique manner, but are defined mostly for the effect they cause, that is: a movement could be coded as approach if it reduces the distance between ourselves and the object we would like to reach, and as avoidance if it enhances the distance between ourselves and the object we do not like. In other words, the meaning assigned to the movement would be due to its goal rather than to kinematic aspects such as the sequence of movements and their direction (Hommel, Müsseler, Aschersleben & Prinz, 2001)

Experiment 1

Chen and Bargh (1999) found that people were quicker when they had to pull the lever towards their body for positive words and when they had to push the lever away for negative words. They claimed that this result depended on the fact that when reading a negative term people activate their arm to make an avoidance movement (i.e. pushing the negative object away), whereas a positive word causes the opposite activation (i.e. bringing the positive object nearer the body).

If the simulations run during word comprehension were quite detailed, than we predicted the results would be influenced by hand posture. More specifically, we asked participants to hit two oversized buttons, placed near / far their body, with the palm of their right hand open. We predicted that since participants' hands are empty, they will no longer associate the arm movement to the movement of an object, as was the case in Chen and Bargh's (1999) experiment, but rather to the action of grasping an object or of withdrawing from it. Participants should therefore be quicker in reaching the "far" button when reading a positive word, as they simulate reaching for the object, and in taking their hand back near the body for negative words, as they simulate avoiding contact with a negative object by withdrawing from it. The results should therefore reverse those obtained by Chen and Bargh (1999): we expect in fact that arm extension will be interpreted as an approach movement and arm flexion as an avoidance one.

Method

Participants. Twenty-five students from the University of Bologna took part in a pilot study to select the stimuli and an independent group of forty-two new students from the University of Bologna took part in the experiment. Two participants were then discarded because they made too many errors, classifying more than 15% of the stimuli in a different manner from the normative one (i.e. a word that was classified as positive / negative in the stimuli preparation process was then classified as negative / positive by the participant). The 40 participants left were 17 men and 23 women, aged between 20 and 30 years old and with an average age of 23.33 (with a standard deviation of 2.39). All had normal or corrected to normal vision.

Stimuli. We selected the original 92 words used by Chen and Bargh (1999; see also Bargh, Chaiken, Govender & Pratto, 1992), translated them into Italian and then asked 25 students from the University of Bologna to evaluate them using a questionnaire. The questionnaires were collected from a sample population of 15 men and 10 women, with an average age of 23.08 and a standard deviation of 2.0. For each word, the positive and negative valence were evaluated using two separate Likert scales, both ranging from 1 to 4. Then, for each word, the following scores were computed using the same method as Bargh et al. (1992):

1. A positive or negative evaluation, ranging from -3 to 3: this was defined as the average of all the differences between the positive and the negative scores. Words which obtained an overall evaluation ranging from -3 to 0 were classified as negative, while the others were categorized as positive;
2. A word-ambivalence evaluation, ranging from 0 to 6: this was defined as the average of all the differences between the sum of the positive and the negative scores and the absolute value of their difference.

Words with an evaluation score between -2 and 2 were discarded since they were not sufficiently emotionally charged. We also removed all words that had an ambivalence score that was greater than 1.0 since, as demonstrated by Bargh et al. (1992), ambivalence strongly influences RTs. The 29 negative and 33 positive stimuli we obtained were reduced to a total of 58 stimuli used for the experiment. The 4 positive stimuli that presented the greatest standard deviation in their ambivalence score (i.e. those that were less homogeneously evaluated) were selected to be used in the training session, together with six stimuli with an evaluation score of just below -2 or just above 2. The training session consisted of 10 stimuli, followed by 58 experimental stimuli, both presented using random selection. Each word was seen only once by each participant (a list of the stimuli used can be found on the web at http://laral.istc.cnr.it/borghi/freina-baroni-borghi-nicoletti-stimuli.htm).

Apparatus. A modified keyboard with only the space bar and two oversized buttons was used. The response buttons were labelled with the words *POSITIVO* (positive) and *NEGATIVO* (negative), written in a large font so that the labels could be easily read. The keyboard was turned lengthwise, with the narrow part facing the participant, so that one of the two response buttons was near the participant's body while the other was far away from the body and near the computer screen. The space bar was located in the middle between the two response buttons. The experiment took place in a dimly lit and noiseless room. Participants were seated facing a 17" cathode-ray tube screen driven by a 700 MHz computer. E-Prime 1.1 software was used.

Procedure. Participants were asked to classify each word, as quickly as possible, as positive or negative by hitting the corresponding button with their right hand open. To start each trial participants had to press the central part of the space bar, which forced the right hand into a central position. After the space bar was pressed, a cross appeared in the middle of the screen for 500 milliseconds, after which it was replaced by a word. The stimulus remained on the screen until participants pressed either the positive or the negative button with their open hand. Participants received feedback for both correct and incorrect responses, and to start the next trial the central space bar had to be pressed again.

In the *Positive Far - Negative Near* (PosFar) condition participants had to press the "far" button for positive words and the "near" button for negative words. In the *Positive Near - Negative Far* (PosNear) condition the instructions were reversed. Each participant was randomly assigned to the PosFar or the PosNear condition. Therefore participants assigned to each condition were selected from the same pool, around the same period of time and were treated in exactly the same way. We predicted that the PosFar condition would produce faster RTs compared to the PosNear condition since it was congruent with the grasping movement for positive words and with the avoidance movement for negative ones.

Results and Discussion

Errors, which amounted to 3.75% of the overall data, were not considered for the data analysis. An ANOVA on errors revealed that there was no speed-accuracy trade-off: Nor the main effects of Instruction and Word Valence nor the interaction between these two factors turned out in fact to be significant ($p = .19$; $p = .65$; $p = .65$, respectively). Therefore we focused on the RT analyses. To screen for outliers, scores 2 standard deviations higher or lower than the mean participant score were removed for each participant. This trimming method led to the removal of another 4.18 % of the collected data. The remaining RTs were submitted to two mixed 2x2 ANOVAs. In the analysis with participants as random factor (from now on F_1) the Instruction factor (PosFar vs. PosNear) was manipulated between participants and the Word Valence factor (Positive vs. Negative) was manipulated within participants. In the ANOVA with materials as random factor (from now on F_2) the Instruction factor (PosFar vs. PosNear) was manipulated within items and the Word Valence factor (Positive vs. Negative) was manipulated between items.

As predicted, the PosFar condition was significantly faster than the PosNear one, F_1 $(1,38) = 5.94$; $MSe = 45802.68$; $p < .020$ (836 ms vs. 953 ms, respectively), F_2 $(1,56) = 219.25$; $MSe = 1231.66$; $p < .001$. Participants were faster at reaching than at withdrawing when they read a positive word and faster at withdrawing than at reaching when they processed a negative word. The interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs.

Negative) was also significant, F_1 (1,38) = 17.10; MSe = 2152.42; $p < .001$ (see Fig. 1), F_2 (1,56) = 43.39; MSe = 1231.66; $p < .001$.

Insert Figure 1 about here

Due to the presence of a main effect of the Instruction factor, we ran separate analyses, one for positive and one for the negative terms. In both cases we ran two different ANOVAs: analysis of participants (F_1) and materials (F_2).

The Instruction factor showed significant differences for negative stimuli: as expected, RTs in the PosFar condition were faster than in the PosNear one, F_1 (1,38) = 11.51; MSe = 22094.76; $p < .0016$ (822 ms vs. 981 ms, respectively), F_2 (1,28) = 402.14; MSe = 700.94; $p < .001$ (844 ms vs. 984 ms, respectively). Also the analysis of positive stimuli showed that RTs in the PosFar condition were faster than RTs in the PosNear one, but the difference reached significance only in the analysis of materials: F_1 (1,38) = 2.1; MSe = 25860.43; $p = .16$ (851 ms vs. 925 ms, respectively), F_2 (1,28) = 23.61; MSe = 1762.34; $p < .001$ (875 ms vs. 928 ms respectively).

The results of Experiment 1 demonstrate that hand posture influences RTs. In Chen and Bargh’s (1999) experiments, in which a lever had to be pushed away or pulled towards the body, participants were faster at extending their arm when faced with a negative term, since arm extension is considered a movement of avoidance, and faster at retracting their arm when processing a positive word, since arm retraction can be conceived as an attraction movement. In our experiment, in which participants were required to hit either a “far” or a “near” button with the open hand, the opposite results were obtained: People were faster at withdrawing from the negative object and at reaching the positive one. So, the same movement of the arm can be interpreted as an avoidance or an approach one depending on the response modality and the hand posture used (lever – close hand vs. open empty hand) .

Experiment 2

In this experiment, we wanted to investigate whether the different interpretation of arm movement we found comparing our Experiment 1 with the Chen and Bargh' (1999) one was really due to hand posture and not to other factors. Therefore we designed an experiment which was exactly the same as Experiment 1, apart from the fact that participants had to hit the oversized buttons with a tennis ball held in their hand. We hypothesized that since participants are holding something in their hand, they could no longer interpret the movement as reaching for / avoiding something, but rather as pushing / pulling something away from / near their body.

More specifically, if participants are asked to hold a tennis ball in their hand while answering, we predict the same result as that obtained in the study by Chen and Bargh (1999), even though their task implied moving a lever while our task implied moving a graspable object and placing it elsewhere. In other words, we predicted that since participants have an object in their hand they would associate the pressing of the "far" button with the pushing away of the object. The "near" answer would then be associated with pulling something towards the body.

Method

In Experiment 2 we used exactly the same apparatus, procedure and stimuli as in Experiment 1. The only difference was that participants were asked to respond by hitting the response buttons with a tennis ball held firmly in their right hand.

Participants. Forty-seven new students from the University of Bologna took part in the experiment. Seven participants were later discarded because their classification errors went over the 15% threshold. The 40 participants left were 18 men and 22 women, all within an age bracket of 19 to 29 years old, and with an average age of 23.13 (with a standard deviation of 2.33). All had normal or corrected to normal vision.

As in the previous experiment, in the *Positive Far - Negative Near* (PosFar) condition participants had to press the “far” button for positive words and the “near” button for negative words. In the *Positive Near - Negative Far* (PosNear) condition the instructions were reversed. Each participant was randomly assigned to the PosFar or the PosNear condition.

Results and Discussion

Errors represented 4.35 % of the overall data. An ANOVA on errors revealed that there were no main effects of Instruction and Word Valence ($p = 1.00$; $p = .41$, respectively). Only the interaction between these two factors turned out to be significant ($p < .04$), probably due to the fact that in the PosNear condition negative items elicited less error than positive items. However, the Newman-Keuls post-hoc test showed no significant differences. We then focused on the RT analyses. The same trimming method as in Experiment 1 was used. This trimming method led to the removal of another 3.92% of the data. The remaining RTs were submitted to two mixed 2x2 ANOVAs. In the analysis with participants as a random factor (F_1), the Instruction factor (PosFar vs. PosNear) was manipulated between participants and the Word Valence factor (Positive vs. Negative) was manipulated within participants. In the ANOVA with materials as random factor (F_2) the Instruction factor (PosFar vs. PosNear) was manipulated within items and the Word Valence factor (Positive vs. Negative) was manipulated between items.

We obtained a significant difference between the positive and the negative Word Valence in the analysis with participants as a random factor, F_1 (1,38) = 12.738; MSe = 1760.76; $p < .001$

(968 ms vs. 934 ms, respectively), but not in the analysis of materials, F_2 (1,56) = 3.94; *MSe* = 8993.16; $p = .052$. There was a significant interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs. Negative), F_1 (1,38) = 18.55; *MSe* = 1760.76; $p < .001$, (see Fig. 2), F_2 (1,56) = 21.05; *MSe* = 1740.72; $p < .001$. In both analyses, the Instruction factor did not reach significance.

Insert Figure 2 about here

For both positive and negative terms two separate ANOVAs were performed, one with participants (F_1) and one with materials (F_2) as random factor.

The Instruction factor showed significant differences for positive stimuli, even if this difference reached significance only in the analysis of materials, showing that RTs in the PosFar condition were slower than in the PosNear one: F_1 (1,38) = 2.007; *MSe* = 34613.94; $p = 0.165$ (976 ms vs. 893 ms, respectively); F_2 (1,28) = 37.43; *MSe* = 2209.03; $p < .001$ (975 ms vs. 899 ms, respectively). For the negative stimuli, no difference was found: F_1 (1,38) = 0.002; *MSe* = 31443.38; $p = 0.94$ (969 ms for the PosFar condition vs. 967 ms for the PosNear one); F_2 (1,28) = .22; *MSe* = 1272.41; $p < .64$ (974 ms for the PosFar condition vs. 970 ms for the PosNear one).

Even if we found that RTs tended to be faster when participants had to move an object towards their body while processing positive words, results were not as predicted for negative stimuli, since with negative words we did not find faster RTs when people had to push the object in their hand away from their body. This last result could be due to two possible causes:

1. It is possible that pushing the response button with the tennis ball was associated with

the action of hitting the object rather than moving it toward or away from the body, specially when the stimulus is an object that can be squashed (e.g. “spider”);

2. There was a 500 ms delay between the hitting of the central space bar (aimed at placing the hand in the middle between the two response buttons) and the stimulus onset. During Experiment 1 we observed that people tended to leave the hand on the central button while waiting for the word to appear. On the other hand, in Experiment 2 participants hit the button with the ball and their hand bounced back in the air. This could allow participants to move the hand freely, therefore the hand position was not controlled at stimulus onset. We therefore ran a third experiment to address these two points.

Experiment 3

This experiment replicates Experiment 2. Two changes were introduced to address the previously discussed points. The words that referred to objects that could be squashed were discarded and the experiment was run with a subset of the previously selected items. In addition, the 500 ms delay between the hitting of the central space bar and the stimulus onset was eliminated.

Method

In Experiment 3 we used exactly the same apparatus as in Experiment 1 and 2.

Stimuli. From the 58 stimuli used in the previous 2 experiments, 18 were discharged because they represented objects that could be squashed. Stimuli evaluation was carried out separately by 4 native Italian speakers and only stimuli that were considered possible to squash by at least 3 judges have been eliminated. In order to maintain the same number of positive and negative terms 2 further positive stimuli were eliminated. We choose 2 positive words that were considered squeezable by two different judges. The remaining materials consisted of 44 words, 22 positive ones and 22 negative ones (see http://laral.istc.cnr.it/borghi/freina-baroni-borghi-nicoletti-stimuli.htm). Each word was presented twice to each participant.

Procedure. The procedure was the same as in Experiment 2, except for the elimination of the 500 ms of delay between the hitting of the central space bar and the stimulus onset.

As in the previous experiments, in the *Positive Far - Negative Near* (PosFar) condition participants had to press the "far "button for positive words and the "near" button for negative words. In the *Positive Near - Negative Far* (PosNear) condition the instructions were reversed. Each participant was randomly assigned to the PosFar or the PosNear condition.

Participants. Thirty-five new students from the University of Bologna took part in the experiment. Three participants were later discarded because their classification errors went over the 15% threshold. The 32 participants left were 11 men and 21 women, with an average age of 21.63 (with a standard deviation of 2.03). All had normal or corrected to normal vision, three were left handed.

Results and Discussion

Errors represented 4,90 % of the overall data. An ANOVA on errors revealed that there was no speed-accuracy trade-off: nor the main effects of Instruction and Word Valence nor the interaction between these two factors turned out to be significant (p = .56; p = .18; p = .43, respectively). So, we focused on the RT analyses. The same trimming method as in the previous experiments was used. This trimming method led to the removal of another 4,87 % of the data. The remaining responses were submitted to two mixed 2x2 ANOVAs. In the analysis with participants as random factor (F_1) the Instruction factor (PosFar vs. PosNear) was manipulated between participants and the Word Valence factor (Positive vs. Negative) was manipulated within participants. In the ANOVA with materials as random factor (F_2) the Instruction factor (PosFar vs. PosNear) was manipulated within items and the Word Valence factor (Positive vs. Negative) was manipulated between items.

As predicted, the PosNear condition was significantly faster than the PosFar one, F_1 (1,30) = 5.75; *MSe* = 16637.61; $p < .023$ (949 ms vs. 872 ms, respectively), F_2 (1,42) = 165.66; *MSe* = 817.86; $p < .001$ (950 ms vs. 872 ms, respectively). Participants were faster at pulling the tennis-ball towards themselves when they read a positive word and faster at pushing the ball away when they processed a negative word. The interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs. Negative) was also significant, F_1 (1,30) = 7.96; *MSe* = 1857.09; $p < .008$ (see Fig. 3), F_2 (1,42) = 26.71; *MSe* = 817.86; $p < .001$.

Insert Figure 3 about here

Due to the presence of a main effect of the Instruction factor, we ran separate analyses for positive and for the negative terms, in order to check if the effect is present for both kind of stimuli. In both cases we ran two different ANOVAs: the analysis of participants (F_1) and materials (F_2) .

The Instruction factor showed significant differences for positive stimuli: as expected, RTs in the PosFar condition were slower than in the PosNear one, F_1 (1,30) = 11.50; *MSe* = 8064.16; $p < .002$ (953 ms vs. 846 ms, respectively), F_2 (1,21) = 163.53; *MSe* = 813.69; $p < .001$ (956 ms vs. 846 ms, respectively). Also the analysis of negative stimuli showed that RTs in the PosFar condition were slower than RTs in the PosNear one, but the difference reached significance only in the analysis of materials: F_1 (1,30) = 1.69; *MSe* = 10430.36; $p = .20$ (944 ms vs. 897 ms, respectively), F_2 (1,21) = 29.51; *MSe* = 822.03; $p < .001$ (944 ms vs. 897 ms respectively).

The results of Experiment 3 demonstrate that hand posture influences RTs. While in Experiment 1, in which participants were required to hit either a “far” or a “near” button with an open hand, people were faster at withdrawing from the negative object and reaching for the positive one, in this experiment opposite results were obtained: People were faster at pushing the ball away from themselves when reading a negative word and pulling it towards their bodies when reading a positive term. Therefore we can claim that arm flexion can be interpreted as an avoidance movement when participants responded with the open and empty hand and as an approach movement when participants are asked to respond holding a tennis ball in their hand. The opposite is true for arm extension.

General discussion

This study clearly shows that motor responses to emotive concept-words are strongly influenced by hand posture. Our results not only support theories claiming that word comprehension activates a simulation, but they help to specify the characteristics of this simulation (Gallese & Goldman, 1998; Zwaan, 2004). Namely, they suggest that the simulation run during word comprehension and evaluation is quite detailed as different hand postures (open / close hand) led to assign to the same movement (arm flexion / extension) an opposite meaning of approach or avoidance.

In our three experiments participants had to classify words as positive or negative pressing two buttons placed near or far to their bodies. The movements required were then similar to those of Chen and Bargh’s (1999) experiments, that is an arm flexion when pressing the “near” button or an arm extension when pressing the “far” button. Differently from Chen and

Bargh (1999), in our experiment we focused on the hand posture participants were asked to respond with. In Experiment 1 participants pressed the response buttons with their right hand open. Results showed that they simulated the movement of reaching something good (approach) or avoiding something bad (avoidance). Therefore, even if the movement performed was the same as in Chen and Bargh (1999), the results we obtained were the opposite. In two further experiments we asked participants to push the response buttons while holding a tennis ball in their right hand. We found opposite results with respect to Experiment 1 but similar to those of Chen and Bargh (1999). This suggests that, while holding an object in their hand, participants simulated to push away something bad (avoidance movement) and to bring something good toward them (approach movement). Results were stronger with stimuli that could not be squashed (e.g., “spider”). The results are straightforward; the fact that in a couple of cases the difference was significant in the analysis with items, but not with participants as random factor simply reveals that there is some variability across participants, probably due to the fact that the mapping of valence to arm motions depends on the participants' construal of the task.

Taken together our experiments show that hand posture has a crucial role in determining the approach /avoidance meaning of response movements. This result helps to confute some theoretical accounts of approach-avoidance movements. Namely, theories based on a specific muscle activation account (see Cacioppo et al., 1993; Tops & de Jong, 2006) or on evaluative aspects (see Eder & Rothermund, 2008) could hardly explain our results. Our data

clearly depend on a combination of motor and conceptual aspects and on a re-enactment of previous affective motor responses. For this reason the embodied account seems to be the best framework to explain our data with: The simulation theory leads in fact to a better explanation of the different meanings participants assigned to the same movement.

Overall, we believe that our results have important implications also for theories on the relationship between language comprehension and the motor system that assign relevance to goals for action representation. Namely, they reveal that participants are sensitive to very fine aspects of hand postures, such as responding with an open hand in comparison with when the hand is holding an object. At a theoretical level, this suggests that the simulation run during comprehension is not only sensitive to the action goals, oriented to elements that are external to the participant's body, but also to kinematics aspects, i.e. to sensory codes coming from the participant's own body, representing fine-grained aspects such as those related to the hand posture. Importantly, however, this happens when the sensitivity to fine-grained aspects related to hand posture influences the more general action goal, and induces the participant to assign a different meaning to the whole movement (Hommel et al., 2001).

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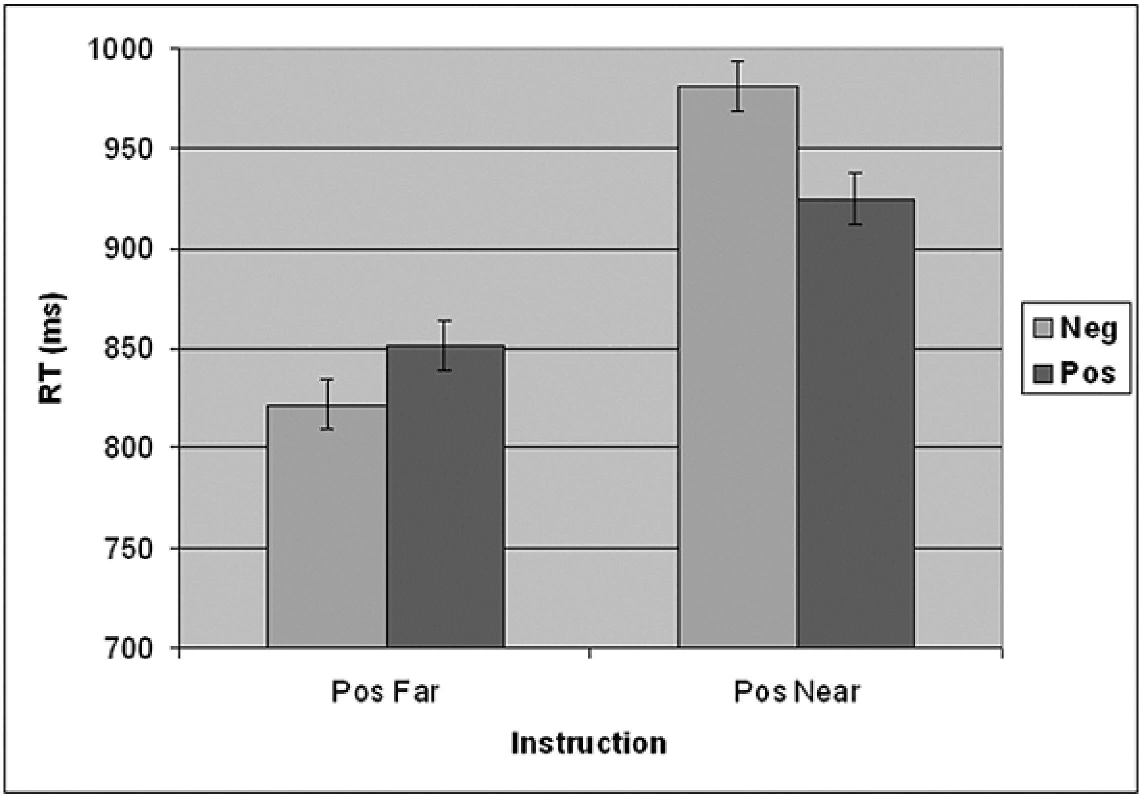
Figure Captions

Figure 1. Experiment 1. Interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs. Negative) factors.

Figure 2. Experiment 2. Interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs. Negative) factors.

Figure 3. Experiment 3. Interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs. Negative) factors.



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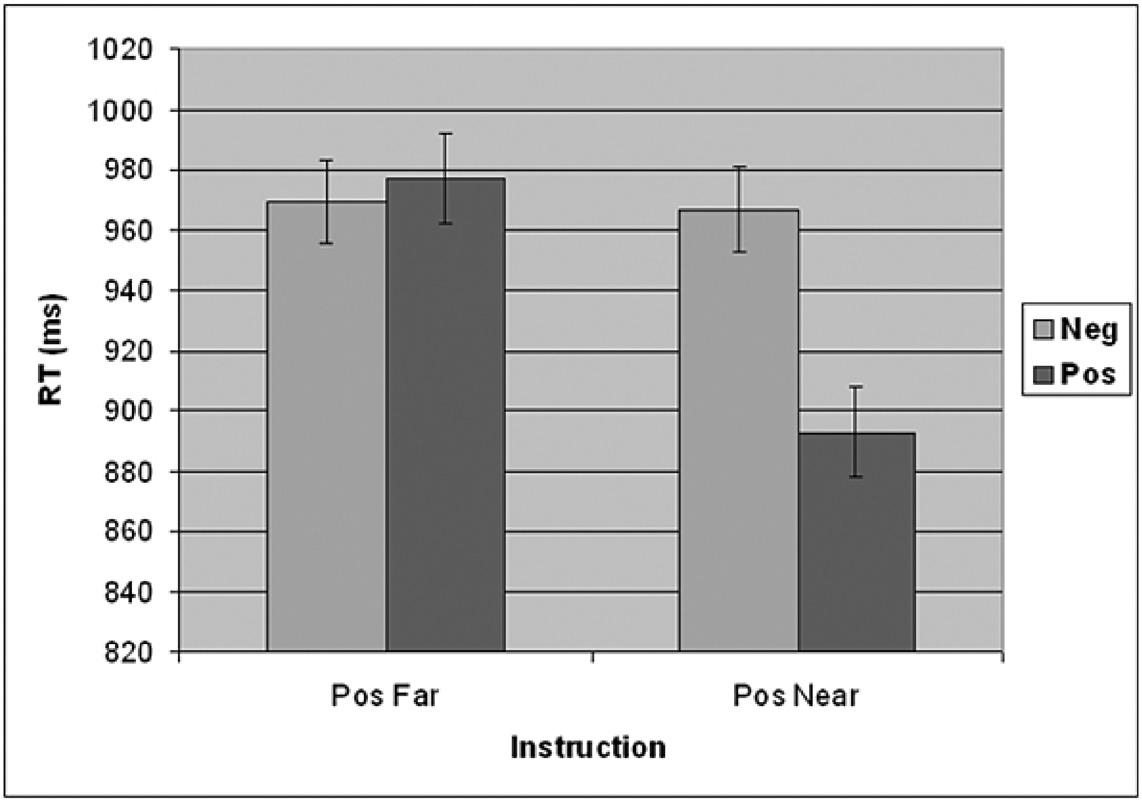

Figure 2. Experiment 2. Interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs. Negative) factors.

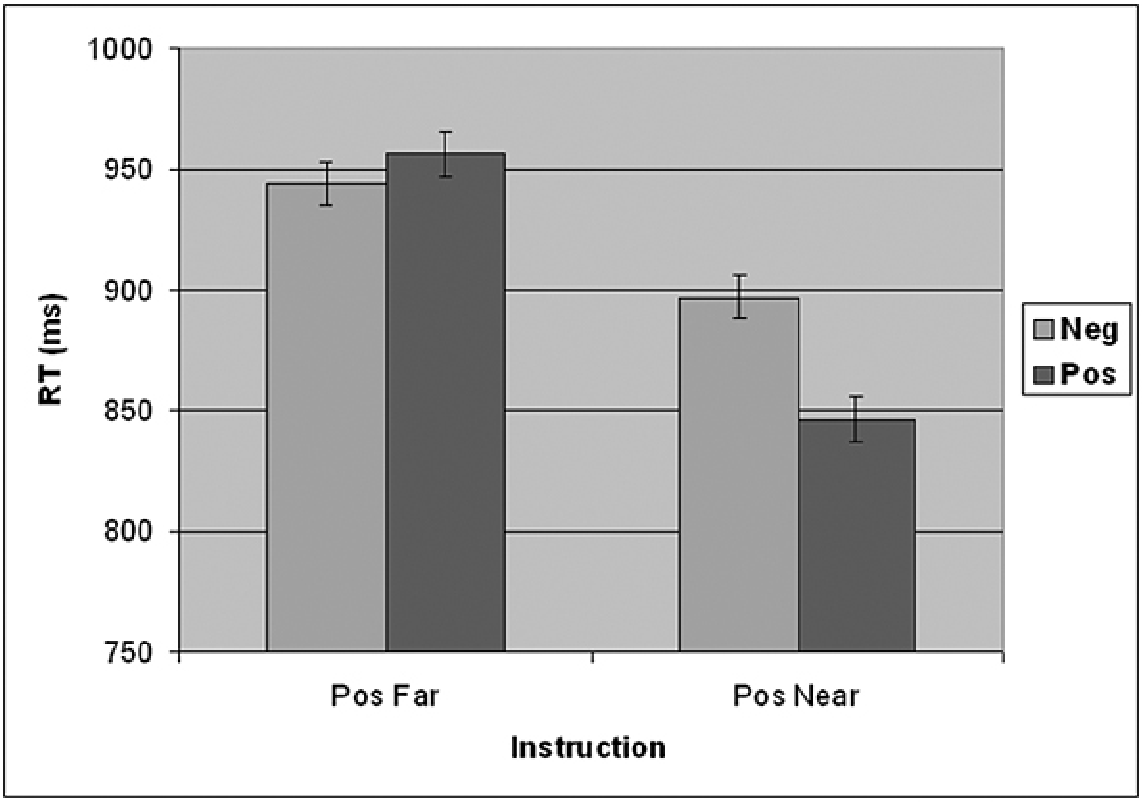

Figure 3. Experiment 3. Interaction between Instruction (PosFar vs. PosNear) and Word Valence (Positive vs. Negative) factors.