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Emotional valence and physical space: Limits of interaction

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Abstract

According to the body-specificity hypothesis, people associate positive things with the side of space that corresponds to their dominant hand, and negative things with the side corresponding to their non-dominant hand. Our aim was to find out whether this association holds also true for a response time study employing linguistic stimuli, and whether such an association is activated automatically. Four experiments explored this association using positive and negative words. In Exp. 1, right-handers made a lexical judgment by pressing a left or right key. Attention was not explicitly drawn to the valence of the stimuli. No valence-by-side interaction emerged. In Exp. 2 and 3, right-handers and left-handers made a valence judgment by pressing a left or a right key. A valence-by-side interaction emerged: For positive words, responses were faster when participants responded with their dominant hand, whereas for negative words, responses were faster for the non-dominant hand. Exp. 4 required a valence judgment without stating an explicit mapping of valence and side. No valence-by-side interaction emerged. The experiments provide evidence for an association between response side and valence, which, however, does not seem to be activated automatically but rather requires a task with an explicit response mapping to occur.

Keywords: grounded cognition, body-specificity hypothesis, emotional valence, handedness

Emotional valence and physical space: Limits of interaction

In many languages, there are idioms and words associating right with positive, and left with negative. In English, *right* does not only denote a direction but does also mean *correct*. In German, the word for law, *Recht,* is closely related to the word denoting the direction, *rechts,* whereas *linkisch,* derived from *links* (*left*), describes an awkward person, just like *gauche* and *maladroit* do in French. Where do such expressions come from? Do people tend to associate positive entities with that part of their surrounding space that corresponds to their dominant hand and negative entities with the side corresponding to their non-dominant hand? Do these idioms then result from the fact that most people are right-handers?

The body-specificity hypothesis (Casasanto, 2009a), derived from the theory of grounded cognition (Barsalou, 2008; Zwaan, 2004), states that right-handers tend to associate positive ideas with the right side and negative ideas with the left, whereas for left-handers, the reverse holds true. This affective mapping can presumably be attributed to the different experiences right- and left-handers have. For right-handers, performing motor actions is easier with the right, and for left-handers with the left, that is, people are more fluent with their dominant hand. According to Winkielman, Schwarz, Fazendeiro, and Reber (2003), fluency is associated with positive affect, leading to the idea that people should associate their dominant hand with positive emotions (Casasanto, 2009a). Possibly, this association holds for the whole side of physical space corresponding to the dominant hand.

Casasanto and colleagues employed various paradigms to investigate this hypothesis. Evidence was found in a series of experimental studies, as well as in the analysis of observational data. For example, Casasanto (2009a) found that right-handers tend to draw ‘good’ animals on the right and ‘bad’ animals on the left side, whereas left-handers prefer to draw ‘good’ animals on the left, and ‘bad’ ones on the right. In a study involving stroke victims, patients who had been right-handed prior to the stroke were submitted to the same task. In those cases in which the participants could still use their right hand, they assigned the ‘good’ animal to the right and the ‘bad’ animal to the left. However, for nearly all of those participants who could now only use their left hand, this assignment was reversed (Casasanto & Chrysikou, 2011), providing evidence for the fundamental role of motor experiences for the body-specificity hypothesis. With regard to observational data, the analysis of gestures made by presidential candidates yielded a preference of right-handers to use their right hand during positive assertions and their left hand for negative ones, and vice versa for left-handers (Casasanto & Jasmin, 2010). In short, evidence in favor of the body-specificity hypothesis comes from different areas. However, there are still some issues that have not been addressed up to now. First, the association between dominant side and valence has not yet been corroborated by response-time data. It would be interesting to see whether the preferences observed in the studies by Casasanto and colleagues for associating valence and space will also be reflected in measures of processing effort, as can be gathered in response-time paradigms. Second, the handedness-modulated association between horizontal space and valence has not been shown for the processing of linguistic stimuli so far, such as, for instance, the processing of words referring to entities with a positive or negative connotation. In the present paper we are concerned with the question of whether an association between emotional valence and dominant side affects response times in an experimental task employing linguistic stimuli.

According to our view, there are arguments for as well as arguments against this assumption. On the one hand, there is ample evidence that sensory-motor representations play an important role in language comprehension: Linguistic processes and representations are affected by the bodily experiences a recipient has available (e.g., Bub, Masson, & Cree, 2008; Glenberg & Kaschak, 2002; Zwaan & Taylor, 2006). Thus, if the dominant hand is associated with fluency, and accordingly with positive emotion, then it seems quite possible that such an association between valence and hand is also effective when linguistic stimuli with positive or negative valence are being processed.

On the other hand, it is well known in the literature on language comprehension that certain metaphoric associations between attribute dimensions affect linguistic processing. For example, the metaphor *good is up, sad is down* (cf. Lakoff & Johnson, 1980) presumably has an effect on the processing of affective words, resulting in shorter response times for evaluations of positive words appearing in the upper part of the screen, and of negative words appearing in the lower part (Meier & Robinson, 2004). Valenzuela and Soriano (2009) found evidence for an influence of the metaphor *control is up* on response time when participants processed linguistic stimuli expressing a relationship between a controlling and a controlled entity. According to the metaphoric mapping theory, metaphors help us to structure and conceptualize an abstract domain by projecting the structure of a concrete concept onto it (Lakoff & Johnson, 1980). Often, these conceptual metaphors are also reflected in linguistic expressions, leading to the existence of a linguistic metaphor (in the case of the metaphor *sad is down* for example an expression such as *I am feeling down today,* in the case of *control is up*, for example expressions such as *to be on top of a situation, to have control over someone*, or *his power rose*, Lakoff & Johnson, 1980). But why should the fact that metaphoric associations affect linguistic processing speak against the hypothesis that one might find evidence for the association between valence and dominant side in linguistic processing? The reason is that there is a strong *metaphoric* association between horizontal space and valence that differs crucially from the one referred to in the body-specificity hypothesis. This metaphoric association that is reflected in many linguistic expressions (see above) maps positive and negative valence onto the right and left side, respectively, not onto the dominant vs. non-dominant hand. Left-handers and right-handers share, of course, the same linguistic experiences. Thus, if they grew up in France or Germany, they should both be familiar with the expression *avoir deux mains gauches* / *zwei linke Hände haben* (being clumsy), and Spanish left- as well as right-handers will probably both say a sentence like *hoy me he levantado con el pie izquierdo* (literally, *Today I got up with the left foot*) to express that they are having a bad day. Thus, both left- and right-handers should be familiar with the metaphoric mapping between valence and space, in which positive valence is mapped to the right side, and negative valence is mapped to the left. In consequence, if this metaphoric association is in effect during linguistic processing, it might well override any influence of the association between valence and dominant side, thus preventing us from finding evidence for the body-specificity hypothesis during the processing of linguistic stimuli.

There is, however, one problem with the argument in the previous paragraph. Many conceptual metaphors are assumed to be grounded in bodily experiences. One example is the metaphor *control is up*, whose physical basis is, among others, that the winner of a physical fight tends to be on top (Lakoff & Johnson, 1980). Similarly, the basis for the metaphor *happy is up, sad is down* is that we tend to stand erect when we are feeling good, but assume a drooping posture when feeling sad (Lakoff & Johnson, 1980). Thus, strictly speaking, when finding evidence that metaphoric associations of this type affect linguistic processing, we do not know whether the effect is really an effect of the metaphoric mapping. In all of the investigated cases of metaphoric mapping, the bodily experiences and the conceptual and/or linguistic metaphors involved a consistent mapping. We can therefore not be sure which of those factors – bodily experiences, conceptual metaphors, linguistic expressions or any combination of these three – is responsible for the effects during language comprehension. Accordingly, even in the light of the evidence cited above (i.e., the studies by Meier and Robinson, 2004, and Valenzuela and Soriano, 2009) we may still expect to find evidence for the body-specificity hypothesis with linguistic stimuli.

To sum up, the question under consideration is whether an association between valence and dominant hand affects response times in an experimental paradigm that employs linguistic processing. As reasoned above, there are good arguments for expecting that the evidence obtained for the body-specificity hypothesis in the non-linguistic domain will generalize to an experimental task involving linguistic stimuli. On the other hand, it also seems possible that different factors are decisive depending on the task employed. Possibly, linguistic metaphors are preferably activated when linguistic stimuli are being processed. In this case, we might find evidence for an association between positive vs. negative valence and right vs. left side, rather than evidence for the body-specificity hypothesis (linguistic metaphor hypothesis).

A second aim of the present study was to investigate the conditions under which an association between valence and side would emerge for linguistic processing. In particular, we were interested in whether such an association only becomes evident if the experimental task obliges the recipient to focus on the valence of the stimuli, or alternatively, if it becomes activated automatically during reading. Again we can see arguments against as well as arguments in favor of the automatic view. On the one hand, the literature on embodied sentence processing has recently provided evidence that certain spatial mappings, which produce strong effects when the recipients' attention is focused on the domain under consideration, do not affect processing in more implicit tasks not requiring recipients to pay attention to the source domain. For instance, in a recent study by Ulrich and Maienborn (2010), the authors found evidence for the mental timeline where past is mapped on the left and future on the right only when participants' task involved focusing on the temporal content of the stimulus material. Thus, applied to our topic, it seems quite possible that an association between valence and side affects linguistic processing only if the experimental task explicitly requires participants to process the valence of the stimuli. On the other hand, we know from literature concerned with the processing of positive and negative words that recipients process the valence of linguistic stimuli even if the task does not require them to do so. For instance, studies investigating the emotional Stroop task, where participants have to name the color a word appears in, have shown that participants tend to respond slower to an emotional word that posits a threat to them than to neutral words (e.g., Williams, Mathews, & MacLeod, 1996). Similar results have been found in lexical decision experiments. Here, positive words are typically processed faster than neutral words, which in turn are usually processed faster than negative words (Kuchinke et al., 2005; for positive and negative words only: Wentura, Rothermund, & Bak, 2000). Different processing times for positive and negative stimuli even emerge if the words are matched for frequency and arousal (Estes & Verges, 2008). Thus, if valence is processed automatically, then the mapping between valence and side might also be activated during comprehension.

In this paper, we present four experiments in which participants read words with positive, negative, or neutral connotations (e.g., *love, hate,* and *table,* respectively). In Experiment 1, the experimental task was a lexical decision task, with participants responding with the right to a word and with the left to a non-word, or vice versa. Thus, although valence was not a relevant dimension for this experimental task, there were trials that were congruent (a positive word is responded to with a right-hand response and a negative word is responded to with a left-hand response, for right-handed participants), and trials that were incongruent (reversed response sides). In Experiments 2 and 3, a more explicit task was used. Participants performed a valence judgment task by responding to positive words with a response with their right hand and to negative words with a response with their left hand, or reverse. Finally, the experimental task in Experiment 4 required participants to pay attention to the valence of the stimuli in a go/nogo paradigm but did not explicitly map valence onto response side in the task instructions. Participants in Experiments 1, 2, and 4 were right-handed, those in Experiment 3 were left-handed.

If the association between valence and response side is automatic, then positive and negative words should automatically activate a spatial response code (cf. Vallesi, Binns & Shallice, 2008), which in turn should facilitate congruent responses (see also Hommel & Prinz, 1997; Umiltà & Nicoletti, 1990). Thus, we should observe an interaction between valence and side, independent of whether the experimental task explicitly focuses on the valence of the presented stimuli. In contrast, if the association is not activated automatically, interaction effects probably only emerge with an explicit response mapping between positive and negative valence, and responses to the right and the left side, respectively. In addition, if the body-specificity hypothesis generalizes to linguistic response time tasks, then we would expect to find evidence for an association between positive valence and the right side and negative valence and the left side in the experiments with right-handed participants, and a reverse association in the experiment with left-handers. In contrast, if linguistic processing is affected rather by linguistic metaphors, then we might find an association between positive valence and the right side and negative valence and the left side, independent of participants' handedness (i.e., potentially in all experiments).

Experiment 1

In this experiment, right-handers made a lexical decision by pressing a key with their right hand for words and a key with their left for non-words, or vice versa. Emotionally connoted words constituted only a third of the stimulus material. The experimental task therefore did not direct attention towards emotional valence. If the grounding of valence in space is automatic, we would expect an association between positive valence and right side, and negative valence and left side. Such an association could be explained by the body-specificity hypothesis as well as by the linguistic metaphor hypothesis.

Method

Participants

32 participants, 16 women and 16 men, took part in this study. We assessed handedness using a translated version of the Edinburgh inventory (Oldfield, 1971). All participants were classified as right-handed (*M* = 75.8; score range: +43 to +100). Mean age of participants was 25.2 years (*SD* = 3.2). All participants were native German speakers and left naïve with respect to the aim of the study. Sex was distributed evenly on the two experimental versions.

Materials

Stimulus material consisted of 60 German words and 60 pseudowords. Besides, 24 words and 24 non-words served as stimuli during practice trials. Words and pseudowords were matched with regard to length. A third of the words had positive connotations (e.g., *beach* or *friends*), a third negative connotations (e.g., *war* or *poverty*), and a third neutral connotations (e.g., *table* or *drawer*).

Words had been rated with respect to their emotional connotation by volunteers who did not participate in the actual experiment. Participants rated in total 106 words and 90 non-words on a bipolar Likert-scale with seven levels that ranged from "very negative" (-3) to "very positive" (+3). Selection of rated items was carried out in two steps. First, positively connoted words with a mean of 2.04 or higher and negatively connoted words with a mean of -2.00 or lower were selected, as well as neutral words with a mean between -0.34 and 0.48. In a second step, word length and frequency were matched across the three categories of valence, resulting in 20 positive (syllables: *M* = 2.35, *SD* = 0.93; letters: *M* = 7.75, *SD* = 2.86), 20 neutral (syllables: *M* = 2.05, *SD* = 0.83; letters: *M* = 6.55, *SD* = 2.39), and 20 negative words (syllables: *M* = 2.3, *SD* = 1.08; letters: *M* = 7.6, *SD* = 2.98). Frequencies of the words were obtained from a corpus (Wortschatz Universität Leipzig, http://wortschatz.uni-leipzig.de). An ANOVA did not show any differences between positive, negative and neutral words with regard to their frequency ($F < 1$). With respect to the non-words, the aim was to select items with a neutral rating (M = -0.17, SD = 1.01) and a similar length (syllables: M = 2.25, SD = 0.66; letters: M = 6.67, SD = 1.28) as the words.

Apparatus

Responses were collected with a computer keyboard placed in front of the screen. Participants responded by pressing “Q” with their left and “9” (on the number pad) with their right. Participants’ hands rested on these keys.

Procedure and Design

Each trial started with a fixation cross appearing in the center of the screen for 400 ms. Then the stimulus appeared for 2,000 ms. Participants were to react during this period. A blank screen was then shown for 1,000 ms. Afterwards, written feedback (practice trials) or a blank screen (experimental trials) showed up for 1,500 ms.

Half of the participants started by pressing a right key for words and a left key for non-words. In the second part of the experiment, this assignment was reversed. For the other half of participants, this order was the other way around. The same set of stimuli was used in both parts of the experiment. Each of the two parts of the experiment consisted of 24 practice trials and 120 experimental trials. The experimental design thus included three factors: response side (left vs. right), valence of stimuli (positive vs. neutral vs. negative), and order of the stimulus – response mapping.

Results and Discussion

Participants reacted correctly in 98.4% of all trials. For the response time analyses, only correct responses were taken into account. The response times (RTs) were submitted to two 3 (valence: positive vs. neutral vs. negative) × 2 (side of response: left vs. right) × 2 (order of conditions: right-hand responses for words and left-hand responses for non-words vs. left-hand responses for words and right-hand responses for non-words) ANOVAs, one treating participants as random factor (F_1) and one treating items as random factor (F_2). Order of conditions was included in the analyses to reduce error variance, but due to lacking theoretical relevance, its results will not be reported.

Overall response time was 580 ms. A main effect of side emerged ($F_1(1, 30) = 6.02$, $MSE = 1{,}600$, $p = .02$, $\eta_p^2 = .17$; $F_2(1, 57) = 18.57$, $MSE = 666.7$, $p < .001$, $\eta_p^2 = .25$), with right-hand responses being faster than left-hand responses (573 vs. 587 ms; cf. Table 1 for mean reaction times). A main effect for valence was found in the by-participants analysis ($F_1(2, 60) = 11.83$, $MSE = 596$, $p < .001$, $\eta_p^2 = .28$; $F_2(2, 57) = 2.35$, $MSE = 4{,}109.6$, $p = .11$, $\eta_p^2 = .08$). Numerically, responses to positive words were faster than those to neutral words, and these in turn were faster than those to negative words (571 vs. 578 vs. 591 ms). Separate 2×2 ANOVAS confirmed this pattern: Positive items led to faster RTs than negative items ($F_1(1, 30) = 31.44$, $MSE = 437.3$, $p < .001$, $\eta_p^2 = .51$; $F_2(1, 38) = 5.79$, $MSE = 656$, $p = .02$, $\eta_p^2 = .13$). Neutral items also led to faster RTs than negative items, but this was only significant in the by-participants analysis ($F_1(1, 30) = 7.98$, $MSE = 700.8$, $p = .01$, $\eta_p^2 = .21$; $F_2(1, 38) = 1.85$, $MSE = 4{,}432.6$, $p = .18$, $\eta_p^2 = .05$). The difference between positive and neutral items was not significant ($F_1(1, 30) = 2.78$, $MSE = 649.71$, $p = .11$, $\eta_p^2 = .08$; $F_2 < 1$). The contrast between response speed to positive and negative items is consistent with earlier studies investigating the processing of linguistic stimuli with positive or negative valence in a lexical decision task (Kuchinke et al., 2005; Estes & Verges, 2008).

Crucially, we found no significant interaction between side and valence ($F_1(2, 60) = 1.49$, $MSE = 1{,}017.9$, $p = .23$, $\eta_p^2 = .05$; $F_2(2, 57) = 2.65$, $MSE = 666.7$, $p = .08$, $\eta_p^2 = .25$). Response to positive words was faster with the right hand than with the left hand (568 vs. 573

ms); however, the same held true for neutral words (566 vs. 590 ms) and even for negative words (584 vs. 598; cf. Fig. 1).[1]

Under the assumption that there is an association between valence and side that is activated automatically, we had expected an interaction between side and valence, which was not observed. There are several possibilities why this interaction was not found in the present experiment. First, although all participants were right-handed according to the Edinburgh inventory (Oldfield, 1971), handedness scores had a rather wide range (from +43 to +100). Thus, maybe some of the participants were not right-handed enough to show the expected effect. In order to evaluate this possibility, we ran a separate ANOVA with only those participants that scored above the median (+75.74). No valence-by-side interaction emerged in this analysis, either, even if only positive and negative items were compared ($F_1 < 1$; $F_2 = 1.10$). The main effect of valence was significant in this analysis ($F_1 = 13.55$; $F_2 = 3.06$), indicating that power was not the problem.

Second, it might be that the response side in the current experiment was not salient enough to influence the processing of emotionally connoted words. Possibly, the impact of response side is stronger if participants perform a movement to the right or to the left rather than simply pressing a key with their right or left hand. We investigated this possibility in two separate experiments in which right-handed participants initiated a movement either with one or with both of their hands to respond to the lexical decision task. The two experiments employed different input devices. The first experiment employed a modified keyboard with participants moving their right hand to the right or their left hand to the left when responding. The second experiment made use of a slider which participants moved with their dominant

[1] The marginally significant side – valence interaction in the by-items analysis reflects the fact that the numerical difference between left- and right-hand responses reached significance only with negative items ($F_2(1, 19) = 6.84$, $MSE = 632.1$, $p = .02$, $\eta_p^2 = .26$) and neutral items ($F_2(1, 19) = 16.19$, $MSE = 688.1$, $p < .001$, $\eta_p^2 = .46$). There was no main effect for response side for positive items ($F_2 < 1$). A look at the mean RTs for items showed that contrary to our predictions, participants were slower to respond to negative (and neutral) items with their left hand than with their right (600 vs. 585 ms for negative items, 590 vs. 566 ms for neutral items).

hand. In both experiments, main effects for response side and valence emerged (all Fs > 3.70), but no interaction was found (all Fs < 1).

Third, maybe the body-specificity hypothesis does not generalize to the processing of linguistic stimuli. However, if so, why did we not find evidence for an effect of the metaphoric association between space and valence in this experiment? If the body-specificity association is not in effect during linguistic processing then at least the linguistic or conceptual metaphors that people are familiar with should have affected response times. For such an effect to show, however, it is not only necessary that participants know the linguistic metaphors, but also that these linguistic metaphors are actually considered as evoking a positive respectively a negative association. Thus, to make sure that our participants were indeed familiar with the respective linguistic expressions and their metaphoric interpretation, and, furthermore, that sentences employing the respective metaphors were indeed rated as describing a situation with a negative or positive valence, we conducted a cloze test with our participants after the actual experiment as well as a separate sentence rating study. These tests indicated that participants were indeed familiar with the linguistic metaphors, and rated the valence of the respective sentences as positive or negative according to the metaphoric interpretation (a more detailed report of these tests can be found in a separate paragraph below). Thus, there must be another plausible reason why no interaction between space and valence emerged in the present experiment.

A fourth possibility is that the association between valence and horizontal space does not affect processing effort and therefore does not occur in experimental paradigms with response times as dependent variables. In other words, just because there is a preference for a congruent assignment, such as the assignment of positive entities to the dominant side and negative entities to the non-dominant side, as observed by Casasanto (2009a) in his first experiment, this does not imply necessarily that there is response facilitation for a congruent assignment in a RT task. However, as other studies have provided evidence for response facilitation, reflected in shorter RTs, in trials in which the mapping of valence and vertical space is congruent, we do not consider this a very likely explanation. For instance, response facilitation was observed by Meier and Robinson (2004), who asked participants to evaluate positive and negative stimuli. Participants responded faster to the words when they appeared in a congruent position, that is, when positive words appeared at the top and negative words at the bottom of the computer screen. We do not see any reason why the association between vertical space and valence should affect RTs whereas the association between horizontal space and valence should not.

Finally, the possibility that we consider most likely is that the association between valence and side is not activated automatically but instead emerges only if the participants' attention is explicitly focused onto the valence of the stimuli, or even more extreme, an explicit response mapping between valence and side is being instructed.

In order to investigate these possibilities, we presented linguistic stimuli to right-handers (Experiment 2) and left-handers (Experiment 3). However, this time participants were required to pay attention to the emotional valence of the words. If the reason why we did not find an interaction between valence and side in Experiment 1 has to do with the fact that the experimental task in this experiment did not focus participants' attention towards the valence of the stimuli, then a valence-by-side interaction should now emerge in Experiments 2 and 3. In contrast, if one of the alternative explanations is correct, we should again find only main effects, but no such interaction.

Testing the Assumptions concerning the Linguistic Metaphors: Cloze Test and Rating Study

In order to rule out some of the alternative explanations for the fact that no interaction emerged in Experiment 1, we wanted to make sure, as stated above, that participants in this experiment were familiar with the linguistic metaphors in question. For this purpose, we designed a cloze test consisting of 10 figures of speech, 3 of which referred to the linguistic metaphor *good is right, bad is left*. In those figures of speech we blanked out the words “right” and “left”, and asked participants to complete the sentences (e.g., *Klaus has always been really clumsy. His mother says: “You have two ____________ hands.“* where *left* is the word we were looking for). Every item consisted of two sentences. The first sentence (e.g., *Klaus has always been really clumsy.*) set the mood for the linguistic metaphor in question, which had to be completed in the second sentence. All participants filled in the expected words in the critical figures of speech, with the exception of one participant, who got two out of three correct. On the basis of this data, we concluded that our participants were indeed familiar with these expressions, and hence with the metaphoric association *good is right, bad is left*.

To further investigate whether linguistic expressions based on the metaphor *good is right, bad is left* are indeed evaluated as positive or negative, we conducted an additional rating study. In this study, we presented participants with 24 figurative sentences, of which 7 referred to the metaphor *good is right, bad is left* (2 for g*ood is right*, 5 for *bad is left*, e.g., *Michael is the president’s right hand* or *Susan has two left hands*, respectively). 20 right-handed volunteers (mean age = 25.0 years, *SD* = 2.5 years) who did not participate in Experiment 1 assessed the valence of those figures of speech on a 9-point scale using the self-assessment manikin developed by Lang (1980; Hodes, Cook, & Lang, 1985). The figures of speech employing *good is right* received on the scale ranging from 1 (positive) to 9 (negative) a mean value of 2.18 (*SD* = 0.32), whereas the figures of speech employing *bad is left* received a mean value of 6.82 (*SD* = 0.68), indicating the expected relationship between metaphoric expressions and valence judgements.

Experiment 2

Experiment 2 investigated whether the lack of an interaction between valence and side in Experiment 1 was due to the fact that participants did not have to focus on the valence of the stimuli. For this purpose, we now employed a valence judgment task. We asked participants to make a valence judgment and explicitly instructed them to map a positive word to their right and a negative to their left hand or the other way around.

Method

Participants

20 right-handers took part in Experiment 2. All participants were native German speakers. One participant was excluded due to the number of errors in go-trials (≥ 10%), reducing the number of participants to 14 women and 5 men (mean age = 21.7 years, *SD* = 2.0).

Materials

The linguistic stimuli were taken from the materials used in the previous experiments. In total, there were 20 positive words, 20 negative words, and 40 pseudowords. Due to the nature of the task, no neutral words were used.

Apparatus and Procedure

Apparatus and procedure were the same as in Experiment 1, except that participants performed a valence judgment task. Participants responded only to words (go-trials), not to pseudowords (nogo-trials). Half of the participants started with responding to positive stimuli with the right and to negative with the left. In the second half of the experiment, the response mapping was the other way around. For the other half of participants, this order was reversed. In total, the experiment contained 160 experimental trials and 40 practice trials.

Results and Discussion

We analyzed the data in the same way as in the previous experiment, with the exception that the factor valence now contained two levels (positive vs. negative) instead of three (positive vs. neutral vs. negative).

Participants responded correctly in 98.2% of all trials and in 96.6% of the go-trials. Overall response time was 684 ms. As in the previous experiments, a main effect for valence emerged ($F_1(1, 17) = 53.26$, $MSE = 839$, $p < .001$, $\eta_p^2 = .76$; $F_2(1, 38) = 22.61$, $MSE = 4{,}016$, $p < .001$, $\eta_p^2 = .37$), with faster responses to positive than to negative words (660 vs. 709 ms). There was no main effect for side of response ($F_1 < 1$; $F_2 < 1$). However, an interaction between valence and side of response emerged ($F_1(1, 17) = 6.85$, $MSE = 1{,}607.5$, $p = .02$, $\eta_p^2 = .29$; $F_2(1, 38) = 16.84$, $MSE = 1{,}334$, $p < .001$, $\eta_p^2 = .31$; see Table 1 for means). Participants reacted faster to positive words with their right hand than with their left hand (650 vs. 671 ms), and faster to negative words with their left hand than their right hand (695 vs. 722 ms; cf. Fig. 2). We conducted separate analyses for positive and negative words respectively. For positive words, there was a tendency in the by-participants analysis ($F_1(1, 17) = 3.70$, $MSE = 1{,}114.8$, $p = .07$, $\eta_p^2 = .18$) and a main effect of response side in the by-items analysis ($F_2(1, 19) = 5.29$, $MSE = 1{,}603.8$, $p = .03$, $\eta_p^2 = .22$). For negative words, a main effect of response side emerged in both analyses ($F_1(1, 17) = 7.37$, $MSE = 961.5$, $p = .02$, $\eta_p^2 = .30$; $F_2(1, 19) = 13.49$, $MSE = 1{,}064.3$, $p = .002$, $\eta_p^2 = .42$).[2]

[2] One minor finding of this experiment needs to be discussed, namely the observed main effect of valence with shorter RTs for positively connoted words. This finding replicated the main effect of valence observed in Experiment 1 with a lexical decision task. However, this effect stands in contrast to other studies (e.g., Estes & Verges, 2008; but see Unkelbach et al., 2010), where shorter RTs for negative words emerged in a valence judgment task. One reason might be that the words used here had not been matched for arousal. Arousal predicts RT, with more arousing words eliciting faster responses (Estes & Adelman, 2008). We conducted a post-hoc rating of the items used in Experiments 1 and 2. Participants ($N = 18$) rated the arousal of words on a 5-point scale with the help of the self-assessment manikin developed by Lang (1980; Hodes, Cook, & Lang, 1985). Negative words were rated as more arousing than positive words ($t(17) = 8.47$, $p < .001$), and positive words as more arousing than neutral words ($t(17) = 2.77$, $p = .01$). According to Estes and Adelman (2008), the higher arousal level of negative words should have provoked shorter RTs. Welford (1980), however, sees the association between arousal and response as an inverted U. According to this view, a mediate level of arousal would provoke fastest responses in contrast to a very low and a very high level of arousal. It is open to speculation whether the arousal level of the positive items used in our studies, situated between the lower arousal level of neutral and the higher level of negative words, can be considered as an optimal level of arousal with respect to RT.

An interaction between emotional valence and side emerged in this experiment, which employed a valence judgment task instead of a lexical decision task. Right-handers responded faster with a right key press to positive words and with a left key press to negative words. As we did not find such an interaction between valence and space in previous lexical decision tasks, we conclude that the association between valence and space depends on whether or not participants focus their attention towards the valence of the stimuli. However, these results do not tell us anything about the mechanisms underlying the association between valence and space. As stated in the introduction, there are two possible explanations for such an association that are mutually exclusive. According to the first explanation (linguistic metaphor hypothesis), the association might reflect the linguistic pattern of using expressions related with *right* for positive concepts, and expressions related with *left* for negative concepts. A second explanation, however, would draw on the body-specificity hypothesis to account for the findings.

An easy way to decide between these two possibilities is to repeat the valence judgment task with left-handed participants. If the results of Experiment 2 are due to participants' linguistic experiences, then the same pattern of RTs should emerge for left-handers, i.e., faster responses with the right for positive and with the left for negative words. If, however, the results reflect bodily experiences participants make – e.g., greater fluency for the dominant hand –, then we would expect left-handers to respond faster with their left hand to positive stimuli, and with their right hand to negative stimuli. Experiment 3 explored this issue.

Experiment 3

In Experiment 3, left-handed participants conducted the same task as right-handed participants in Experiment 2, i.e., a valence judgment task. The body-specificity hypothesis would expect faster responses with the left hand to positive stimuli and faster responses with the right hand to negative stimuli. The linguistic metaphor hypothesis, on the other hand, would predict faster responses with the right to positive, and with the left to negative items.

Method

Participants

In Experiment 3, 32 left-handers participated. All of them were native German speakers. Due to a high number of errors in go-trials ($\geq$ 10%), 5 participants were excluded, reducing the total number of participants to 20 females and 7 males. Mean age of the remaining participants was 23.7 years (*SD* = 2.6).

Materials, Apparatus and Procedure

The linguistic stimuli as well as the apparatus and the procedure were the same as used in Experiment 2.

Results and Discussion

We analyzed the data in the same way as in Experiment 2. Participants reacted correctly in 98.2% of all and in 96.8% of the go-trials. Overall mean response time was 693 ms. They responded faster to positive than to negative items (676 vs. 711 ms; $F_1(1, 25) = 27.96$, MSE = 1,206, $p < .001$, $\eta_p^2 = .53$; $F_2(1, 38) = 5.28$, MSE = 8,784, $p = .03$, $\eta_p^2 = .12$). As in Experiment 2, there was no main effect for response side ($F_1 < 1$; $F_2 < 1$), but again, an interaction between valence and side of response emerged ($F_1(1, 25) = 5.97$, MSE = 4,595, $p = .02$, $\eta_p^2 = .19$; $F_2(1, 38) = 26.96$, MSE = 1,777, $p < .001$, $\eta_p^2 = .41$; see Table 1 for means). In contrast to Experiment 2, participants in this experiment responded faster to positive items with their left than with their right (657 vs. 694 ms) and faster to negative items with their right than with their left hand (697 vs. 724 ms; cf. Fig. 2). Separate analyses for positive and negative words, respectively, reflected these differences. A significant main effect of response side emerged for positive items ($F_1(1, 25) = 5.30$, MSE = 3,434.3, $p = .03$, $\eta_p^2 = .18$;

$F_2(1, 19) = 15.73$, $MSE = 1{,}679.6$, $p < .001$, $\eta_p^2 = .45$). For negative items, the main effect of response side was significant in the by-items analysis only ($F_1(1, 25) = 2.76$, $MSE = 3{,}576.1$, $p = .11$, $\eta_p^2 = .10$; $F_2(1, 19) = 11.53$, $MSE = 1{,}874.5$, $p = .003$, $\eta_p^2 = .38$).

We also submitted the data from Experiments 2 and 3 to two combined analyses of variance with the additional factor handedness. These 2 (valence: positive – negative) × 2 (side of response: left vs. right) × 2 (order of conditions: experiment started with right-hand responses for positive words and left-hand responses for negative words vs. experiment started with left-hand responses for positive words and right-hand responses for negative words) × 2 (handedness: left-handers vs. right-handers) ANOVAs yielded a main effect of valence ($F_1(1, 42) = 72.32$, $MSE = 1{,}057$, $p < .001$, $\eta_p^2 = .63$; $F_2(1, 38) = 12.96$, $MSE = 10{,}299$, $p < .001$, $\eta_p^2 = .25$), but no effect of handedness ($F_1 < 1$; $F_2(1, 38) = 1.32$, $MSE = 2{,}500.8$, $p = .26$, $\eta_p^2 = .03$) nor of response side ($F_1 < 1$; $F_2 < 1$). Most important, a three way interaction emerged between valence, response side and handedness ($F_1(1, 42) = 11.55$, $MSE = 3{,}386$, $p = .001$, $\eta_p^2 = .22$; $F_2(1, 38) = 51.06$, $MSE = 1{,}331$, $p < .001$, $\eta_p^2 = .57$). This interaction reflects the fact that right-handers respond faster to positive words with their right hand and to negative words with their left had, whereas for left-handers this association is the exact opposite. Left-handers respond faster to positive words with their left hand and to negative words with their right hand.

The results of Experiments 2 and 3 do not confirm the predictions of the linguistic metaphor hypothesis. According to this hypothesis, the association between valence and space reflects the linguistic metaphor that associates positive entities with the right side and negative entities with the left side, independent of whether readers are right- or left-handers.

However, the results of Experiments 2 and 3 *do* fit nicely with the body-specificity hypothesis. In both experiments, participants preferred to respond to positive words by pressing a key located on the dominant side of their body and to negative words by pressing a key located on their non-dominant side. As far as we know, such an association between valence and side has not yet been observed in a RT study employing linguistic stimuli. The results of the two experiments are remarkable as they clearly show that the association between side and valence does not stem from linguistic distinctions. For right- and for left-handers, linguistic distinctions associate right with positive and left with negative (see introduction). Nevertheless, left-handers preferred to respond to positive words with a left key and to negative words with a right key. Thus, it seems that the association between side and valence is grounded in bodily experiences, as proposed by the body-specificity hypothesis: Both right-and left-handers preferred to respond to positive stimuli by pressing a key located on the dominant side of their body, and to negative stimuli by pressing a key located on the non-dominant side.[3]

Experiments 2 and 3 showed a valence-by-side interaction with a task that requires participants to pay attention to the valence of the stimuli. At the same time, the task involved an explicit response mapping, i.e., positive stimuli were mapped to the right and negative stimuli to the left, or vice versa. The question remains, therefore, whether paying attention to the valence of the stimuli is sufficient for the valence-by-side interaction to emerge, or whether an explicit response mapping is needed as well. Experiment 4 was designed to investigate this issue.

Experiment 4

In Experiments 2 and 3, an interaction between valence and side emerged in a paradigm that related valence and side explicitly in the instructed response mapping. However, these studies still leave open the exact conditions under which the association between valence and

[3] Strictly speaking, our experiments leave open whether the relevant factor is indeed the response side, or alternatively the response hand. In the experiments by Casasanto (2009a), an association between valence and side was found even if participants only used their dominant hand for drawing, suggesting that side, not hand, is the relevant factor. We are currently conducting various studies to investigate this issue.

response side is being activated. It is unclear whether it suffices to explicitly focus participants' attention towards the valence of the stimuli or whether it is necessary to explicitly relate valence and response side in the instructed response mapping for the experimental task. In the latter case, the effect could be characterized as a memory effect reflecting the fact that a response mapping that is congruent with ones own bodily experiences is easier to remember than a response mapping that is incongruent with ones own bodily experiences. Experiment 4 was designed to further investigate this possibility. As in Experiments 2 and 3, participants were required to attend to the valence of the stimuli; however, in contrast to these experiments, there was now no explicit mapping of positive or negative stimuli to the left or the right hand.

Method

Participants

Forty participants took part in Experiment 4. All participants were native German speakers, and right-handers as assessed by a translated version of the Edinburgh inventory (*M* = 82.5; score range: +44 – 100). Two participants were excluded due to the number of errors in go-trials (≥ 10%), reducing the number of participants to 32 women and 6 men (mean age = 24.9, *SD* = 3.9).

Materials, Apparatus and Procedure

The stimuli employed in this experiment consisted of the 20 positive and 20 negative items used in Experiments 1 to 3. The apparatus was the same as in the previous experiments, but the task and procedure were different. Participants were required to perform a valence judgment in a go/nogo paradigm. In half of the trials, participants were instructed to respond only to positive words, and in the other half only to negative words. Each word appeared on the screen surrounded either by a dotted or by a dashed frame. Depending on the frame, participants were instructed to respond with the right or the left hand. Thus, the task required a valence judgment, but there was no explicit response-stimulus mapping. More specifically, items were divided into two subsets for this experiment. The experiment consisted of four blocks. All items appeared in all four blocks. In each block, one of the subsets appeared in a dotted frame and the other in a dashed frame. In the subsequent block, this assignment changed. In Blocks 1 and 3, participants responded only to positive (negative) items, and in Block 2 and 4, only to negative (positive) ones. In Block 1 and 2, participants responded with the right (left) to dotted and with the left (right) to dashed frames. In Block 3 and 4, this assignment was reversed. Accordingly, there were eight different lists in this experiment to counterbalance the order of conditions. Prior to each block, participants practiced the assignment relevant to the particular block in 16 practice trials.

Results and Discussion

We analyzed the data in the same way as in the previous experiments. As in Experiments 2 and 3, the factor valence only had two levels (positive vs. negative). The counterbalancing factor order of conditions, which was included to reduce error variance, had 8 levels.

Participants responded correctly in 96.5% of all trials and in 93.6% of the go-trials. Overall, participants responded with a mean of 763 ms. As in the previous experiments, a main effect for valence emerged ($F_1(1, 30) = 4.37$, $MSE = 2379.3$, $p = .05$, $\eta_p^2 = .13$; $F_2(1, 38) = 3.99$, $MSE = 10{,}781$, $p = .05$, $\eta_p^2 = .09$). Responses to positive items were faster than to negative items (755 vs. 771 ms; cf. Table 1 for means). No main effect for response side was found ($F_1(1, 30) = 1.18$, $MSE = 1{,}435.6$, $p = .29$, $\eta_p^2 = .04$; $F_2(1, 38) = 1.30$, $MSE = 3{,}520.1$, $p = .26$, $\eta_p^2 = .03$). Crucially, no interaction between valence and response side emerged ($F_1 < 1$; $F_1 < 1$; cf. Fig. 3).

The results shed further light on the nature of the valence-by-side interaction observed in the reported RT studies. While a valence-by-side interaction emerged when the task explicitly required to map valence onto side (Experiments 2 and 3), no such interaction was found in Experiment 4, where no explicit valence – side mapping was instructed. As participants were required to assess the valence of the presented words in order to decide whether to respond at all in this experiment (go/nogo paradigm), these results indicate that valence judgments are not sufficient to activate the association between valence and response side. One possible interpretation is that one needs to explicitly focus the participants' attention on the mapping of valence to response side. It might be that the valence-by-side association only becomes effective when people consciously reason about this mapping. Alternatively, the valence-by-side interaction reported in Experiments 2 and 3 could be interpreted as a kind of memory effect: a congruent stimulus – response mapping (positive items require a response with the dominant hand, negative items a response with the non-dominant hand) might be remembered better and be implemented with less effort than an incongruent stimulus–response mapping (positive items require a response with the non-dominant, negative items with the dominant hand). What we find surprising is that this memory effect is obviously not driven by the available linguistically grounded metaphoric associations, but rather by the participants' individual bodily experiences. Thus, for a left-handed participant it is apparently easier to play out an instruction relating positive valence with the left and negative valence with the right, although this same participant has lots of experiences with linguistic expressions that involve a contrary valence-by-side mapping, namely relating positive valence with the right and negative valence with the left. In this sense, the results of the present study provide strong evidence for the validity of the body-specificity hypothesis, according to which the fluency with which one performs tasks with one's own hands has a strong impact on which side is associated with positive affect and which with negative affect.

General Discussion

We conducted four experiments using positively and negatively connoted linguistic stimuli to investigate the association between valence and side. Following the body-specificity hypothesis, we expected shorter RTs for responses with the dominant compared to the non-dominant hand for words with positive connotation. For words with negative connotation, we expected shorter RTs for responses with the non-dominant compared to the dominant hand. In the first experiment, in which participants performed a lexical decision task, no such valence-by-side interaction was observed. However, Experiments 2 and 3, in which participants performed a valence judgment task, did yield significant interactions between valence and side. This interaction seems to depend on the explicit stimulus-response mapping used in those experiments, as Experiment 4 indicates.

Taken together, the results of the experiments reported in this article indicate that there is an association between valence and response side. As stated in the introduction, the existence of such an association might be explained by the body-specificity hypothesis as well as by the linguistic metaphor theory. However, while both theories predict the same pattern for right-handers – namely a faster response when classifying positive stimuli with the right and classifying negative stimuli with the left –, they differ with regard to their predictions for left-handers. If the association is due to the linguistic metaphor *right is good, left is bad*, then left-handers should respond faster to positive items with their right and to negative items with their left, just like right-handers. The body-specificity hypothesis, on the other hand, assumes that people always associate positive entities with their dominant and negative entities with their non-dominant hand, leading left-handers to respond faster with their left hand to positive stimuli and with their right hand to negative stimuli. Prior to our study, the literature provided evidence for the body-specificity hypothesis with regard to the processing of non-linguistic stimuli (Casasanto, 2009a; Casasanto & Jasmin, 2010). In principle, it would have been possible that a linguistic metaphor such as *good is right, bad is left* is primarily activated during a task involving linguistic stimuli. Our experiments, however, indicate that this is not the case. Whereas the results of Experiment 2 only showed the existence of an association between valence and horizontal space, Experiment 3 narrowed the source of this association down. Taken together, Experiments 2 and 3 reveal that people are faster when responding to positive words with a key on the dominant side of their body and to negative words with a key on the non-dominant side when making emotional valence judgments. As the dominant sides differ for right- and left-handers, this result clearly shows that the grounding of valence in space does not result from linguistic distinctions but rather from bodily experiences, as proposed by the body-specificity hypothesis (Casasanto, 2009a).

It should be emphasized that our experiments were conducted with German native speakers who have been exposed all their life to the various linguistic manifestations of the metaphor *good is right, bad is left* that can be found in the German language. We can therefore assume (and the cloze test following Experiment 1 supports this assumption) that all participants were familiar with this linguistic metaphor; nevertheless, this did not seem to influence their responses in the valence judgment task.

An interesting question in this regard is the exact relationship between bodily experiences, conceptual metaphors and linguistic metaphors (see also Casasanto, 2009b). Do linguistic metaphors always reflect underlying conceptual metaphors? If not, can linguistic metaphors give rise to conceptual metaphors? The standard case is one where bodily experiences, linguistic metaphor and conceptual metaphor all reflect the same association. In this case, there are two possibilities: Either the conceptual metaphor is grounded in bodily experiences and gives rise to the linguistic metaphor, or the linguistic metaphor is grounded in bodily experiences and gives rise to the conceptual metaphor. With regard to the association between horizontal space and valence, that is, the topic of the present paper, matters are more complicated. For right-handers, things are pretty straightforward: There is an association between positive valence and the right side which is based on bodily experiences – performing motor actions with the right hand is easy, whereas performing them with the left is a lot harder. This association then either gives rise to the conceptual metaphor *good is right*, which in turn finds its reflection in linguistic expressions, probably due to the fact that the vast majority of people share this conceptual metaphor. Alternatively, the association may directly give rise to the corresponding linguistic expressions which then result in the development of the corresponding conceptual metaphor. In both cases, linguistic metaphor, conceptual metaphor and bodily experiences are congruent.

For left-handers, however, things are different. If conceptual metaphors develop due to bodily experiences, then these people should possess incongruent conceptual and linguistic metaphors (*good is left* and *good is right*, respectively). If on the other hand conceptual metaphors develop due to linguistic metaphors, then left-handers should possess congruent conceptual and linguistic metaphors (*good is right*) which would both be incongruent with their bodily experiences (*good is left*). It is also possible, of course, that conceptual metaphors develop due to bodily experiences and linguistic metaphors. In this case, we would expect left-handers to have two incongruent conceptual metaphors, one congruent with their bodily experiences (*good is left*) and one congruent with their linguistic experiences (*good is right*). The experiments reported in the present manuscript were not designed to differentiate between these possibilities, and accordingly to allow a decision. However, we nevertheless think that our results make the first possibility appear most likely. First, as we did not find the valence-by-side interaction with the more implicit lexical decision task but only with the more explicit valence judgment task, we consider it unlikely that the interaction directly reflects bodily experiences. It seems more plausible to assume that the interaction reflects some kind of metaphoric mapping that is based on bodily experiences. As the observed interaction differed qualitatively for left- and right-handers, the metaphor(s) driving the effect cannot be purely linguistic but must involve a conceptual component that is different from the linguistic metaphor. This rules out the second possibility. Thus, left-handers either have a conceptual metaphor that is congruent with bodily experiences but incongruent with linguistic experiences, or they have two different and incongruent conceptual metaphors. However, inconsistent with the latter possibility, we did not observe a diminished interaction effect with left-handed participants which could have been expected had the effect indeed been based on two counteracting conceptual metaphors. We therefore consider it most likely that our interaction effect reflects a conceptual metaphor that is based on bodily experiences related to the fluency of motor actions. For right-handed participants, this conceptual metaphor is congruent with their linguistic metaphor, for left-handed participants, it is not. However, linguistic metaphors do not seem to affect RTs in the valence judgment task employed in our experiments. Of course future studies are needed that address this issue in a planned rather than a post-hoc manner. One interesting point in this regard is that the metaphor activated could vary according to the task. For example, Torralbo, Santiago, and Lupiáñez (2006) found in an investigation of the two metaphors *left is past, future is right* and *back is past, future is front* that the metaphor activated depended on the task. There might be cases where, in a similar manner, only the linguistic metaphor is activated, but not the body-specific metaphor.

Our results suggest that the association of valence and horizontal space is not activated automatically during linguistic processing. In Experiment 1, participants performed a lexical decision task for which emotional valence was irrelevant. Shorter RTs emerged for positively connoted words, a result commonly found in lexical decision studies (cf. Estes & Adelman, 2008; Wentura, Rothermund, & Bak, 2000). Participants therefore seem to have processed the valence of the stimuli, although the fact that emotionally connoted words constituted only a third of the item material suggests that this was not a conscious process. In spite of this effect of valence, no interaction between side and valence was found, indicating that valence did not automatically activate a particular spatial response code. What is more, Experiment 4 implies that for a valence-by-side interaction to emerge, it might not suffice to explicitly focus participants' attention towards the valence of the stimuli. An experimental task with an explicit valence – side mapping seems necessary to activate the association. One possible interpretation is that the effect is a kind of memory effect. In other words, a congruent response mapping is easy to remember and can be implemented with low effort compared to an incongruent response mapping. An alternative explanation would be that participants' attention not only needs to be focused on the valence of the stimuli but also on the mapping of valence to response side. Maybe the valence-by-side association only becomes effective when people consciously ponder about this mapping. In both cases, what we find surprising is that the effect is driven by bodily experiences rather than by the available metaphoric associations. Considering that people are probably consciously aware of the metaphoric associations that are reflected in the language they speak, but possibly not as much aware of their bodily experiences, one could have expected to find evidence for bodily grounded associations in more implicit tasks but evidence for linguistically grounded associations in more explicit tasks. Thus, the fact that bodily grounded associations stood up to linguistically grounded associations even in a very explicit task like judging the valence of words and mapping it onto a left vs. right response underscores the importance of bodily experiences for cognition. In this sense, the results reported in the present manuscript can be considered as constituting strong support for the grounded cognition framework.

In conclusion, the studies described in this manuscript provide evidence for a non-automatic association between valence and response side that affects RTs in experimental tasks involving linguistic stimuli. The direction of this association depends on the handedness of the reader, supporting the assumptions of the body-specificity hypothesis. Further studies are needed to investigate the exact conditions under which an association between valence and response side emerges. Our studies suggest that it does not suffice to focus participants' attention towards the valence of the stimuli in order to activate this space by valence association. Rather, what seems to be needed is an explicit response mapping, linking valence to response side.

References

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617-645.

Bub, D. N., Masson, M. E. J., & Cree, G. S. (2008). Evocation of functional and volumetric gestural knowledge by objects and words. *Cognition*, *106*, 27-58.

Casasanto, D. (2009a). Embodiment of abstract concepts: Good and bad in right- and left-handers. *Journal of Experimental Psychology: General, 138*(3), 351-367.

Casasanto, D. (2009b). When is a linguistic metaphor a conceptual metaphor? In V. Evans & S. Pourcel (Eds.), *New Directions in Cognitive Linguistics* (127-145). Amsterdam: John Benjamins.

Casasanto, D., & Chrysikou, E. G. (2011). When left is "right": Motor fluency shapes abstract concepts. *Psychological Science, 22*(4), 419-422.

Casasanto, D. & Jasmin, K. (2010). Good and bad in the hands of politicians: Spontaneous gestures during positive and negative speech. *PLoS ONE* 5(7): e11805. doi:10.1371/journal.pone.0011805

Estes, Z., & Adelman, J. S. (2008). Automatic vigilance for negative words in lexical decision and naming: Comment on Larsen, Mercer, and Balota (2006). *Emotion, 8*(4), 441-444.

Estes, Z., & Verges, M. (2008). Freeze or flee? Negative stimuli elicit selective responding.

Cognition, 108, 557-565.

Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin & Review*, *9*, 558-565.

Hodes, R. L., Cook, E. W., III, & Lang, P. J. (1985). Individual differences in autonomic response: Conditiones association or conditiones fear? *Psychophysiology, 22*(5), 545-560.

Hommel, B., & Prinz, W. (1997). *Theoretical issues in stimulus-response compatibility.* Amsterdam: North-Holland.

Kuchinke, L., Jacobs, A. M., Grubich, C., Võ, M. L. H., Conrad, M., & Herrmann, M. (2005). Incidental effects of emotional valence in single word processing: An fMRI study. *NeuroImage*, *28*, 1022–1032

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by.* Chicago: University of Chicago Press.

Lang, P. J. (1980). Behavioral treatment and bio-behavioral assessment: Computer applications. In J. B. Sidowski, J. H. Johnson, & T. A. Williams (Eds.), *Technology in mental health care delivery systems* (pp. 129-139). Norwood, NJ: Ablex.

Masson, E. J., & Loftus, G. R. (2003). Using confidence intervals for graphically based data interpretation. *Canadian Journal of Experimental Psychology, 57*(3), 203-220.

Meier, B. P., & Robinson, M. D. (2004). Why the sunny side is up: Associations between affect and vertical position. *Psychological Science, 15*(4), 243-247.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9*, 97-113.

Torralbo, A., Santiago, J., & Lupiáñez, J. (2006). Flexible conceptual projection of time onto spatial frames of reference. *Cognitive Science, 30*(4), 745-757.

Ulrich, R., & Maienborn, C. (2010). Left-right coding of past and future in language:

The mental timeline during sentence processing. *Cognition, 117,* 126-138.

Umiltà, C., & Nicoletti, R. (1990). Spatial stimulus-response compatibility. In R. W. Proctor & T. G. Reeve (Eds.), *Stimulus-response compatibility* (pp. 89–116). Amsterdam: North-Holland.

Unkelbach, C., von Hippel, W., Forgas, J. P., Robinson, M. D., Shakarchi, R. J., & Hawkins, C. (2010). Good things come easy: Subjective exposure frequency and the faster processing of positive information. *Social Cognition*, *28*(4), 538-555.

Valenzuela, J., & Soriano, C. (2009). Are conceptual metaphors accessible on-line? Is control really up? A psycholinguistic exploration of the CONTROL IS UP metaphor. In J. Valenzuela, A. Rojo & C. Soriano (Eds.), *Trends in cognitive linguistics: Theoretical and applied models* (pp- 31-50). Frankfurt: Peter Lang.

Vallesi, A., Binns, M. A., & Shallice, T. (2008). An effect of spatial-temporal association of response codes: Understanding the cognitive representations of time. *Cognition, 107*, 501–527.

Welford, A. T. (1980). Relationships between reaction time and fatigue, stress, age and sex. In A. T. Welford (Ed.), *Reaction times* (pp. 321-354). New York: Academic Press.

Wentura, D., Rothermund, K., & Bak, P. (2000). Automatic vigilance: The attention-grabbing power of approach- and avoidance-related social information. *Journal of Personality and Social Psychology, 78*(6), 1024-1037.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*(1), 3-24.

Winkielman, P., Schwarz, N., Fazendeiro, T., & Reber, R. (2003). The hedonic marking of processing fluency: Implications for evaluative judgment. In J. Musch & K. C. Klauer (Eds.*), The psychology of evaluation: Affective processes in cognition and emotion* (pp. 189-217). Mahwah, NJ: Lawrence Erlbaum.

Zwaan, R. A. (2004). The immersed experiencer: Toward an embodied theory of language comprehension. In: B.H. Ross (Ed.), *The Psychology of Learning and Motivation* (Vol. 44, pp. 35-62). New York: Academic Press.

Zwaan, R. A., & Taylor, L. J. (2006). Seeing, acting, understanding: Motor resonance in language comprehension. *Journal of Experimental Psychology: General, 135,* 1-11.

Author Note

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Table 1

Mean response times in Experiments 1 - 4

		Response side	
Experiment	Valence	left	right
Experiment 1	positive	573	568
	neutral	590	566
	negative	598	584
Experiment 2	positive	671	650
	negative	695	722
Experiment 3	positive	657	694
	negative	724	697
Experiment 4	positive	751	758
	negative	768	775

Figure 1. Mean response times in Experiment 1 for responses to positive, neutral, and negative linguistic stimuli with the right or left hand. The error bars represent confidence intervals for within-subject designs and were computed as recommended by Masson and Loftus (2003).

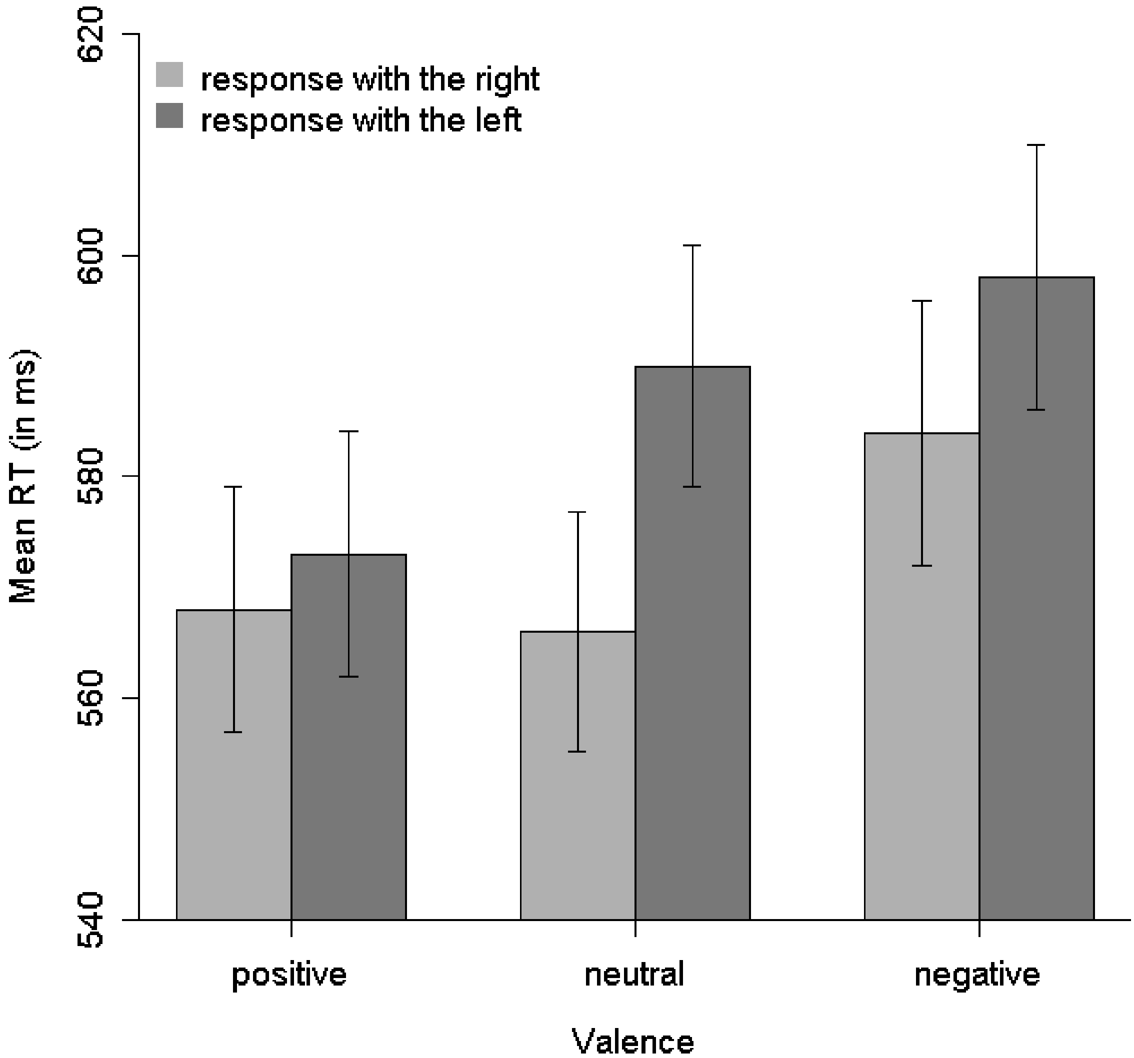

Figure 2. Mean response times in Experiment 2 (right-handers; on the right) and Experiment 3 (left-handers; on the left) for classification of positive and negative linguistic stimuli with the right or left hand. The error bars represent confidence intervals for within-subject designs and were computed as recommended by Masson and Loftus (2003).

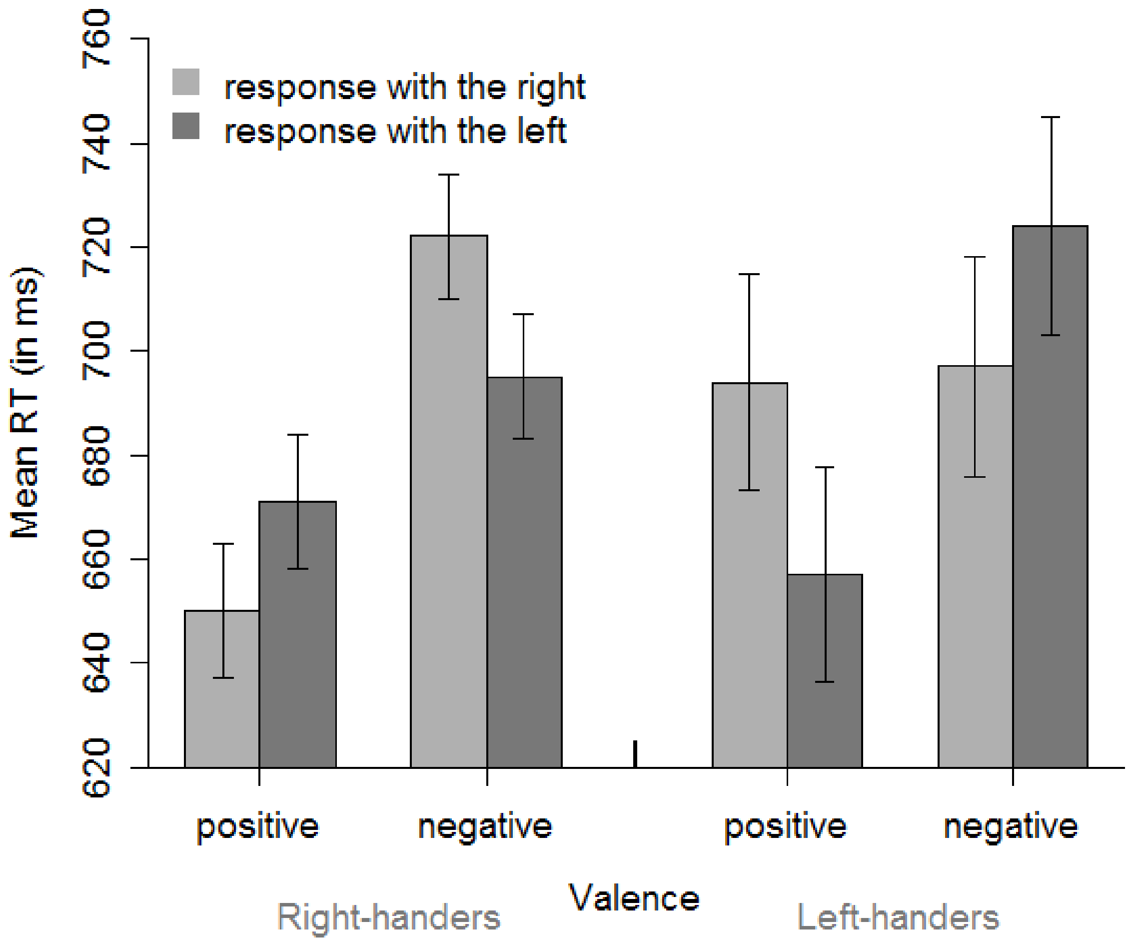

Figure 3. Mean response times in Experiment 4 for responses to positive and negative linguistic stimuli with the right or left hand. The error bars represent confidence intervals for within-subject designs and were computed as recommended by Masson and Loftus (2003).