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# Being someone's *right hand* doesn't always feel right: bodily experiences affect metaphoric language processing

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Recent research has found impact of bodily experiences on language understanding. However, there is no clear evidence whether previous experiences influence only literal linguistic expressions or whether they affect also the processing of metaphoric or idiomatic language. If bodily experiences influence understanding of metaphoric language, then left-handers should have more difficulties in processing metaphors that map *good* to the right and *bad* to the left than right-handers, as the underlying concept of such metaphors is at odds with their experiences. In our study, we found evidence for this assumption: In comparison to control conditions, left-handers processed linguistic left–right metaphors significantly slower than right-handers. This finding constitutes evidence for an influence of bodily experiences on metaphoric language processing.

**Keywords**: embodiment; body-specificity hypothesis; handedness; metaphors



Most researchers nowadays agree that cognition is inextricably linked to bodily experiences such as viewing a scene, moving one's arm or hearing a sound (Barsalou, 1999, 2008; Zwaan, 2004). For example, there exists overwhelming evidence for the idea that language understanding is grounded in experience. People read, for instance, a sentence implying an action such as *Tim turned the volume up* faster when conducting a movement that resembles the implied action (Zwaan & Taylor, 2006; see also Glenberg & Kaschak, 2002). Similarly, studies using functional magnetic resonance imaging (fMRI) showed that the processing of action verbs such as *to kick* or *to pick* activates brain areas that are also activated when the action implied by the verb is actually conducted (Hauk, Johnsrude, & Pulvermüller, 2004). Such findings are usually explained by the assumption that people mentally simulate described actions. Compared to the vast amount of findings in this area of research during the last years (Chatterjee, 2010), relatively few theoretical accounts of this simulation view have been developed (Barsalou, 2010). One of the few theoretical accounts in this area starts from the assumption that all mental representations are experiential (Zwaan & Madden, 2005). According to this account, physical interactions of an individual with the surrounding world leave experiential traces in memory, which become (partially) reactivated upon encountering a word or an expression referring to the involved objects, situations and events. Consequently, the mental simulations, which are based on experiential traces and built up during language processing, should differ for different individuals with different physical experiences.

Evidence for the view that experiential traces constitute the basis of mental simulations comes from different lines of investigation. Several studies have compared the performance or the neural activation of experts versus non-experts during, for example, the observation of actions or the comprehension of expressions used in their area of expertise (Aglioti, Cesari, Romani, & Urgesi, 2008; Beilock, Lyons, Mattarella-Micke, Nusbaum, & Small, 2008; Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005; Cross, Hamilton, & Grafton, 2006; Lyons et al., 2010; Tomasino, Guatto, Rumiati, & Fabbro, 2012). Another line of investigation, which also begins from the assumption that different physical experiences lead to different mental representations, draws attention to the different physical experiences left- and right-handers make throughout their lives, and to the different mental representations they develop as a consequence (*body-specificity hypothesis*; Casasanto, 2009).

Various studies provide evidence for the main assumption of the body-specificity hypothesis that left- and right-handers should develop different mental representations. In one study, for example, right- versus left-handers imagined that they were performing a motoric action, e.g. throwing. During this motor imagery, the cerebral activity found reflected how an individual usually performs this action: Right-handers showed a left-lateralized activation, whereas this activation was right-lateralized for left-handers (Willems, Toni, Hagoort, & Casasanto, 2009). The authors conclude from this finding that different physical experiences result in different neurocognitive

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representations (see also Willems, Hagoort, & Casasanto, 2010). Similarly, handedness also influences the neural correlates of observing an action (Willems & Hagoort, 2009). Interestingly, differences between left- and right-handers show even in tasks not referring to concrete physical manipulations. Left- and right-handers differ with regard to their associations between positive affect and hand (Casasanto, 2009). Both groups associate positive affect with their dominant hand, and negative affect with their non-dominant hand. Thus, left-handers associate positive with their left and negative with their right, and right-handers associate positive with their right hand, and negative with their left hand. These different affective associations are typically attributed to the fact that manual actions are performed more easily with the dominant versus non-dominant hand, and that this fluency is associated with positive affect (see Reber, Winkielman, & Schwarz, 1998; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). Several studies have corroborated this assumption. For example, when participants have to decide whether an alien figure on the left versus on the right looks more intelligent or more attractive, right-handers tend to assign positive traits to the figure on the right, whereas left-handers tend to choose the figure on the left. Similarly, when deciding whether to draw an animal which is presented positively versus an animal which is presented negatively in a box on the left or on the right, right-handers tend to choose the box on the right for the 'good' animal and the box on the left for the 'bad' animal, whereas this is the other way around for left-handers (Casasanto, 2009). These different associations appear to hold already for young children (Casasanto & Henetz, 2012) and are also reflected in response times during a valence judgement task (de la Vega, De Filippis, Lachmair, Dudschig, & Kaup, 2012; de la Vega, Dudschig, De Filippis, Lachmair, & Kaup, 2013).

Interestingly, the different associations of right versus left hand and positive versus negative affect are reflected in many linguistic metaphors and idioms across many different languages. These expressions typically associate right with positive, and left with negative, most probably due to the fact that most people are right-handed (see, for example, Gilbert & Wysocki, 1992; Tan, 1988). For example, people may use expressions such as *Paul is Linda's right-hand man* when they refer to the fact that Paul helps Linda a lot. In contrast, *Paul has two left feet* does not recommend him as a dancer. Such a mapping of *good* to the right and *bad* to the left reflects right-handers' experiences. For right-handers, this linguistic mapping of *good* to the right and *bad* to the left is congruent with their bodily experiences. It is, however, completely at odds with the experiences left-handers have made throughout their lives. For them, the left hand is associated with positive valence and the right hand with negative valence (see Casasanto, 2009; de la Vega, De Filippis, Lachmair, Dudschig, & Kaup, 2012). An interesting question in this regard is whether this incompatibility between physical experiences and metaphorical mapping leads to a different comprehension of these metaphors and idioms for left-handers, as compared to right-handers. If left- and right-handers understand these expressions differently, this should most probably be reflected in longer processing times for left-handers when reading such expressions. On the other hand, we should expect to see shorter processing times for right-handers, whose previous experiences and resulting mental representations are in line with the metaphoric mapping employed in these expressions. Previous research investigating whether experiential traces are activated during the comprehension of metaphoric and idiomatic expressions has often yielded mixed results (for inconsistent results when looking at figurative movement, see Bergen, Lindsay, Matlock, & Narayanan, 2007 versus Dils & Boroditsky, 2010; for inconsistent findings concerning the processing of idiomatic expressions see Raposo, Moss, Stamatakis, & Tyler, 2009 versus Boulenger, Hauk, & Pulvermüller, 2009). Finding evidence for differences between right- and left-handers with respect to the processing of metaphoric and idiomatic expressions would therefore not only be relevant for the body-specificity hypothesis itself but also for the grounded cognition view of comprehension, which assumes that comprehension is tantamount to reactivating experiences comprehenders have made with the described objects, situations and events.

The aim of the present study, therefore, was to investigate whether bodily experiences affect the processing of metaphoric expressions. More specifically, we tested whether left-handers understand left/right metaphors and idioms, which are at odds with their experiences and mental representations, differently in comparison to right-handers. We expected to see a processing cost for left-handers when reading left/right metaphors, which rely on structures that are at odds with left-handers' experience. In contrast, right-handers should benefit from the fit between the linguistic information given and their bodily experiences.

## Experiment

We conducted a reading time (RT) experiment to test our hypothesis that left-handers process linguistic metaphors and idioms that map *good* to the right and *bad* to the left slower than right-handers. The reason for predicting slower processing times for left-handers is that these kinds of metaphors are at odds with the experiences of left-handers resulting from bodily interactions with the physical world. To rule out alternative explanations of such a finding, we employed two control conditions. First, we controlled for the argument that a difference between left- and right-handers with regard to the processing of

Table 1. Examples of the items used in the experiment.

| Block | Sentences | Filler sentences | Order Vers. 1 | Order Vers. 2 |
|---|---|---|---|---|
| A | Christina ist die rechte Hand vom Chef.<br>*lit., Christina is the bosses' right hand.*<br>Lisa hat einfach zwei linke Hände.<br>*lit., Lisa simply has two left hands.* | Heute Mittag trank Ben ein Bier.<br>*This midday, Ben drank a beer.*<br>Maria ist ein netter Mensch.<br>*Maria is a nice person.* | 1 | 3 |
| B | Da fiel Hans wirklich aus allen Wolken.<br>*lit., Hans fell out of all clouds (was very surprised).* | – | 2 | 2 |
| C | Anna steht rechts von Martin.<br>*lit., Anna is standing right of Martin.*<br>Das linke Auto ist hellblau.<br>*lit., The left car is light blue.* | Lukas reitet auf dem Pferd.<br>*Lukas is riding on a horse.*<br>Martin schlendert hinter Karin.<br>*Martin is strolling behind Karin.* | 3 | 1 |



left/right metaphors might be merely due to the use of the words *left* and *right*. To control for this alternative explanation, we included literal sentences containing *left* and *right* in the experiment (see Table 1 for examples). Another alternative explanation might be that left-handers process metaphors differently than right-handers in general. To control for this argument, sentences containing other metaphors, that is, metaphors that do not refer to the left–right axis, were included (Table 1).

Participants were instructed to read the sentences and to press a key when they had understood it. If it is true that people have difficulties processing linguistic information that is at odds with their bodily experiences, then we expect longer RTs for left-handers in comparison to right-handers, but only for left/right metaphors, not for literal left/right sentences, and not for sentences containing other metaphors. In other words, according to this hypothesis, we expected an interaction between handedness and sentence type.

## Method

### *Participants*

Thirty left-handers ($M_{Age}$ = 22.8 years, $SD_{Age}$ = 4.3) and 30 right-handers ($M_{Age}$ = 22.9 years, $SD_{Age}$ = 4.2) took part in the experiment. All participants (41 females and 19 males) were German native speakers. An additional two participants were replaced because they had taken part in a similar experiment employing the same stimulus set. Participants received course credit or a financial reimbursement of 8 Euros per hour. They all had normal or corrected to normal vision.

### *Materials and apparatus*

The experiment consisted of three blocks with different sentence types. In the experimental block, participants read 32 sentences containing left/right metaphors (Block A; 12 sentences contained metaphoric or idiomatic expressions mapping *good* to the right and 20 contained metaphoric or idiomatic expressions mapping *bad* to the left; see Appendix 1). The two control blocks consisted of 36 metaphors or idioms not referring to left or right (Block B) and 80 sentences containing literal left/right information (Block C; see Table 1 for examples). Furthermore, blocks A and C contained filler sentences to distract participants from the frequent usage of *left* and *right* (Block A: 32 filler sentences; Block C: 80 filler sentences).

The sentences were presented as a whole on the screen. Participants pressed the space bar of a computer keyboard when they had understood the sentence. They were instructed to respond with their dominant hand. To ensure that participants really paid attention to the sentences, roughly a third of all sentences were followed by a comprehension question, to which participants responded with a key press ('V' for 'yes', 'N' for 'no').

### Procedure and design

There were two versions of the experiment that differed only with respect to the order of the blocks: In Version 1, the order was Block A (left/right metaphors) – Block B (sentences containing other metaphors) – Block C (literal sentences containing the words *left* and *right*). In Version 2, the order was reversed (Block C, Block B, Block A) to control for possible influences of left/right metaphors on literal left/right sentences and vice versa. This factor was counterbalanced across participants and did not enter analysis.

## Results

On average, participants responded correctly to 81.6 out of 86 comprehension questions. No participant responded correctly to less than 72 questions. Filler sentences were excluded from the analysis of the RTs. RTs under 100 ms and over 15,000 ms were discarded. The remaining RTs were submitted to two 2 (Handedness: left vs. right) × 3 (Sentence type: left/right metaphors vs. sentences

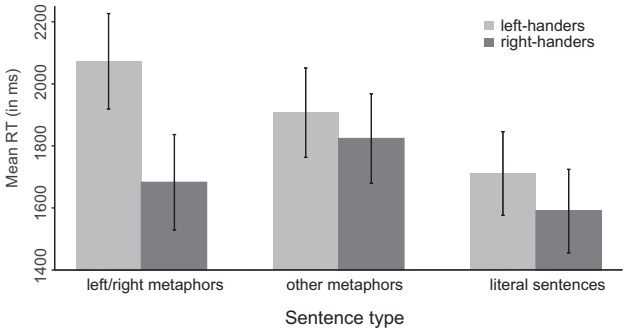


Figure 1. Mean RTs for left- versus right-handers and the different sentence types (sentences containing left/right metaphors, sentences containing other metaphors and literal sentences containing *left* and *right*). The error bars represent confidence intervals for within-subject designs and were computed as recommended by Masson and Loftus (2003).

containing other metaphors vs. sentences containing *left* and *right*) analyses of variances (ANOVAs), one treating participants as random factor ($F_1$) and one item, that is, the sentences used ($F_2$).

The overall RT was 1798 ms. Although RTs were shorter for right-handers than for left-handers (1699 vs. 1898 ms), this difference was significant only in the by-items analysis, $F_1(1, 58) = 1.48$, MSE = 1201,520; $F_2(1, 145) = 83.84$, MSE = 25,741, $p < 0.001$. A main effect for sentence type emerged, $F_1(2, 116) = 13.95$, MSE = 70,727, $p < .001$; $F_2(2, 145) = 21.14$, MSE = 85,372, $p < 0.001$, with significantly shorter RTs for literal sentences (1650 ms) in comparison to left/right metaphors (1879 ms), $F_1(1, 58) = 14.24$, MSE = 109,735, $p < 0.001$; $F_2(1, 110) = 32.94$, MSE = 72,386, $p < 0.001$, as well as in comparison to sentences containing other metaphors (1866 ms), $F_1(1, 58) = 27.37$, MSE = 50,847, $p < 0.001$; $F_2(1, 114) = 25.40$, MSE = 90,531, $p < 0.001$. However, this main effect was most probably due to an artefact as the different sentences types were not matched on length, syllable number or other variables. Most important for our hypothesis, an interaction between handedness and sentence type emerged, $F_1(2, 116) = 5.95$, MSE = 70,727, $p = 0.003$; $F_2(2, 145) = 19.58$, MSE = 25,741, $p < 0.001$. Separate 2 × 2-analyses revealed that this interaction was due to different RTs for left- vs. right-handers in the experimental condition in comparison to the two control conditions (Figure 1). A handedness-by-sentence type interaction showed when we compared left/right metaphors to other metaphors, $F_1(1, 58) = 13.68$, MSE = 51,599, $p < 0.001$; $F_2(1, 66) = 23.42$, MSE = 33,898, $p < 0.001$, and also when we compared left/right metaphors to literal sentences, $F_1(1, 58) = 4.97$, MSE = 109,735, $p = 0.03$; $F_2(1, 110) = 33.05$, MSE = 25,218, $p < 0.001$. Although the difference in RTs between left- and right-handers was greater for the literal sentences containing *left* and *right* than for the sentences containing other metaphors (121 vs. 84 ms), no interaction emerged when we compared the two control conditions, $F_1 < 1$; $F_2 < 1$. In addition to the ANOVA, we fitted a mixed-effects model to the data using the lmer function contained in the lme4 package (Bates, Maechler, & Bolker, 2012) in the statistical environment R (R Development Core Team, 2012). The model contained random intercepts for participants and for items, by-participant random slopes for sentences, and by-item random slopes for handedness[1] (see Barr, Levy, Scheepers, & Tily, 2013). The interaction model Handedness × Sentence type fitted the data better than the additive model Handedness + Sentence type, $\Delta \chi^2 = 11.90$, $p = 0.003$. This interaction model rendered *t*s > 2 for both critical interactions, namely the one between handedness and left/right metaphors versus literal sentences ($t = 2.23$) and the interaction between handedness and left/right metaphors versus other metaphors ($t = 3.57$). Thus, in line with our hypothesis, left-handers needed more time to process left/right metaphors in comparison to other sentences.

## Discussion

Do left-handers understand metaphors mapping *good* to the right and *bad* to the left differently than right-handers? To test this hypothesis, left- and right-handers read sentences containing linguistic metaphors and idioms that map *good* to the right and *bad* to the left. As right-handers are much more fluent with the right hand, and consequently associate positive entities with the right and negative entities with the left, such metaphors are consistent with the experiences they make when interacting with their physical environment. However, left-handers perform manual actions much more easily with their left hand. Linguistic metaphors and idioms associating *good* with right and *bad* with left are, therefore, at odds with their bodily experiences. If these experiences affect the processing of left/right metaphors, then left-handers should encounter more difficulties in processing such expressions than right-handers.

This is exactly what we found. A significant interaction between handedness and sentence type emerged in the RT experiment. Left-handers needed more time to process left/right metaphors versus literal sentences containing the words *left* and *right*, and versus other metaphoric expressions when compared to right-handers. Right-handers, in contrast, benefited from the fit between the underlying structure of these metaphors (*right is good, left is bad*) and their bodily experiences. Our results provide compelling evidence for the idea that language understanding is grounded in experience, and that this does not only hold true for the linguistic expressions of concrete entities or actions. An influence of previous physical experiences can even be found on the comprehension of metaphoric expressions relying on a mapping which is at odds or in line with such experiences.

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## Note

1. In lmer model syntax: RT ~ Handedness × Sentence type + (1 + Handedness| Item) + (1 + Sentence type | Subject).

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Appendix 1. The experimental trials (left/right metaphors) in German and their English translations

| Christina ist die rechte Hand vom Chef. | Christina is the boss's right hand. |
|---|---|
| Marlene ist Michaels rechte Hand. | Marlene is Michael's right hand. |
| Tante Lotte war Manfreds rechte Hand. | Aunt Lotte was Manfred's right hand. |
| Tom ist die rechte Hand vom Abteilungsleiter. | Tom is the right hand of the department manager. |
| Er ist mit dem linken Fuß aufgestanden. | He got up on the wrong side of bed (lit., with the left foot). |
| Klaus ist heute mit dem linken Fuß aufgestanden. | Klaus got up on the wrong side of bed today (lit., with the left foot). |
| Sie ist heute mit dem linken Fuß aufgestanden. | She got up on the wrong side of bed today (lit., with the left foot). |
| Kim ist heute mit dem linken Fuß aufgestanden. | Kim got up on the wrong side of bed today (lit., with the left foot). |
| Katharina hat zwei linke Hände. | Katharina has two left hands. |
| Onkel Konrad hat zwei linke Hände. | Uncle Konrad simply has two left hands. |
| Lisa hat einfach zwei linke Hände. | Lisa simply has two left hands. |
| Max hatte schon immer zwei linke Hände. | Max has always had two left hands. |
| Tom hat einfach das Herz am rechten Fleck. | Tom's heart simply is in the right place. |
| Anna hat das Herz wirklich am rechten Fleck. | Anna's heart is really in the right place. |
| Sandra hatte das Herz am rechten Fleck. | Sandra's heart was in the right place. |
| Christoph hatte das Herz am rechten Fleck. | Christoph's heart was in the right place. |
| Peter ist wirklich ungewöhnlich linkisch. | Peter is really extraordinarily clumsy. |
| Christiane ist einfach so linkisch. | Christiane is simply very clumsy. |
| Dora war wirklich schon immer linkisch. | Dora has really always been clumsy. |
| Onkel Anton war ein linkischer Mensch. | Uncle Anton was a clumsy person. |
| Dorothea ist wirklich ziemlich link. | Dorothea is really pretty crooked. |
| Matthias war schon immer etwas link. | Matthias has always been rather crooked. |
| Der Autohändler gestern war ziemlich link. | The car dealer yesterday was pretty crooked. |
| Die neue Kollegin ist einfach link. | The new colleague is simply crooked. |
| Der Kerl gestern wollte mich ganz klar linken. | The guy yesterday definitely wanted to deceive me. |
| Der Makler wollte mich gestern linken. | The estate agent tried to deceive me. |
| Markus wollte Tanja eindeutig linken. | Markus wanted to deceive Tanja. |
| Der Verkäufer wollte Moritz linken. | The shop assistant wanted to deceive Moritz. |
| Da kam Michael vom rechten Weg ab. | Michael went astray (lit., came off the right path). |
| Samuel kommt noch vom rechten Weg ab. | Samuel will go astray (lit, will come off the right path). |
| Carolin ist vom rechten Glauben abgefallen. | Carolin went astray (lit., fell off the right faith). |
| Andrea fiel vom rechten Glauben ab. | Andrea went astray (lit., fell off the right faith). |