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# When Left Is "Right": Motor Fluency Shapes Abstract Concepts

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## Abstract

Right- and left-handers implicitly associate positive ideas like "goodness" and "honesty" more strongly with their dominant side of space, the side on which they can act more fluently, and negative ideas more strongly with their nondominant side. Here we show that right-handers' tendency to associate "good" with "right" and "bad" with "left" can be reversed as a result of both long- and short-term changes in motor fluency. Among patients who were right-handed prior to unilateral stroke, those with disabled left hands associated "good" with "right," but those with disabled right hands associated "good" with "left," as natural left-handers do. A similar pattern was found in healthy right-handers whose right or left hand was temporarily handicapped in the laboratory. Even a few minutes of acting more fluently with the left hand can change right-handers' implicit associations between space and emotional valence, causing a reversal of their usual judgments. Motor experience plays a causal role in shaping abstract thought.

## Keywords

abstract concepts, body-specificity hypothesis, metaphor, motor training, space, valence

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Across many cultures, the right side is associated with things that are good and lawful, and the left side with things that are dirty, bad, or prohibited. According to the King James Bible, "The wise man's heart is at his right hand; but the fool's heart is at his left" (Ecclesiastes 10:2). According to Islamic law, Muslims should use their right hand for eating and drinking because only Satan uses his left. The association of "good" with "right" and "bad" with "left" is evident in positive and negative idioms like *my right-hand man* and *two left feet*, and in the meanings of English words derived from the Latin for "right" (*dexter*) and "left" (*sinister*).

People also associate positive and negative ideas implicitly with "right" and "left," but not always in the way that linguistic and cultural conventions suggest. When asked to decide which of two products to buy, which of two job applicants to hire, or which of two alien creatures looks more trustworthy, right- and left-handers respond differently. Right-handers tend to prefer the product, person, or creature presented on their right side, but left-handers tend to prefer the one on their left (Casasanto, 2009). This pattern persists even when people make judgments orally, without using their hands to respond.

Children as young as 5 years old already make evaluations according to their handedness, judging animals shown on their dominant side to be nicer and smarter than animals on their nondominant side (Casasanto & Henetz, 2011). Beyond the laboratory, people's association of "good" with their dominant side can be observed in their spontaneous gestures. In the final debates of the 2004 and 2008 U.S. presidential elections, positive speech was associated with right-hand gestures and negative speech with left-hand gestures in the two right-handed candidates (Bush, Kerry), but the opposite association was found in the two left-handed candidates (McCain, Obama; Casasanto & Jasmin, 2010).

Overall, these patterns cannot be predicted or explained by conventions in language and culture, which consistently associate "good" with "right" and "bad" with "left." Rather, these results support the *body-specificity hypothesis*, according to which people with different kinds of bodies think differently in predictable ways, even about highly abstract ideas (Casasanto, 2009; Casasanto & Henetz, 2011; Casasanto & Jasmin, 2010; Willems, Hagoort, & Casasanto, 2010).

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Yet an important question remains: *Why* do right- and left-handers associate good and bad things with opposite sides of space? One possibility is that people's experience of interacting with the physical environment more fluently on their dominant side and less fluently on their nondominant side could lead to the formation of implicit associations in memory. More fluent perceptuomotor processing often leads to more positive feelings and evaluations (Beilock & Holt, 2007; Oppenheimer, 2008; Reber, Winkielman, & Schwarz, 1998). The dominant side may be good in people's minds because dominant-side actions tend to be more fluent than nondominant-side actions. Alternatively, different spatial mappings of "good" and "bad" could result from genetically determined neurological differences between right- and left-handers: That which gives rise to handedness could also give rise to handedness-related differences in judgments (Davidson & Fox, 1982; Kinsbourne, 1978). In principle, the body-specific association between space and emotional valence could be experience independent.

In the experiments reported here, we investigated whether motor experience can establish implicit associations between space and valence that are independent of genetic handedness. We tested whether "induced handedness" due to long- and short-term changes in motor fluency can influence judgments about the spatial correlates of "good" and "bad."

## Experiment 1: Plasticity of Space-Valence Mappings Following Unilateral Stroke

To evaluate the effects of long-term changes in motor fluency, we tested naturally right-handed patients with hemiparesis or hemiplegia (weakness or paralysis on one side of the body) following unilateral cerebrovascular accident (CVA). If the body-specific association between space and valence is due to natural handedness per se, then regardless of their poststroke functional handedness, these patients should show the "good is right" mapping found in healthy right-handers. Alternatively, if the association between "dominant" and "good" is a consequence of habitually acting more fluently on one's dominant side, then patients whose natural right-handedness is preserved should continue to show the "good is right" mapping, but patients whose handedness is effectively reversed should show the opposite, "good is left," mapping.

### Method

The hemiparesis and hemiplegia patients ($N$ = 13) were right-handed prior to brain injury. Right-hemisphere CVA in 5 of the patients preserved their natural right-handedness. Left-hemisphere CVA in the remaining 8 patients made them effectively left-handed poststroke (for more information about the patients, see Table S1 in the Supplemental Material available online). No patients had anosagnosia. Participants were tested at the University of Pennsylvania Hospital or in their homes after giving informed consent.

The materials and procedure were identical to those used in Experiment 3 of Casasanto's (2009) study, except that the Dutch instructions were translated into English. Amid filler tasks, patients performed a two-question diagram task that elicits contrasting space-valence judgments from healthy right- and left-handers. Participants saw a cartoon character's head in the center of a page between two empty boxes, one on his right and the other on his left (see Fig. S1 in the Supplemental Material). They were told that the character loves zebras and thinks they are good, but hates pandas and thinks they are bad (or vice versa). Participants then indicated where the character would put each of the animals if he were going to put the good animal in one box and the bad animal in the other. The assignment of positive or negative valence to the animals was counterbalanced across participants within each CVA group. The order in which participants were asked about the good and bad animals was also counterbalanced, to ensure that any associations between space and valence in participants' judgments were not confounded with temporal order. Participants' judgments were made orally. To prevent pointing, the experimenter removed the diagram from view before requesting the responses. There was no manual motor component to the diagram task, so the possibility of on-line effects of motor fluency on responses was eliminated.

During debriefing, participants were asked to explain their responses. No one mentioned handedness or motor fluency (pre- or poststroke) as an explanation.

### Results and discussion

For 12 of the 13 patients, judgments varied according to their poststroke motor fluency (sign test on 12 vs. 1, $p$ = .003). All 5 patients with left hemiparesis or hemiplegia (100%) indicated that the good animal should go in the right box and the bad animal in the left box, the pattern consistent with their pre- and poststroke right-hand dominance. By contrast, 7 of the 8 patients with right hemiparesis or hemiplegia (88%) indicated that the good animal should go in the left box and the bad animal in the right box, the pattern contrary to their premorbid right-handedness but consistent with their poststroke left-hand dominance. This association of poststroke dominant hand (right, left) with response (good = right, bad = right) was significant, Pearson's $\chi^2(1, N = 13) = 12.17$, $p$ = .0005; Fisher's exact test $p$ = .005, two-tailed.

Thus, prolonged reversal of natural hand dominance can reverse right-handers' usual tendency to associate "good" with "right."

## Experiment 2: Plasticity of Space-Valence Mappings Following Short-Term Handicap

The stroke patients' brain injuries led not only to lasting changes in motor fluency, but also to long-term neural reorganization. The locus of CVAs varied widely across the patients (see Table S1 in the Supplemental Material), so it would be challenging to explain our results on the basis of neural changes per se, as opposed to resultant changes in motor fluency. Still, we cannot rule out the possibility of such an explanation, in principle.

In order to determine whether changes in motor fluency that are independent of any long-term changes in neural organization can affect space-valence mappings, we conducted a two-part training experiment. Healthy right-handers performed a motor fluency task (training phase) and then the same diagram task used with the stroke patients (test phase).

## Method

Native Dutch-speaking undergraduates ($N$ = 55) participated in Experiment 2 for payment. All were right-handed according to prescreening, and handedness was confirmed using a Dutch adaptation of the Edinburgh Handedness Inventory (EHI; Oldfield, 1971; Van Strien, 1992), which was administered at the end of the testing session. Two participants were excluded from analysis on the basis of the debriefing. For the remaining 53 participants, the mean EHI score was 78.73 ($SD$ = 2.59). Twenty-six of the participants (mean EHI = 82.20, $SD$ = 3.25) were randomly assigned to wear a ski glove on their left hand during training; 27 (mean EHI = 75.39, $SD$ = 3.99) were assigned to wear a glove on their right hand. EHI scores did not differ significantly between groups, $t(51)$ = 1.32, n.s.

During the training phase, participants were seated at a table, the top of which was covered with a mat that was 120 cm wide by 60 cm deep. On the mat were 80 dots spaced approximately 12 cm apart, in eight horizontal rows. In the center of the mat was a cardboard box containing two sets of dominoes (84 pieces).

In what was ostensibly a test of motor coordination, participants were instructed to place dominoes on the dots as quickly as possible for 12 min. To induce an asymmetry in motor fluency, we assigned participants to wear a bulky ski glove on one hand, with the other glove dangling from the same wrist (see Fig. S2 in the Supplemental Material). Manipulating the dominoes was thus much more difficult with the gloved hand than with the free hand. To avoid calling attention to the assignment of the glove to one hand or the other, the experimenter handed each participant only one of the gloves and then fastened the second glove to the wrist of the first (once the participant had put on the first glove). Participants were instructed to remove the dominoes from the box in pairs, one in each hand, and place the dominoes on the dots in a symmetrical pattern. Participants' hands moved in synchrony, with the left hand placing dominoes on the left side of the table and the right hand placing dominoes on the right side of the table. The dominoes were placed standing upright on the dots, with the spots facing the participants. If dominoes were knocked over, participants had to repair the arrangement before proceeding, using the appropriate hand. They were not allowed to use the free hand to help the gloved hand or to prevent the dangling ski glove from knocking over the dominoes. Participants were aware that they were being videotaped throughout the training phase.

After the training phase, participants removed the glove and were escorted to a different room, where a different experimenter administered three brief, ostensibly unrelated questionnaires (two were fillers). The change of location and personnel was intended to enhance the impression that the training and test phases were unrelated. For the relevant questionnaire, participants performed the same animals task used in Experiment 1, with prompts in Dutch rather than English. Participants responded orally without using their hands; this procedure eliminated any trivial forms of transfer from the training phase to the test phase.

Finally, the second experimenter debriefed participants extensively about the purpose of the experiments. Even though participants were asked explicitly whether they noticed any relationships between the experiments, only 2 reported any connection between the training and test phases. Their data were excluded from further analyses.

## Results and discussion

Of the participants whose left hand was handicapped during training (so that their natural right-handedness was preserved), 77% assigned the good animal to the right box, $z$ = 2.29, $p$ = .01. Of the participants whose right hand was handicapped (making them effectively left-handed), 63% assigned the good animal to the left box, $z$ = 1.83, $p$ = .03. Overall, participants were more than 5 times more likely to assign the good animal to the box on the side of the hand that had been free during the training phase than to the box on the side of the hand that had been gloved, Wald $\chi^2(1, N = 53) = 8.01$, $p$ = .005; odds ratio = 5.67, 95% confidence interval: [1.71, 18.83]. After becoming effectively left-handed during the motor training task, natural right-handers spatialized "good" and "bad" the way natural left-handers do.

# General Discussion

Changing the way people use their hands can change their judgments about the abstract ideas of goodness and badness. Long-term changes in motor fluency can reverse implicit associations between emotional valence and left/right space. In the short term, even a few minutes of acting more fluently with the left hand than the right can cause natural right-handers to associate "good" with "left," as natural left-handers do. The effects of short-term motor asymmetries are presumably temporary, but the same associative learning mechanisms that change people's judgments in the laboratory may result in the long-term changes we found in stroke patients, and may shape natural right- and left-handers' space-valence mappings in the course of ordinary motor experience. Using one's lopsided body, and therefore interacting with the physical environment more fluently on one side of space than the other, may serve as a kind of natural motor training.[1]

This finding does not rule out the possibility that innate neurobiological factors also contribute to the body-specific mappings observed in natural right- and left-handers. But the fact that right-handers' judgments *reversed* with long- or short-term changes in motor fluency demonstrates that motor experience is sufficient to determine the direction of space-valence associations, and even to overwhelm any innate predisposition to associate "good" with one's naturally dominant side.

Motor fluency has been linked previously with preferences for things that people can act on with their hands. People prefer graspable objects, such as spatulas, when the objects' handles are oriented to make them easy to grasp (Ping, Dhillon, & Beilock, 2009). Skilled typists prefer pairs of letters that are easy to type, even when they are not typing (Beilock & Holt, 2007). These effects can be readily explained in terms of motor affordances: People mentally simulate performing the action that an object would afford if they were to act on it, such as picking up a spatula or typing letters, and their preference judgments vary according to how fluent this action would be.

Yet motor tendencies also predict judgments about abstract ideas and things people can never manipulate with their hands, as when left- or right-handers attribute more intelligence or honesty to alien creatures depicted on their dominant side of a page than to those depicted on their nondominant side (Casasanto, 2009). In the present study, changes in motor fluency influenced participants' judgments about the spatialization of imaginary creatures, on the basis of the creatures' intangible qualities. These results demonstrate a causal link between manual motor fluency and abstract judgments and suggest that this link is not necessarily mediated by mental simulation of action affordances. Associations between emotional valence and left/right space may be established through habits of fluent and disfluent hand actions, but these associations generalize to influence judgments about things people can never see or touch. It remains a challenge for future research to characterize the neurocognitive mechanisms by which physical experience generalizes to shape abstract conceptions of good and bad.

## Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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## Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

## Note

1. Previous studies have shown that the link between fluency and evaluation is also malleable. Under certain circumstances, the less fluent alternative is judged to be more positive, true, or familiar than the more fluent alternative (Briñol, Petty, & Tormala, 2006; Unkelbach, 2006, 2007). The present study shows a different kind of reversal in that the fluent side was still associated with "good," regardless of long- or short-term motor training.

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