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# Motor Imagery Shapes Abstract Concepts

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**Abstract**

The concepts of "good" and "bad" are associated with right and left space. Individuals tend to associate good things with the side of their dominant hand, where they experience greater motor fluency, and bad things with their nondominant side. This mapping has been shown to be flexible: Changing the relative fluency of the hands, or even observing a change in someone else's motor fluency, results in a reversal of the conceptual mapping, such that good things become associated with the side of the nondominant hand. Yet, based on prior studies, it is unclear whether space–valence associations were determined by the experience of fluent versus disfluent actions, or by the mere expectation of fluency. Here, we tested the role of expected fluency by removing motor execution and perceptual feedback altogether. Participants were asked to imagine themselves performing a psychomotor task with one of their hands impaired, after which their implicit space–valence mapping was measured. After imagining that their right hand was impaired, right-handed participants showed the "good is left" association typical of left-handers. Motor imagery can change people's implicit associations between space and emotional valence. Although asymmetric motor experience may be necessary to establish body-specific associations between space and valence initially, neither motoric nor perceptual experience is needed to change these associations subsequently. The mere expectation of fluent versus disfluenct actions can drive fluency-based effects on people's implicit spatialization of "good" and "bad." These results suggest a reconsideration of the mechanisms and boundary conditions of fluency effects.

*Keywords:* Conceptual metaphor; Body specificity; Fluency; Handedness; Emotional valence; Mental imagery

## 1. Introduction

Conventions in many cultures link the abstract concepts of "good" and "bad" with particular spatial locations: The right is good and the left is bad (Clark, 1973; McManus,

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2002). However, people's implicit associations between left–right space and negative–positive emotional valence may not follow these conventions in language and culture. Casasanto (2009) first measured this space–valence association with the "Bob goes to the zoo" task, in which participants are presented with a cartoon character's head, seen from above, with one empty box on his left and another on his right. They were told that the character was planning a trip to the zoo and that he loved pandas and thought they were good, but he hated zebras and thought they were bad (or vice versa, as animal to valence assignment was counterbalanced). Participants were asked to place the good animal in the box corresponding to good things, and the bad animal in the box corresponding to bad things. Results showed that right-handers associated positive ideas with the right, but left-handers showed the opposite association of positive ideas with the left. In other words, at the individual level, "good" is associated with one's more fluent side of space and "bad" is associated with one's less fluent side. These novel findings were consistent with numerous previous studies showing that greater fluency, defined as the subjective ease with which a stimulus can be processed or a task can be performed, leads to more positive evaluations (for reviews, see Reber, Schwarz, & Winkielman, 2004; Oppenheimer, 2008).

To determine whether the experience of asymmetries in motor fluency is sufficient to cause people to associate "good" with their fluent side of space, Casasanto and Chrysikou (2011) asked right-handed participants to perform an asymmetrical manual motor task. Participants stood dominoes on end, arranging them according to a symmetrical pattern on a table top, using both hands simultaneously while wearing a bulky ski glove on one hand (randomly assigned to either the left or right hand). The glove made the task difficult and disfluent with that hand. After this motor training phase, the glove was removed and participants were tested in an oral version of the Bob task. Participants tended to assign the bad animal to the side that corresponded to the gloved hand, demonstrating that asymmetries in hand fluency are sufficient to determine which poles of the lateral spatial continuum are associated with "good" and "bad."

Here, we investigated two possible mechanisms by which changes in motor fluency can cause changes in people's space–valence mappings. Participants in Casasanto and Chrysikou's (2011) experiment had two sources of information from the ski glove task. First, as participants arranged the dominoes, they received visual and kinesthetic feedback: error signals indicating the discrepancy between the intended motor action and the actual action performed (Jeannerod, 2006; Oppenheimer, 2008). The strength of this error signal is presumably increased when people use their nondominant hand, or when their dominant hand is impaired by wearing a ski glove, as these sources of disfluency cause greater discrepancies between the intended actions and the actions performed. Second, independent of the actions performed, participants knew what kinds of outcomes to expect: more fluent and successful outcomes on the side of the dominant (or free) hand, and more disfluent and unsuccessful outcomes (e.g., dominoes knocked over) on the side of the nondominant (or gloved) hand.

A study by de la Fuente, Casasanto, and Santiago (2015) partly disentangled the influences of *experienced fluency* and *expected fluency* on space–valence mappings. Participants observed another person performing the ski glove-domino task, after which they associated "good" with the side of the other person's free hand and "bad" with the side of their gloved hand. This result could not have been due to the kinesthetic experience of motor fluency, as the participants were not acting with their hands, but it could still have been driven either by participants' visual experience of fluent versus disfluent actions, or by their expectations of the fluency versus disfluency they would feel if they were to perform the task themselves.

In this study, we aimed to disentangle the effects of experienced versus expected disfluency on the association between emotional valence and space more definitively, by removing overt action and perceptual feedback altogether. We tested space–valence associations in right-handed participants who only *imagined* carrying out the ski glove-domino task with a gloved right or left hand (Casasanto & Chrysikou, 2011) and compared them with the space–valence associations in participants who actually carried out the task. All participants saw the same materials and received nearly the same instructions. Half of them (the imagery group) only imagined that they were performing the domino task, and the other half (the action group) physically carried out the task. Their implicit space–valence associations were then tested, using an oral version of the Bob task (see Casasanto, 2009, Experiment 3).

As a manipulation check, the time taken to complete the task (either physically or in the imagination) was measured, and the imagination group was also asked to carry out the task physically at the end of the session. If they indeed imagined performing the task during the imagery condition, this mental practice should generate a facilitation of the subsequent physical performance of the same task (Jeannerod, 2006; Morris, Spittle, & Watt, 2005).

In the action group we expected to replicate the results by Casasanto and Chrysikou (2011): Wearing the glove on the left hand would preserve the right-handers' natural good-is-right association, whereas wearing the glove on the right hand would reverse this association. If imagining fluent and disfluent actions is sufficient to modulate people's associations between space and valence, then participants in the imagery condition should show a similar pattern of responses to the participants in the action condition: People who imagine acting fluently on one side of space should associate "good" with that side, whether or not this association accords with their natural handedness. Alternatively, if kinesthetic or perceptual feedback is essential for fluency effects to occur, then the imagery group should differ from the action group.

## 2. Method

### 2.1. Participants

Ninety-six (22 male, average 20.6 years, range 18–45) undergraduate students from the Psychology Department of the University of Granada volunteered to take part in this study. All of them were right-handed, with an average score on the Edinburg Handedness Inventory (EHI; Oldfield, 1971) of 78. They received course credit for their participation.

### 2.2. Design

Each participant was randomly assigned to one task and glove position condition. The same number of participants (24) were assigned to each condition, resulting in a 2 (task: action or imagery training) $\times$ 2 (glove position: left or right) between subjects design. Two dependent variables were measured: the time required to complete the domino task (either physically or imagined) and the space–valence association.

### 2.3. Procedure

Participants were asked to perform the psychomotor task described by Casasanto and Chrysikou (2011, Experiment 2) either physically (action group, $n$ = 48) or in their imagination (imagery group, $n$ = 48). In the action condition they had to arrange 80 dominoes upright on a 120 $\times$ 60 cm$^2$ surface with equally spaced spots painted on it (8 rows $\times$ 10 columns). Participants had to pick up a domino with each hand and place them over two marks simultaneously with both hands, forming rows in a pre-specified order. During the task they wore a bulky ski glove on one hand with the other glove dangling from the same wrist. The other hand had no glove. If one domino fell down, it had to be placed correctly, without using the other hand to help. Half of the participants in the action group wore the glove on the right hand and half on the left hand. In the imagery condition, participants listened to the instructions and had all the elements in front of them (dominoes, surface, and gloves), but they could not touch them. After seeing the materials and listening to the instructions, they were asked to close their eyes and imagine themselves performing the task. They did not talk during imagination. Half of the participants were asked to imagine they were wearing the glove on the left hand and the other on the right hand. All participants, in both the action and imagery groups, were instructed to continue placing dominoes on the dots until all of the spots on the table were filled, and to say "terminado" ("finished") as soon as they completed the task, and at this point the timer was stopped.

After the glove task (either real or imaginary), participants' space–valence associations were measured using the Bob task, adapted from Casasanto (2009, Experiment 3). Participants in the action group removed the glove. All participants were then presented a cartoon character's head, seen from above, with one empty box on his left and another on his right. Participants were told that the character was planning a trip to the zoo and that he loved pandas and thought they were good, but he hated zebras and thought they were bad (or vice versa, as animal to valence assignment was counterbalanced). Participants were asked to place the good animal in the box corresponding to good things, and the bad animal in the box corresponding to bad things. Responses were given orally.

After the Bob task, participants completed the EHI (Oldfield, 1971) to assess their handedness. For the action group, the experiment finished with the EHI. In the imagery group, after the EHI, participants were asked to perform the task physically, wearing the glove on the same hand they had imagined previously. The time required to complete the task was again measured. In a post-experiment debriefing, participants were asked to explain why they made their choice in the Bob task. Finally, they were asked about what they thought was being studied in this experiment. None of them expressed any suspicion that the domino task was expected to influence their performance on the Bob task.

## 3. Results

In order to confirm that the imagery group did perform the manual fluency task in their imagination, we compared the average time required by both groups to complete the task physically (the imagery group did the task physically at the end of the experiment). People are faster in a task if they have previously imagined themselves doing it (Morris et al., 2005). Therefore, the imagery group should be faster than the action group the first time they carried out the task physically. In order to test this prediction, we submitted execution times of both groups to an ANOVA with the factors group (action, imagery) and glove position (right hand, left hand). The action group required on average 8′31″ (*SD* = 1′31″) to complete the task, whereas the imagery group finished the physical task in 6′54″ (*SD* = 1′36″). That is, during their posttest phase the imagery group completed the real ski glove-domino task faster than the action group had completed it during their training phase, as indicated by a statistically significant main effect of group ($F(1, 92) = 25.30$, $MSE = 8{,}869.97$, $p < .001$, $\eta_p^2 = .22$). There were no differences due to position of the glove (glove on right hand: *M* = 6′55″, *SD* = 1′39″; glove on the left hand: *M* = 6′53″, *SD* = 1′34″; $F(1, 92) = 0.00$, $p = .99$, $\eta_p^2 = .00$), and no interaction between group and glove location ($F(1, 92) = 0.01$, $p = .91$, $\eta_p^2 = .00$). The predicted main effect of group provides evidence that the imagery group was, in fact, imagining performing the task.

Regarding the space–valence association, our action group replicated previous results (Casasanto & Chrysikou, 2011; de la Fuente, Casasanto, and Santiago, 2015): Participants who wore the glove on the left hand, thereby preserving their natural right-handedness, produced twice as many good-is-right as good-is-left responses (16 vs. 8). By contrast, wearing the glove on the right hand reversed this pattern: Participants showed a preference to locate the good animal on the left, like natural left-handers (4 vs. 20). The difference between right- and left-hand ski glove groups was statistically significant (Wald $\chi^2 = 12.34$, $df = 1$, $p < .001$, $OR = 2.5$, 95% CI = 1.38–4.52).

The imagery group showed the exact same number of responses of each kind in each condition as the action group: Participants who imagined wearing the glove on the left hand produced 16 good-is-right versus 8 good-is-left responses, whereas participants who imagined wearing the glove on their right hand produced 4 good-is-right versus 20 good-is-left responses. The statistical analysis for the imagery group is therefore identical to the action group, and space–valence associations did not differ between the two groups (Wald $\chi^2 = 0$, $df = 1$, $p = 1$). These results suggest that imagining differential left- and right-hand fluency generates effects on space–valence associations that are indistinguishable from those produced by the actual experience of motor fluency.

## 4. General discussion

Good and bad things can happen anywhere in space, but people tend to associate good things with the side of space where they have more fluent motor experiences, due to asymmetries in dexterity between the left and right hands (Casasanto, 2009; Casasanto & Chrysikou, 2011). Here, we investigated whether the specifics of people's space–valence associations are necessarily determined by the experience of fluent actions, per se, or whether they can also be determined by the expectation of fluency for actions that are never performed. Although right-handers typically map positive ideas onto the right side of space, impairing the right hand during a fine motor task caused right-handers to show the good-is-left mapping typical of left-handers, consistent with previous results (Casasanto & Chrysikou, 2011; de la Fuente, Casasanto, and Santiago, 2015). Remarkably, identical results were obtained when a new group of right-handers were asked to *imagine* having their right hand impaired while imagining performing the same fine motor task. Thus, expecting that actions will be more or less fluent can influence how people spatialize the abstract ideas of "good" and "bad," no matter whether these actions are actually performed or only imagined.

Before discussing the implications of these findings, we first address a potential concern about their relevance to people's implicit associations between space and valence. Prior studies have provided evidence that the Bob task measures *implicit* space–valence associations, even though the response required is an *explicit* judgment (Casasanto, 2009; Casasanto & Chrysikou, 2011; de la Fuente, Casasanto, Román, & Santiago, 2015). First, participants are mostly unable to explain why they made their choices, and their explanations do not reflect the relevant factors. For example, in de la Fuente, Casasanto, Román, et al. (2015), only 2% of participants guessed that handedness was driving their choice. Second, it is unlikely that a short experience of disfluency acting with a ski-gloved hand would change any explicit belief that the participant may have about the relation between left and right and good and bad, but this training experience does change the good–right association in the Bob task (Casasanto & Chrysikou, 2011). Furthermore, results of the Bob task have been conceptually replicated many times in tasks that require no explicit spatialization of positive and negative stimuli (e.g., reaction time [RT] tasks: De la Vega, de Filippis, Lachmair, Dudschig, & Kaup, 2012; De la Vega, Dudschig, Filippis, Lachmair, & Kaup, 2013; Kong, 2013; memory tasks: Brunyé, Gardony, Mahoney, & Taylor, 2012). Finally, dissociations have been found between measures of people's explicitly held beliefs about the spatialization of "good" and "bad" and their implicit associations, as measured by the Bob task (de la Fuente, Casasanto, Román, et al., 2015). Together, these findings suggest that the Bob task (which has been used in 13 published experiments, run in four languages, on three continents) is a valid measure of implicit associations, despite requiring an explicit judgment of space and valence (see Casasanto, 2009; Casasanto & Chrysikou, 2011; de la Fuente, Casasanto, Román, et al. 2015; de la Fuente, Casasanto, & Santiago, 2015; Kominsky & Casasanto, 2013).

The present results show a kind of fluency effect that is, we believe, previously undocumented, and which constrains theorizing about the mechanisms by which fluency influences thoughts and judgments. Most obviously, our study appears to be the first to show that mental imagery, alone, can generate what Winkielman, Schwarz, Fazendeiro, and Reber (2003) called "the hedonic marking of fluency." A few previous fluency effect studies have used imagery, but in all cases that we are aware of participants in the more fluent imagery condition were also responding to more positive stimuli (e.g., a story about a successful vs. unsuccessful person in their field; Mandel, Petrova, & Cialdini, 2006), or to more fluently processed stimuli (e.g., creating mental images based on clear vs. blurry images; Petrova & Cialdini, 2005), or easy versus hard to compare images (Unkelbach, 2006). In the present experiment, imagined fluency was not linked to any stimuli that were more or less positive, or more or less easy to process (i.e., the same glove, the same dominoes, and the same diagram task were used across conditions). Imagined fluency, per se, appears to be responsible for the reversal in participants' space–valence associations in the imagery group.

Looking more closely, this study provides an exception to two generalizations that have been made about fluency effects. First, a variety of effects have been attributed to the discrepancy between participants' *expected fluency* and *experienced fluency*, consistent with the "discrepancy–attribution account" (Whittlesea & Williams, 1998). According to this account, "the mechanism [driving fluency effects] is comparing an initial expectation to an outcome" (Whittlesea & Williams, 1998, p. 158). This mechanism was proposed to explain effects of fluency on feelings of familiarity, but familiarity effects are closely related to effects of fluency on positive versus negative evaluation (see Zajonc, 1968), and similar mechanisms have been applied to fluency effects more broadly (Oppenheimer, 2008). Yet, comparing the fluency of an expected outcome with an actual outcome cannot possibly explain the effects we report here in the imagery group; there were no action outcomes against which participants could compare their expectations.

Second, Alter and Oppenheimer (2008) have argued that, although fluency effects differ from one another in myriad ways, ultimately they are all united by commonalities, such as the conditions under which participants discount the effects of fluency, causing fluency effects to disappear. Specifically, Alter and Oppenheimer (2008, p. 230) suggest that fluency no longer influences participants' judgments when the fluency manipulation is "too heavy handed" and easily noticeable, or when fluency is believed to arise from an irrelevant source. Yet, in this study, the fluency manipulation was extremely heavy handed, in both the action and imagination conditions: Obviously, the glove manipulation would make the task easier on one side than the other. Furthermore, all participants believed the source of fluency/disfluency to be irrelevant to the judgment they made in the Bob task, as indicated by the finding that not a single participant said they suspected a connection between the training and test phases. Even though the source of fluency was (a) noticeable, and (b) ostensibly irrelevant, participants did not discount the ski glove manipulation, which affected space–valence mappings as predicted. Alter and Oppenheimer (2008, p. 230) argued that discounting fluency under the circumstances that they describe provides evidence for "a common mechanism underpinning [all] effects of fluency on judgment," though this common mechanism was never articulated beyond the suggestion that fluency serves as a "metacognitive cue."

Given that the present effects do not conform to the expected pattern of discounting, and cannot be explained by a discrepancy–attribution account, we suggest that there is likely to be more than one mechanism by which fluency (e.g., perceptual, conceptual, linguistic, or motoric fluency) can give rise to the numerous different effects that have been attributed to fluent versus disfluent processing (e.g., effects on evaluation, familiarity, recognition, fame attribution, truthiness, or typicality; see Alter & Oppenheimer, 2008; Reber et al., 2004). Trying to explain the current results (and others) in terms of a single unified mechanism for all fluency effects brings to mind an aphorism attributed to Albert Einstein: Explanations should be as simple as possible, but no simpler.

This study suggests one factor that could, in principle, contribute to many if not all fluency effects: expectations of fluency (whether or not those expectations were met or violated; cf., Whittlesea & Williams, 1998). Presumably, in experiments where participants *experienced* a particular level of fluency, they also *expected* some level of fluency, at least unconsciously. When experiments induce both expected and experienced fluency, it is difficult to isolate the role of expectations. In the present experiment, the role of expectations is easier to observe because the imagery group had expected fluency only. The finding that space–valence effects were modulated just as strongly by expected fluency as by experienced fluency supports a surprising inference: It appears that expectations were entirely responsible for the observed effects, and experienced fluency added nothing. This inference is also supported by the results of our previous study comparing participants who performed the ski glove-domino task (actors) with participants who only observed someone else performing the task (observers). The effects of performing and observing the ski glove-domino task were nearly identical (de la Fuente, Casasanto, & Santiago, 2015). If the experience of fluency were driving these effects, we should find that space–valence mappings are modulated most strongly by actually performing the motor task, less strongly by watching someone else perform the task (in which case participants had perceptual but not kinematic experience), and least strongly of all by just imagining the task (in which case participants had neither perceptual nor kinematic experience). If expectations of fluency were driving the effects, however, this provides a potential explanation for the consistency of our results across the performed, perceived, and imagined versions of the ski glove-domino task: Overall, the pattern of results suggests that participants generated the same expectations of fluency across tasks, regardless of the strength (or presence) of perceptual or kinematic feedback.

Is it possible to explain the present results without invoking fluency at all? We consider two possibilities. First, could people associate "good" with the side of space to which they devote more (or less) attention? Outside of the laboratory, presumably people act upon the world most frequently with their dominant hand, often on their dominant side of space; it would be sensible, therefore, for people to devote more attention to their dominant side of space. Could this attentional asymmetry explain people's association of "good" with one side of space? The results of the ski glove-domino tasks militate against this possibility. While performing this task, participants spend the majority of their time looking at the side of their gloved hand. Thus, in this task, people direct their attention more often to their “bad” side of space, but ordinarily people direct attention more often to their “good” side of space. Asymmetries in fluency explain the pattern of results across the various Bob experiments, but asymmetries in attention do not.

Alternatively, in principle, it is possible that participants in the ski glove task were influenced by the *outcomes* of the domino task, rather than the fluency with which the outcomes were produced. That is, more dominoes were fumbled on the side of the gloved hand than on the side of the free hand; this pattern was easy to experience, to observe, and presumably to imagine. Could participants have come to associate “bad” with the side of space on which bad outcomes occurred, unmediated by fluency (real or imagined)? We cannot rule out this possibility, but parsimony militates against it because a “purely spatial” account seems unlikely to explain natural space–valence associations beyond the laboratory; therefore, different explanations would be needed for the very similar Bob task results observed in natural right- and left-handers and in laboratory-trained participants. Constructing space–valence associations on the basis of the side on which good and bad outcomes occur may seem plausible in the laboratory, but it is less plausible in the real world. Outside of the laboratory, it is not the case that bad things happen more often on one side of egocentric space than the other, in general. Considering only self-produced actions, it is possible that more negative outcomes occur on the nondominant side, when people use their nondominant hand, but ordinarily people avoid using their less fluent hand for fine motor tasks: Expectations typically drive people to use the more dexterous hand for tasks that require dexterity, thus “bad” outcomes tend to be avoided. A given action may *feel* less fluent if performed with the nondominant versus the dominant hand, even though the outcome is essentially the same.

It remains an open question, however, whether people could form (or modify) a generalizable space–valence mapping based only on the locations of positive and negative things in space. Casasanto (2011, 2014) has argued that there may be nothing special, mechanistically, about the way motor experience shapes space–valence associations. Hand actions may play a privileged role in determining spatial conceptions of “good” and “bad” simply because they provide systematically different experiences of fluency (and perhaps of positive vs. negative outcomes) on the right and left sides of space. It is difficult to find other sources of valenced experiences that differ systematically between the left and the right sides of egocentric space; therefore, acting in the world with our hands plays a crucial role in establishing and modifying space–valence mappings. It is easy to imagine artificially imposed conditions that would systematically link good–bad and left–right without any motor processing, real or imagined, but the effects of such purely spatial manipulations have yet to be tested.

Beyond their theoretical implications for theories of space–valence associations and of fluency effects, the present findings may have practical implications, as well. The people and objects we encounter in our everyday lives often happen to be located on our right or left, and the incidental locations of things in our environment can influence how we feel about them. When shown pairs of alien creatures on a page and asked to judge which looked more honest, intelligent, or attractive, right-handed participants tended to prefer the creature on the right, whereas left-handers tended to prefer the one on the left (Casasanto, 2009, Experiment 4). When asked to decide which of two products to buy, or which of two job candidates to hire, righties and lefties tended to indicate that they would buy the product or hire the person described on their dominant side of a page (Casasanto, 2009, Experiment 5). Beyond the laboratory, participants in a large-scale simulated election showed similar biases: Left-handers were about 15 percentage points more likely than right-handers to vote for the candidate they saw listed on the left of a simulated ballot (Kim, Krosnick, & Casasanto, 2015). If just imagining acting more fluently with one hand or the other can completely reverse space–valence associations in the laboratory, perhaps motor imagery can influence real-world decisions about what to buy, who to trust, or whom to vote for, in previously unimagined ways.

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