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Original Articles

Left is “good”: Observed action affects the association between horizontal space and affective valence

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ABSTRACT

According to the body-specificity hypothesis, people will associate positive and negative emotional valence with the relative fluency of the left or right responding hand. Prior studies have shown that temporary changes in the fluency of the responding hand can influence the association of emotional valence with left or right, even under circumstances of action observation. But the reason why this change occurs is still controversial. The purpose of the present study was to replicate this finding and to identify the underlying mechanism. Experiment 1 duplicated a modified paradigm “Bob goes to the zoo” to verify the existence of space-valence association for Chinese right–handers. The results indicated that they had the same pattern of right-good/left-bad. However, after action training and observation in Experiment 2 that reduced the fluency of the right hand temporarily, both actors’ and observers’ space-valence associations were reversed as well. However, when observers’ potential motor capacities were constrained by binding their responding hands behind them (Experiment 3) or in front of them (Experiment 4), the observers associated the positive affect with their dominant right hand instead of the left hand in Experiment 3, whereas the observers in Experiment 4 still showed the same association pattern as the actors and the observers in Experiment 2. This study provides further evidence that the effect of alternative motor fluency on space-valence association in the observer is mainly modulated by the connection between the outcomes and space, with body posture also influencing the association.

1. Introduction

In Chinese traditional culture, the concept of right-left horizontal space possesses abundant connotations, which represent good-bad emotional valence and the level of power, as well as location. The same expression occurs in English, such as, “right” also has the meaning of “correct”. Why do people employ right-left space to express positive-negative emotion? Wilson and Nisbett (1978) found that the position of pantyhose stockings had a significant influence on participants’ evaluations when they were asked to choose which of four identical stockings was of the best quality. Participants chose a stocking in one of the two right positions more often than a stocking in one of the two left positions. Natale, Gur, and Gur (1983) found similarly that participants gave more positive evaluations for faces presented on the right side of a screen rather than the left. These results indicated that the association between right-left space and emotional valence could appear not only in language expression, but also in the process of cognitive selection and judgment. The phenomenon of associating right space with positive valence and the left space with negative valence is called mapping from spatial location to *emotional valence* (Casasanto, 2009).

Subsequent studies imply that space-valence mapping takes on the character of body specificity. Casasanto (2009) used different types of experimental materials to study the association of space-valence, finding that for several kinds of materials, right-handed and left-handed persons made the opposite choice: The right-handers revealed a right-good and left-bad pattern, whereas the left-handers preferred the left-good and right-bad mapping. These relations were found in other studies employing different paradigms. Kong (2013) engaged left- and right-handed Chinese college students to judge emotional words (Experiment 1) and emotional pictures (Experiment 2) as positive or negative with a left or right keypress. Right-handers responded more quickly with the mapping of positive words or pictures to the right key and negative ones to the left key than with the alternative mapping, but left-handers showed the opposite result pattern. de la Vega, Dudschig, De Filippis, Lachmair, and Kaup (2013) had participants cross their hands on the keyboard and then judge the positive-negative valence of

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words presented in the middle of the screen. Their results provided evidence that the valence was associated with the responding hand instead of response position.

Based on results of the type just described, researchers have proposed the *body specificity hypothesis* (Casasanto, 2009). This hypothesis argues that the body and its interaction with the outside world play a crucial role in cognition. Especially, the hypothesis emphasizes that physical experience and the motor-sensory system have profound effects on cognitive processing. One of the main body specificities is handedness as right-handers and left-handers interact with the environment in different ways. When people experience motor fluency from their activities, the fluency originates mainly from the dominant hand and dominant side of the body. Prior studies provided results consistent with the view that individuals generate more positive feelings and evaluations when they gain smooth motor experience in the process of interacting with stimuli (Jasmin & Casasanto, 2012; Milhau, Brouillet, Dru, Coello, & Brouillet, 2017; Oppenheimer, 2008). Right-handers tend to associate right space with positive valence, whereas left-handers link left space to positive valence (Casasanto & Henetz, 2012; de la Fuente, Casasanto, Román, & Santiago, 2015; de la Vega et al., 2013; Kong, 2013).

According to the body specificity hypothesis, because fluency of the dominant hand is a key factor influencing the association of space-valence, if the individual's fluency changes, the space-valence mapping should change. Casasanto and Chrysikou (2011) selected patients who had a hemiplegia caused by stroke as the participants. Those with left hemiplegia (100%) placed an animal identified as "good" in a right box and one identified as "bad" in a left box. To the contrary, those with right hemiplegia (88%) preferred to place the good animal in the left box, just like a typical left-hander. In Casasanto and Chrysikou's experiment, the right hand of right hemiplegia patients was impaired, and the left hand experience was more fluent than that of the right hand. Later, Casasanto and Chrysikou employed a psychomotor task where right-handed participants were required to wear a bulky ski glove on their right or left hand and place dominoes on a special table as quickly as possible for 12 min to induce a temporal asymmetry in motor fluency. The results showed that most of those whose left hand was impeded still placed the good animal in the right box, whereas participants whose right hand was impeded assigned the good animal to the left box, just like people who are naturally left-handed do. In that experiment, part of the participants' right hand was temporarily impaired, and the left hand experience was more fluent than that of the right hand.

Subsequently, de la Fuente, Casasanto, Martínez-Cascales, and Santiago (2017) asked participants to imagine that the motor ability of one of their hands was weakened in an exercise task. Right-handed participants showed an atypical left-is-good pattern when they imagined their right hand was impaired. This result suggests that just the expected fluency and disfluency can change the implicit association between space and emotional valence. It provides further evidence consistent with the hypothesis that motor fluency has a critical role in spatial valence mapping, even if it is only perceived, or expected, fluency. Based on these findings, we anticipated that a manipulation that changes the hand fluency temporarily by using a psychomotor task (Casasanto & Chrysikou, 2011) could clarify why this temporary change occurs, so it was employed in our study.

As the research on space-valence association went even further, researchers found that action training was not the only way to change hand fluency: Just observing the movements of the actors had a similar effect. de la Fuente, Casasanto, and Santiago (2015) recruited right-handers who were randomly divided into two pairs, an actor and an observer. There were two stages in this experiment: First, the actor completed the motor task described by Casasanto and Chrysikou (2011), which makes the right-handers turn into left-handers for the moment. In this process, the observer was told to observe the operation of the actor carefully. Second, the actor and observer finished the task of space-valence judgments. The results showed that the space-valence mappings of both the observers and actors were inverted, providing evidence that the mapping of participants could be changed by observing the actions of others, even without the direct experience of the action training.

The cause of the change of space-valence pattern during action observation is still controversial. Studies of mirror neurons in neurobiology have provided ideas for the mechanism of action perception and execution matching in action observation and observational learning. Based on this, Gallese (2005) proposed embodied simulation theory, which is built on the mirror mechanism. According to this theory, individuals have knowledge of self and of others' motor experience, and the mirror neuron mechanism matches the two kinds of motor experience with a pairing process. Gallese (2014) hypothesizes that embodied simulation is a system that includes and unifies multiple higher social cognitive functions. People not only can intuitively perceive others' actions and emotional feelings by action observation, motor simulation and imagination, but also arouse individual experience and the internal representation of physical state related to this, making the observer have resonance with the actor. This simulation is thought to be an unconscious, pre-reflective process of the mirror-neuron system (Gallese, 2014), and seems to be highly automatic (de la Fuente et al., 2015). An alternative possibility is that participants observe the space in which the consequence of a response happens, and then link the positive evaluation with the space with a positive result and negative evaluation with the space with a negative result, which influences their own tasks.

Brouillet, Milhau, and Brouillet (2015) adopted a modified version of a "Bob goes to the zoo" task, which was first employed to measure the space-valence association by Casasanto (2009) and has been shown to gage implicit associations of space-valence (de la Fuente et al., 2015). Brouillet et al. found that the consequence of action execution had a significant influence on the space-valence mapping. They set the left and right positions in a special way where participants would place pictures, with one position having a stable support and the other being unstable and on the verge of collapse. The results showed that participants preferred to allot good picture versus bad picture in the more stable position, regardless of whether this position was on the side of their dominant hand. Consequently, we sought to distinguish whether embodied simulation or the association of space and behavioral outcome causes the reversal of the space-valence pattern during action observation.

A study of Iani, Rubichi, Ferraro, Nicoletti, and Gallese (2013) provides a new perspective for clarifying the underlying mechanism of the space-valence association under action observation. They used a transfer of learning paradigm to study the occurrence conditions of observational learning, in which participants were asked to observe the effect of computer-generated responses of a task with a spatially incompatible mapping and then to perform a Simon task, for which stimulus location was irrelevant. Typically, the Simon task yields a spatial correspondence effect, called the Simon effect, with faster responses when the stimulus location corresponds with the location of response than when it does not (Lu & Proctor, 1995). When an incompatibly mapped spatial task is performed prior to the Simon task, the Simon effect is eliminated or reversed to favor the incompatible mapping (Proctor & Lu, 1999). In Iani et al.'s Experiment 1, observation of the incompatibly mapped spatial task eliminated the Simon effect on the subsequent task. But when participants' hands were tied during observation of the incompatible spatial task in Experiment 2, the Simon effect was evident. This result suggests that observational learning did not happen when the hands were tied and the potential motor capacity of the observer was restricted.

Similar results were shown in a study of Song, Li, Yang, and You (2018) that explored observational learning under conditions in which the participants' hands were tied in front of them (Experiments 2) and observational learning disappeared. As a result, we assume that when observers' hands are tied in front of or behind them during observation, the observers cannot conduct embodied simulation. In that case, the observers' and actors' space-valence mappings should dissociate, which would illustrate that embodied simulation may be the main mechanism for space-valence association under the observation situation. Alternatively, if tying the observers' hands does not affect their observation of the execution result of the action, and they can still connect space with affective valence according to the results of movement, then the association pattern should be the same as that of the actors.

We conducted four experiments to explore the mechanism of the association between horizontal space and affective valence. Experiment 1 was designed to show Chinese right-handers' connecting pattern for horizontal space and affective valence via a culturally appropriate modification of the Bob goes to the zoo task. In Experiment 2, a motor task, for which half of the participants assigned dominoes in the designated area while the other half of the participants observed the performers' movements, was employed to verify the critical role of motor fluency in space-valence association. If the reversal of space-valence connecting pattern occurs for observation as well as action training, observers should behave in the same way as the performers. Experiments 3 and 4 were aimed at disentangling possible bases of the effects on the association between emotional valence and space by tying observers' hands, to the back or front, respectively, when they observed the motion of actors. If the results for observers in Experiment 2 were a matter of imagining the movements according to observing the consequence of response, the same results should be obtained in Experiment 3 and 4. However, if potential motor capacity is the critical factor, as proposed by the embodied simulation theory, tying the hands should inhibit motor simulation and there should be a separation between the actor and the observer's space-valence mapping.

2. Experiment 1

There are many studies on the effect of association between vertical space and valence in China, but the number of studies that focused on horizontal space and valence is small and only used reaction-time tasks (Kong, 2013; Li, 2014; Yan, 2015). To verify and measure the affective valence pattern in horizontal physical space, a modified version of the "Bob goes to the zoo" task was employed. Participants were directed to complete a task in which they chose to place good and bad animals in the left and right boxes of a chart freely.

2.1. Method

2.1.1. Participants

A total of 110 students (80 women, 30 men) were recruited for credits toward a course requirement or gifts, age ranging from 18 to 26 years (M = 21.5 years). Handedness was assessed prior to the experiment using the Edinburgh Handedness Inventory (EHI; Oldfield, 1971), for which a positive score indicates dominance of the right hand, with the maximum value being 100. The data of one left-handed person with a score of 20 were excluded; the remaining participants were right-handed, with an average score of 67 ($\geq$40 means right-handed). The study was approved by the research ethics board at Shaanxi Normal University; all participants signed consent forms and agreed to participate in this study. They were healthy, with normal or corrected-to-normal vision, and naïve to the purpose of the study.

2.1.2. Materials

The experimental task was based on the "Bob goes to the zoo" task (Casasanto, 2009). To be more suitable for Chinese citizens, the name was changed to "Xiao Ming goes to the zoo". Casasanto (2009) used zebra and panda as the chosen objects, however, preliminary evaluation of the experimental materials showed that the liking of the panda was significantly higher than the zebra for Chinese undergraduates. As a result, we chose zebra and giraffe, for which the level of liking and familiarity are similar.

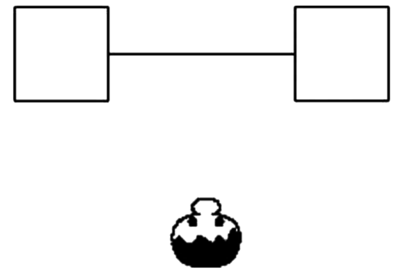

Fig. 1. Schematic diagram of "Xiao Ming goes to the zoo" task.

2.1.3. Procedure

Participants completed the "Xiao Ming goes to the zoo" task: Firstly, a picture was presented. In the picture, there was a cartoon character called Xiao Ming. In front of Xiao Ming, two boxes respectively located to the right and left of the middle point (see Fig. 1). The task scenario was that Xiao Ming planned to visit the zoo. The instruction indicated that Xiao Ming thought the zebra was friendly and good, but the giraffe was unfriendly and bad. The participants needed to choose the left or right box to assign one of the animals from the perspective of Xiao Ming and write their name in the box, and then write the name of the other animal in the other box.

To eliminate the influence of the animal preference and the order of questions, animal-to-valence assignment was counterbalanced: Half of the participants were told zebra was unfriendly and the giraffe was friendly, and half the opposite. Moreover, half of the participants were asked to assign the good animal first and the other half to assign the bad animal first. Referring to previous studies, when the test was finished, participants answered three questions to determine whether they knew the association between the task and the hand habit: (1) Why did you make such a choice? (2) Do you think your hand habit would affect your choice? (3) What do you think the task is testing?

2.2. Results

All participants showed the correct understanding of the experimental instructions, and completed the paper and pencil test and the EHI. The results of the final questions indicated that the participants were not aware of the purpose of the experiment. The raw data for all experiments are included in Song, Yi, Zhang, and Proctor (2019).

The result showed that 70.6% (77/109) of the participants chose the right box in which to place the good animal, and only 29.4% (32/109) placed the bad animal in the right box. A sign test indicated that this difference was significant, with the good animal being arranged in the right box more often than the bad animal, 77 vs. 32, Z = 4.21, p < 0.001, see Fig. 3.

Previous studies have shown that horizontal space is associated with temporal order (Clark, 1973; Dehaene, Bossini, & Giraux, 1993), so it is necessary to analyze the effect of the order with which the animals were assigned first. A total of 55 participants assigned the good animal first, and the rest of the participants (54) assigned the bad animal first. 69% of the right-handed participants located the good animal in the right box when they were directed to assign that animal first. If they were told to locate the bad animal first, 72% participants chose the right box to locate the good animal when they assigned it second. Order was used as the independent variable and the association of space-valence (good-is-right/bad-is-left) as the dependent variable. Binary logistic regression was conducted on the difference. The result showed that the placement order had no effect on the association of space-valence, p = 0.995.

2.3. Discussion

The results showed the right-is-good/left-is-bad spatial pattern for Chinese undergraduates, demonstrating the association between the space and the valence in the modified spatial affective valence judgment task. This association is implicit in the sense that none of the participants were able to explain why they made this choice, and no one considered that their hand habits or the fluency of their movements can be linked to the choice. This result is consistent with several prior studies (Casasanto & Henetz, 2012; Casasanto, 2009; de la Fuente et al., 2015), indicating that the finding that handedness creates a preference for choice between horizontal space and emotional valence generalizes to a Chinese sample. Individuals are used to associating their good objects with the dominant hand or the fluent side and the bad items with the subordinate hand or the non-fluent side.

3. Experiment 2

Previous studies have shown that individuals associate positive valence with the dominant hand and negative valence with the non-dominant hand. This relation was verified in Experiment 1 via the "Xiao Ming goes to the zoo" task, which establishes that it is valid to test the relationship between space and valence for Chinese undergraduates. Because of the different motor fluency of the two hands, the more fluent experience of the side of body is hypothesized to lead to a more positive experience. Then the effect of fluent experience on affective valence judgment is based on the impact of people's innate physical structure, forming a difference between the right and the left hand, or manual motor fluency temporarily changing.

Additionally, observational learning theory holds that people can learn not only directly by acting on the environment itself, but also indirectly by observing other people's behaviors (Bandura & Walters, 1977). So, it predicts that the association of space-valence should be changed when participants observe others' actions for which motor fluency is altered temporarily. Experiment 2 was designed on the basis of the results of Experiment 1 to provide evidence regarding the mechanism of the change and generation of the space-valence association.

3.1. Method

3.1.1. Participants

A total of 110 new students (76 women, 34 men, mean age 18.5 years, range 18–20) from the same subject pool as in Experiment 1 participated. Handedness values on the EHI were $M = 70$, the entire participants were right-handed, and also naïve to the purpose of the study. They reported having normal or corrected-to-normal vision.

3.1.2. Materials and procedure

The pictures were the same materials used in the previous experiment. The 110 participants were randomly divided into two groups: one was the actor and the other was the observer, forming 55 pairs in total. The experiment procedure included two stages, an action training or observation phase and a paper and pencil test phase. Actors performed the task used in Casasanto et al.'s (2011) Experiment 2, and observers performed the task used in de la Fuente et al.'s Experiment 1.

In the action training or observation phase, the actors and observers were individually told instructions. Actors were informed that the task was a measure of motor coordination. The task goal was to complete the arrangement of dominoes as soon as possible within 12 min; the task was performed on the table which was approximately 120 cm × 60 cm with 72 slots. To trigger an asymmetrical movement experience of the hands, actors were required to wear a thick ski glove on the right hand; another glove hung on the wrist of the right hand. Actors were directed to take the dominoes from the middle of the table, each hand took one, and arrange the dominoes in a symmetrical position on the table. If a domino fell, the actors had to right it by the corresponding hand. Moreover, they could not use their left hand to help the right hand, or to hold the hanging glove to prevent it from hitting the domino.

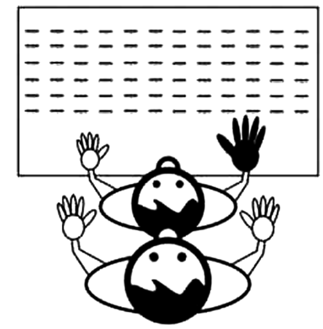

Fig. 2. The operation diagram of the observer and the actor.

When the actors were seated at the table to complete the task, the observers were standing 20 cm behind the actors. At this point, the hands of observers were placed in front of the body with freedom (see Fig. 2). To ensure that the observers focused attention on observing the movements of the actors, the experimenter told the observers to record the number of mistakes that actors made in the task and that the number must be consistent with the experimenter's record. In the test phase, the gloves were removed from the actors' hands, and the actors and observers were taken to another room to separately complete the task of "Xiao Ming goes to the zoo". As in Experiment 1, preference of animals and the order of placement was counterbalanced. We also questioned to determine whether participants knew the purpose of the experiment.

3.2. Results

All participants showed correct understanding of the experimental instructions, and completed the paper and pencil test and the EHI. The results of the handedness questionnaire showed that all the participants were right-handed, so the data of 110 participants were analyzed. Moreover, participants were unaware of the purpose of the experiment or the relation between the action training and test phases.

For actors, 65.5% (36/55) of right-handers located the good animals in the left box and 34.5% (19/55) in the right box, which by sign test is a significant difference, 36 vs. 19, $Z = 2.16$, $p = 0.03$, see Fig. 3. To eliminate the effect of the order, we compared the number of participants who located the bad animal in the right box when told to locate the good animal first (20) or the bad animal first (16). There was not a significant difference, $p = 0.68$, indicating that the placement order had little influence on the association of space-valence.

For observers, 67.3% (37/55) of the right-handed people located the good animal in the left box, and only 32.7% (18/55) located it in the right box. A sign test again showed a significant difference, 37 vs. 18, $Z = 2.56$, $p = 0.01$, see Fig. 3: The good animal was placed in the left box significantly more often than in the right box. Similarly, we compared the two orders to locate the animals, and the difference was not significant, 20 vs. 17, $p = 0.72$.

This contrast compared the result of space-valence judgment between actors and observers via binary logistic regression. There was no significant difference between the actor and the observer in the dislike-right/liking-left choice, Wald = 0.04, df = 1, $p = 0.84$, see Fig. 3. Both the actors and observers were more likely to connect the good animal to the left and the bad animal to the right.

Finally, a combined analysis of Experiments 1 and 2 was conducted to compare the difference of left-good preference between the participants (right-handers) who did not participate in the action training in Experiment 1 and actors (right-handers) in Experiment 2. The results showed a significant difference, with more actors placing the good animal in the left box in Experiment 2 than did participants in the

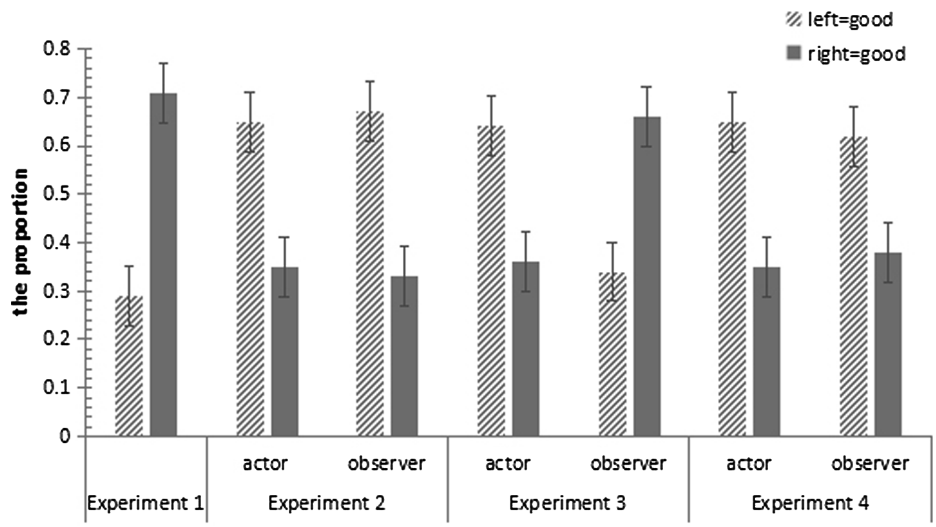

Fig. 3. Experiments 1, 2, 3 and 4: The proportion of participants who allotted the good animal to the right box and the bad animal to the left box in each Experiment. Error bars represent the ± 1 standard error of the mean, computed using the method for within-subjects designs (Cousineau, 2005).

baseline condition from Experiment 1, *Wald* = 18.47, df = 1, $p < 0.001$, OR = 0.22, 95%CI = 0.11–0.44, see Fig. 3.

3.3. Discussion

In Experiment 2, the fluency of the right hand was quashed by wearing a glove, rendering the left hand without a glove the more fluent of the two hands. The short training made right-handed actors become left-handed temporarily. Actors placed more good animals in the left box and bad animals in the right box, just like the left-handers performed in previous studies (Casasanto & Henetz, 2012; de la Fuente et al., 2015; de la Vega et al., 2013; Kong, 2013; Milhau, Brouillet, & Brouillet, 2015). These results highlight the potential of cognition's plasticity. 12 min is less than 20 years of experience of right-hand fluency, however this short experience changes the cognitive processes of space-valence association. This result implies that changing the way people use their hands can alter people's processes mapping abstract concepts to left and right space; Compared to the results of Experiment 1, more actors chose to place the good animal in the side of left hand which did not wear the glove. That is, the pattern changed from "right-good" to "left-good". The results above indicate that motor fluency plays a role in the space-valence association.

Although observers did not experience direct action training, their choices did not differ significantly from those of the actors, with the good animal being placed more in the left box. The results of Experiment 2 agree with those of Casasanto and Chrysikou (2011). The similar selections of the actors and observers are consistent with the view that the implicit association of space-valence can be changed rapidly by transforming the fluency of the hand, no matter whether the asymmetrical motor fluency is caused via brief training or action observation.

4. Experiment 3

In Experiment 2, the pattern of right-handed actors was inverted because of temporary changes in the relative fluencies of the hands, supporting that motor fluency has a profound influence on space-valence association. However, the observers produced a similar choice preference after a brief observation. There are two possible reasons to explain the phenomenon. Firstly, in the training stage, the observer implicitly imitates the behavior of the actor and then deduces the action of the actor. Second, the observer may connect the negative result (clumsiness, messy arrangement) acquiring in the observation with right space, and the positive result (smooth movement, neatly arrangement) with left space, and then carry through the emotional valence judgment. A further experiment was required to distinguish the two different explanations.

By reviewing the previous research on observational learning, evidence can be found suggesting that an observer's motor ability is essential for the processing of others' movements and action results. When an observer's own specific ability to act is constrained, actions of others cannot be processed most efficiently (Ambrosini, Sinigaglia, & Costantini, 2012). Iani et al. (2013) found evidence that in a perceptual-motor task, the effect of observational learning depends on whether the observer's potential motor ability is limited during the stage of action observation. If the ability was limited, the observer would be unable to simulate the movements of the actor, which is presumed to result in the disappearance of action observation. Therefore, if the observer's hands are tied, then the observer should relate the positive valence to her or his own dominant hand, suggesting that the spatial emotional valence association generated by action observation is due to body simulation. Otherwise, if the observer relates the positive valence to his or her non-dominant hand, meaning that the observer will connect the negative result acquiring in the observation with right space, then left-good pattern will occur.

4.1. Method

4.1.1. Participants

A total of 112 new students (80 women, 32 men, average 20 years, range 19–21) from the same subject pool as in Experiments 1 and 2 participated this experiment. All participants finished the EHI to test the hand preference. Handedness values on the EHI were $M = 70$; all participants were right-handed and naïve to the purpose of the study. They reported having healthy and normal vision or corrected-to-normal vision and had not participated in Experiment 1 or 2.

4.1.2. Materials and procedure

The pictures were the same as used in the previous experiments. The experimental procedure was similar to that of Experiment 2, the only difference being that in Experiment 3 the observer's hands were bound and placed behind them prior to observing the motion of the actor.

4.2. Results

All participants were directed to finish the action observation or action training, showing the correct understanding of the experimental instructions, and completed the paper and pencil test and the EHI. The results of the hand questionnaire indicated that all the participants were right-handed, so the data of 112 participants were analyzed. Moreover, participants were not aware of the purpose of the experiment, and the correlation between the action training and the test phase.

For actors, 64.3% (36/56) of right-handers allotted the good animals versus bad animals in the left box; only 35.7% (20/56) of right-handers distributed good animals in the right box. There was a significant difference, 36 vs. 20, $Z = 2.14$, $p = 0.04$, see Fig. 3. To rule out the effect of sequence, we contrasted the number of participants who allotted the bad animal to the right in two sets, placing bad animal first or good animal. There was no significant difference, 20 vs. 16, $p = 0.52$.

Observers chose the right box to distribute the good animal (66.1%) more than the bad animal (33.9%), 37 vs. 19, $Z = 2.41$, $p = 0.02$, see Fig. 3. We also analyzed sequence effect and found the same pattern of result that the placement order had no influence on the association of space-valence, 20 vs. 17, $p = 0.72$.

We also analyzed whether the judgment of affective valence differed between the actors and observers. A binary logistic regression showed that there was a significant difference between the actors and the observers in the choice of the right-good, the observer's preference for the right-good was greater than the actor's, Wald = 9.99, df = 1, $p = 0.002$, OR = 3.51, 95%CI = 1.61–7.63, see Fig. 3.

To further clarify the influence of hands bound on action observation and the space-valence binding, we also analyzed the difference of right-good preference between observers in Experiments 2 and 3. We found there was a significant difference, with higher proportion of observers in Experiment 3 allotting good animal in the right box, Wald = 11.86, df = 1, $p = 0.001$, OR = 4.00, 95%CI = 1.82–8.82, see Fig. 3.

4.3. Discussion

In Experiment 3, the state of the observers' hands was changed when they observed the actors moving the dominoes, as in Experiment 2. The observers' hands were tied and placed behind them, which would limit the ability to mimic the motor actions of the actor. The results showed that more of the actors put the good animal on the left versus the bad animal, consistent with the results of Experiment 2. It was verified again that the glove manipulation, which changes the fluency in short-term action training, caused a reversal of the typical spatial affective valence pattern.

However, the association pattern of the actors and observers in Experiment 3 differed, and most observers put the good animals in the right box, which aligned with the manifestation of right-handed participants. There was also a significant difference between observers in Experiments 2 and 3, with the good animal being placed in the right box more often in Experiment 3, when the hands were bound, than in Experiment 2, when they were not. Because tying the hands behind the back limited simulation of the actor's movements, the results provide evidence in agreement with the hypothesis that such simulation is essential for the observer's placement pattern to mimic that of the actor.

5. Experiment 4

If restricting implicit embodied simulation is the reason for the observer's reversal pattern relative to the actor to occur, then tying the hands behind the back or in front of the observer should have the same reversal of turning observed left-good into right-good. However, tying the hands behind the back in Experiment 3 simultaneously changes at least one other factor compared to Experiment 2. In addition to the restricted hand movements associated with tying the hands behind the back, the body posture of placing the hands behind the back may itself influence emotional response and cognitive processes. There is an antero-posterior space-valence association with forward-good and back-bad (Hao, Xue, Yuan, Wang, & Runco, 2017; Harmon-Jones & Peterson, 2009; Harmon-Jones, Price, & Harmon-Jones, 2015; Price, Dieckman, & Harmon-Jones, 2012; Veenstra, Schneider, & Koole, 2016), and, as shown by these studies, when location of the hands relative to the body changes, the cognitive processes may differ.

Also, according to the polarity correspondence principle proposed by Proctor and Cho (2006), when the polarities of the stimulus (+ or −) and the response (+ or −) are coded the same, there would be a positive facilitation effect. Lakens (2011, 2012) adds that stimulus valence is a vital dimension of categorization tasks. People would encode the positive valence as "+" polarity, negative valence as "−" polarity. As predicted by this principle, when individuals have their hands behind them, the location of back is "−" and forward is "+". If participants integrate the "−" with what they observe (positive outcomes in left space and negative outcomes in right space), this would also lead to the separation of the observer from actor in Experiment 3, with participants more likely to give a more positive evaluation to the right. So tying participants' hands behind them cannot distinguish embodied simulation from the account of outcomes and space connection. In Experiment 4, therefore, we tied the hands in front of the observer to evaluate the possible effect of front and back body location on the association of horizontal space with valence.

5.1. Method

5.1.1. Participants

A total of 110 new students (82 women, 28 men, average 19 years, range 18–22) from the same subject pool as in Experiments 1, 2 and 3 participated in this experiment. All participants finished the EHI to test the hand preference. Handedness values on the EHI were $M = 72$; three observers scored below 40, their test results were excluded from the analysis, participants were right-handed ($M = 74$) and naïve to the purpose of the study. They reported having healthy and normal vision or corrected-to-normal vision and had not participated in Experiment 1, 2 or 3.

5.1.2. Materials and procedure

The pictures were the same as used in the previous experiments. The experimental procedure was similar to that of Experiments 2 and 3, the only difference being that in Experiment 4 the observers' hands were bound and placed in front of them to clarify the confused isolate the influence of binding the hands from the body posture of having the hands behind the back.

5.2. Results

All participants were directed to finish the action observation or action training, showing the correct understanding of the experimental instructions, and completed the paper and pencil test and the EHI (Oldfield, 1971). Only results of right-handed participants (55 actors and 52 observers) were analyzed. Moreover, participants were not aware of the purpose of the experiment, and the correlation between the action training and the test phase.

For actors, 65.5% (36/55) of right-handers allotted the good animals in the left box; only 34.5% (19/55) of right-handers distributed good animals in the right box. This difference was significant, 36 vs. 19, $Z = 2.16$, $p = 0.031$, see Fig. 3. To rule out the effect of sequence, we contrasted the number of participants who allotted the bad animal to the right in two sets, placing the bad or good animal first. There was no significant difference, 20 vs. 16, $p = 0.52$.

Observers chose the right box to distribute the bad animal (63.5%) more than the good animal (36.5%), but it did not quite attain statistical significance, 33 vs. 19, $Z = 1.80$, $p = 0.07$, see Fig. 3. We found a similar pattern of results for the sequence effect: Placement order had no influence on the association of space-valence, 15 vs. 18, $p = 0.73$.

We also analyzed whether the judgment of affective valence differed between the actors and observers. A binary logistic regression showed no significant difference between the actors and the observers in the choice of the right-good, *Wald* = 0.05, df = 1, $p = 0.83$, see Fig. 3.

To further clarify the influence of hands bound on action observation and the space-valence binding, we analyzed the difference of right-good preference between observers in Experiments 2 and 4, and in Experiments 3 and 4. We found there was no significant difference between observers in Experiments 2 and 4, *Wald* = 0.17, df = 1, $p = 0.68$, see Fig. 3, but a significant difference between observers in Experiments 3 and 4, Wald = 10.65, df = 1, p = 0.001, OR = 0.27, 95%CI = 0.12–0.59.

5.3. Discussion

Consistent with the results of Experiments 2 and 3, in Experiment 4, actors put more good animals on the left versus bad animals. However, the space-valence pattern of the observer was not only the same as the actor, but also the same as the observer in Experiment 2, with more people placing the good animal in the left box. Furthermore, there was a significant difference between observers in Experiments 3 and 4. In accordance with embodied simulation, tying hands in front of individuals or behind should have had a similar effect of limiting motor simulation. If so, the results of Experiment 4 are contradictory to the view that motor simulation is necessary for the observer to show a reversal. Instead, most people had a left-is-good tendency when they connected the outcomes with space. This outcome implies that the effect of alternative motor fluency on space-valence associations in the observer was mainly modulated by the connection between the outcomes and the spatial position of the hands.

6. General discussion

As the original acquisition concept, spatial coding participates in the learning and expression of a myriad of abstract concepts. The association of emotional valence and space is a manifestation of the participation of spatial coding in emotional expression. Although many studies have been conducted to explore the issue, there are still numerous questions needing to be clarified, such as the mechanism and influencing factors of the association between the space and valence. Prior studies found that this link is based on the long-term accumulation of motor experience (Casasanto, 2009), but subsequent research provided evidence that brief action training can also affect the association (Casasanto & Chrysikou, 2011), and other studies supported that action observation can also change the association of affective valence and space of individuals (de la Fuente et al., 2015). Hence, in the present study we employed four experiments to investigate the influencing factors of space-valence mapping, and delineate the mechanism of action training and observation on the mapping.

In the body-oriented situation, humans yield the most basic spatial concepts of up-down or right-left, and use these concepts to understand more complex notions. The process of mapping a specific spatial source domain to a relatively abstract valence word target domain is called psychological metaphor (Brookshire, Ivry, & Casasanto, 2010; Casasanto & Dijkstra, 2010; Casasanto, 2009). Metaphorical thinking styles are formed on the basis of experience, and embodied cognition theory hypothesizes that thinking is the psychological simulation of physical experience (Barsalou, 1999; Feldman, 2006; Goldstone & Barsalou, 1998; Lakoff & Johnson, 1999; Prinz, 2002). To a certain extent, individuals can spontaneously recruit spatial metaphors to represent other people (Gozli, Lockwood, Chasteen, & Pratt, 2018), and psychological metaphor helps people to represent abstract concepts through mental simulation. When most people imagine certain emotions or make valence judgments, this may involve mental simulation of the source domain and target domain: The representation of the target domain may reactivate the region of brain or emotional state that once generated this kind of emotional experience. Therefore, the representation of perception for action source domain constitutes the abstract concepts at some level, which can be represented through the way that the same neural and psychological structures perceive and simulate the physical world (Casasanto, 2009).

People often take themselves as the reference frame to process the external world, and the processing of physical horizontal space is also egocentric. In general, people's bodies are asymmetric, and most individuals have a dominant hand, which in the majority of people is the right hand (Corballis & Beale, 1976). If the body is regarded as a midline, the dominant side is more fluent than the subordinate side when we interact with the surrounding environment. In the association between space and emotional valence, the phenomenon that people connect positive valence with the fluent side of body and negative valence with the disfluent side may be the result of the accumulation of long-term asymmetrical perceptual-motor experience of the hands.

In Experiment 1, when participants were asked to make a choice, the spatial metaphor formed by individual's long-term experience of movement would be activated. As a result, positive valence was connected with the dominant hand and negative valence with the subordinate hand, in line with prior studies. Meanwhile, participants cannot explain why they made such choice, which suggests that this space-valence mapping is an implicit association. This conclusion is consistent with that of several other studies (Casasanto & Henetz, 2012; Casasanto, 2009; de la Fuente et al., 2015).

In Experiment 2, a two-person task was conducted. For actors, motor training was carried out to change their hands' fluency. In the task, actors wore a glove on the right hand because all of them were right-handed, which made their left hand become relatively more fluent during the task. Observers only watched the actor perform the task. Aligning with the hypothesis, both actors and observers showed a reversal of space-valence association afterward, with more participants choosing to allot the bad animal to the right box. There was no significant difference between the choice preferences of the actor and the observer. Direct action training and observation had similar effects on space-valence mapping.

Social learning theory emphasizes observational learning, with the assumption that people can learn the corresponding actions without direct experience. Therefore, in the case of action observation, the same spatial emotional valence bond is generated for observers and actors. The reason why this association occurs is not clear: Is it because observers perform the action simulation or connect the result of actors and space? We conducted Experiments 3 and 4 to discriminate these alternatives. During the action observation phase, the hand state of the observers was controlled, with their hands being tied and placed behind or in front of them. Tying the hands was adopted to restrict the possibility of simulation, as the formation of embodied simulation largely depends on the individual's action ability. If the body's resources are occupied or potential action ability is restricted, the embodied simulation would not occur (Ambrosini et al., 2012; Witt, Kemmerer, Linkenauger, Sally, & Culham, 2010).

In Experiment 3, with the hands bound behind the observer, results were similar to those shown typically by right-handers and not like those of the actor, consistent with the idea that action simulation was prevented. However, in Experiment 4, with the hands bound in front of the observer, the behavior pattern was the same as for the actors and the observers in Experiment 2, indicating that binding of the hands in Experiment 3 was not the critical factor. That is, even with the hands bound to prevent action simulation, the observers were more likely to associate the outcomes of the actor's behavior with the space. Thick ski gloves weakened mobility of actors' right hands, which looked clumsier and made more mistakes as they placed the dominoes. In this case, the observer linked the negative performance to the right space, and the positive performance to the other side in egocentric spatial coordinates.

Compared to Experiment 3, the only difference in Experiment 4 was that the hands were in front, but the space-valence association of the observer reversed. Consistent with the polarity correspondence principle, some researchers find that when body posture and cognitive processing are compatible, this compatibility can facilitate reactions or produce a more positive evaluation (Hao et al., 2017; Harmon-Jones & Peterson, 2009; Harmon-Jones et al., 2015; Price et al., 2012). Dru and Cretenet (2008), Cretenet and Dru (2004) also found that for right-handers, right-arm flexion and left-arm extension led to more positive evaluations than left-arm flexion and right-arm extension, where right and left arms associate with positive and negative, and flexion and extension with approach and avoidance, respectively. In other words, congruence would cause a positive evaluation, whereas incongruence would lead to a negative evaluation. In this way we can explain why observers showed a right-is-good preference in Experiment 3 but a left-is-good preference in Experiment 4. For observers whose hands were behind their backs, "back" and clumsy right space were "negative", and the judgment associated these two polarities, triggering more positive evaluation of right space; for observers whose hands were in the front the positive association was of "front", instead. This speculative account suggests body location and motor compatibility are important parts of the affective processes.

However, there is another simpler account of the results. Within the visual field, when the hands are bound in front, the observer's left and right arms are still visible and can be distinguished. In contrast, when the observer's hands are bound behind the back, the arms are not visible and there is no visual basis for distinguishing the left and right arms. Consequently, no new associations with hand and location are formed from the observation.

6.1. Conclusion

Our experiments provide corroborating evidence that there is a "right-is-good and left-is-bad" pattern of categorization for right-handed Chinese individuals. They also establish that action training and observation have similar effects on the association between space and valence, even though short-term action training could transfer the association pattern. During the observation phase, the different states of the responding hand play disparate roles in the process of space-valence mapping, which provides evidence consistent with the view that the effect of indirect action observation on space-valence association is based on the connection between outcomes and space, with body posture also influencing the association.

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