# The Role of Moral Emotions in Moral Metaphor Mapping and Their Neural Mechanisms

**Authors:** Li Ying, Zhang Can, Wang Yue, Wang Yue

**Date:** 2019-03-11T00:00:00+00:00

## Abstract

The processing of moral metaphors is essentially a process of mapping bodily perceptual experiences from the source domain onto the target domain to represent abstract moral concepts. Recent research from a cognitive neuroscience perspective has revealed the neural mechanisms underlying moral metaphor processing, further exploring the role of emotional factors in moral metaphor mapping. The mechanism of moral metaphor mapping represents the result of interactions among bodily perceptual experience, emotional experience, and cognitive processing within specific moral contexts. Future research should expand the dimensions and directions of moral metaphor mapping, enrich and refine research paradigms in social interaction environments, and enhance ecological validity and cross-cultural validity.

## Full Text

## The Effect of Moral Emotions on the Metaphorical Mapping of Morality and Its Neural Mechanism

**LI Ying[1]; ZHANG Can[2],[1]; WANG Yue[1]**
([1] School of Education, Zhengzhou University, Zhengzhou 450001, China)
([2] Laboratory of Applied Brain and Cognitive Sciences, Shanghai International Studies University, Shanghai 201620, China)

## Abstract

The processing of moral metaphors is essentially a dynamic process of mapping a concrete source domain with sensorimotor experience to an abstract target domain and representing abstract moral concepts. And it should also be regarded as a result of interactive activity amid physical experience and moral emotions. Researches on the neural mechanism of moral metaphors showed that physical

and emotional experience influence the processing of moral metaphors, and discussed the effects of moral emotions on the metaphorical mapping of morality. Future researches should enrich the range of subject and directions of mapping, and improve the ecological validity and cross-cultural validity by modifying the experimental paradigms in social interactions.

**Keywords:** moral metaphor; moral emotion; embodied cognition; neural mechanism

## 1 Introduction

Since ancient times, morality has been intimately intertwined with real life and social culture. Whether in modern moral cognition and moral language expression or traced back to ancient cultural periods, people have consistently utilized bodily experience to perceive and judge morality. Taking the moral cleanliness metaphor as an example, major world religions—including Catholic baptism rituals and bathing ceremonies in Islam and Buddhism—all emphasize that physical cleansing leads to religious cultivation or achieves moral nobility and spiritual purity. In Shakespeare' s work, Lady Macbeth attempts to wash away her murderous guilt with water, a phenomenon scholars have termed the "Macbeth effect" to describe how immoral behavior triggers individuals' desire for cleansing (Zhong & Liljenquist, 2006).

Moral metaphor represents a significant research question in moral psychology, with conceptual metaphor theory and embodied cognition theory exerting important influences on this field. Lakoff and Johnson' s conceptual metaphor theory posits that metaphorical representation essentially involves processing familiar experiences in a source domain (such as spatial orientation, color, and bodily movement) and constructing abstract concepts like time, social relationships, and morality in a target domain. The process of migrating from familiar experience to abstract concepts in the target domain constitutes metaphorical mapping (Chen Yuming, Guo Tianyou, He Liguo, Yan Liangshi, 2014). Since the 1970s, second-generation cognitive science has shifted its focus from establishing individual psychological processing models to emphasizing the interaction between bodily experience and the environment (Li Qiwei, 2008). The embodied cognition perspective holds that most abstract concepts have metaphorical meaning, with mappings in the target domain originating from experience formed by the body' s sensorimotor system. Moral metaphor processing represents an integrated mechanism coupling three factors: cognition, environmental characteristics, and bodily experience (Li Zijian, Zhang Jijia, Qiao Yanyang, 2018). Cognitive semantics research also demonstrates that moral concept processing has metaphorical properties, with individual moral cognition rooted in embodied cognitive experiences of the physical environment (Yu, Wang, & He, 2016).

Conceptual metaphor theory addresses the origin of individual moral cognitive concepts, while embodied cognition theory explains the specific processing mech-

anisms of moral metaphors. In recent years, research in the moral metaphor domain has further verified through behavioral indicators that different types of moral metaphors possess psychological reality, involving cleanliness metaphors, spatial metaphors, visual color metaphors, and tactile metaphors related to moral concepts (Chen Yuming et al., 2014). Some studies have also preliminarily revealed the neural mechanisms underlying moral metaphor processing from a cognitive neuroscience perspective. The process of moral cognition results from the interaction between brain regions responsible for emotion and cognitive processing and those related to theory of mind (Luo Yuejia, Li Wanqing, Peng Jiaxin, Liu Chao, 2013; Wang Yunqiang, Guo Benyu, 2017). This study provides reference for further research on the psychological mechanisms of moral metaphors by reviewing and evaluating recent advances in this field.

## 2 Emotional Factors in the Cognitive Neural Mechanisms of Moral Metaphor

Current research on moral metaphors primarily focuses on dimensions such as cleanliness, spatial, visual color, and tactile metaphors related to moral concepts. On one hand, individuals'perception of bodily cleanliness, spatial position, visual color, and tactile information is relatively direct and sensitive, with corresponding behavioral response indicators being more explicit and variable factors easily manipulated under laboratory conditions. On the other hand, previous behavioral studies have established relatively mature research paradigms. Existing brain imaging research has focused more on examining the psychological reality of moral metaphors and their reflection in neurophysiological activity. In fact, as subjective feelings, emotions accompany moral cognition and moral judgment processes and are difficult to separate from moral metaphor processing. In recent years, studies have gradually examined the important influence of moral emotions on moral metaphor processing and attempted to further validate this from a cognitive neuroscience perspective.

### 2.1 Neural Mechanisms of Moral Cleanliness Metaphor and the Influence of Moral Emotion

Research on moral cleanliness metaphors has primarily explored the relationship between moral purity and bodily cleansing behavior around the "Macbeth effect." Studies have found that after recalling immoral behavior, participants generated more words related to cleanliness concepts (e.g., soap, shower) in word-completion tasks and showed greater desire for cleaning products (Zhong & Liljenquist, 2006). The Macbeth effect also substantially influences individuals'moral cognition, as participants who completed cleansing priming tasks rated moral dilemmas lower and applied more lenient moral judgment criteria (Schnall, Benton, & Harvey, 2008). However, Zhong, Strejcek, and Sivanathan (2010) found that participants made harsher moral judgments about social events after completing cleansing tasks. This reflects the high complexity of the mechanism through which moral purity metaphors influence moral judgment, prompting

subsequent studies to adopt cognitive neuroscience techniques for deeper investigation. Some studies using functional magnetic resonance imaging (fMRI) found that when participants engaged in immoral behavior, bilateral sensorimotor brain regions showed significant activation, and rating cleaning products also triggered activation in the left sensorimotor region, indicating that the brain' s sensorimotor cortex plays a central role in moral purity metaphors (Denke, Rotte, Heinze, & Schaefer, 2016; Schaefer, Rotte, Heinze, & Denke, 2015).

Emotional factors in moral purity metaphors have long been a research hotspot. Haidt' s social intuition theory identifies emotion as a decisive factor in moral judgment, and recent experimental research has examined the influence of moral emotions on moral purity metaphor processing through brain physiological activity indicators (Yan Liangshi, Yan Zhixiong, Ding Daoqun, Zou Xia, and Fan Wei, 2014). Studies have found that after moral disgust emotion priming, participants processing semantic materials related to cleanliness concepts elicited larger mean LPC amplitudes, indicating that participants experienced strong emotional feelings that enabled more refined cognitive processing. Individuals alleviate negative moral emotions by processing stimuli related to cleanliness concepts, which importantly influences subsequent moral cognition and decision-making. This also supports the view of Li Jian, Wang Yan, and Tang Yiyuan (2011), who, by analyzing the spatiotemporal characteristics of brain electrical signals when participants made moral decisions, argued that individuals make moral decisions by inhibiting moral emotions within specific moral cognitive contexts.

The role of emotion in moral metaphor processing also manifests in how conflicts between moral emotion and executive control affect moral metaphor mapping. Tang et al. (2017) found that both actual bodily cleansing and cleansing stimulus priming could reduce participants' feelings of guilt and shame, with actual bodily cleansing inducing more positive emotions. By analyzing amplitude of low-frequency fluctuation (ALFF) in task-based fMRI, the study found significant differences in brain activation patterns between actual bodily cleansing and cleansing stimulus priming in moral cleanliness metaphors: participants in the bodily cleansing group showed significantly reduced ALFF in the right insula and medial prefrontal cortex—brain regions related to moral emotion processing—meaning bodily cleansing can alleviate negative emotions caused by immoral behavior and reduce interference from moral emotions in executive control, thereby making moral judgments harsher. Participants in the cleansing stimulus priming group showed significant ALFF changes in the right superior frontal gyrus and right middle frontal gyrus—brain regions related to executive control processing—indicating that cleansing stimulus priming increased conflict between moral emotion and executive control, requiring participants to make more moral cognitive decisions to alleviate this conflict. The metaphorical consistency effect and metaphorical compensation effect manifested in participants' behavioral responses during moral metaphor mapping result from conflicts between moral emotion and executive control. This research supports the view that moral purity metaphors originate in the sensorimotor cortex, with individu-

als constructing moral metaphors through sensorimotor experience, while moral emotions regulate the relationship between moral motivation and executive control during moral metaphor mapping, manifested through moral cognition and behavioral responses.

### 2.2 Neural Mechanisms of Moral Spatial Metaphor and the Influence of Moral Emotion

Individuals' vertical spatial cognition holds important significance for moral concept processing. Numerous previous studies have demonstrated a metaphorical mapping relationship between moral cognition and visual spatial perception characterized by "moral is up, immoral is down," with the mapping strength being unbalanced—the mapping from moral concepts to visual spatial perception is stronger than that from visual spatial perception to moral concepts (Jia Ning, Jiang Gaofang, 2016; Lu Zhongyi, Jia Lining, Zhai Dongxue, 2017; Wang Zeng, Lu Zhongyi, 2013; Hill & Lapsley, 2009; Meier, Sellbom, & Wygant, 2007). Brain imaging research on moral spatial metaphors has also found differences in processing different directions along the vertical spatial dimension. Wang, Lu, and Lu (2016) used event-related potential (ERP) technology and a cue-target task to examine the time course of participants' processing of moral concept words along the vertical spatial dimension. Results showed significant interactive effects between word morality attributes and vertical spatial dimension on N1, P2, and LPC amplitudes. In processing moral words, the "moral-up" mapping appeared earlier, while the "immoral-down" effect emerged only later in processing immoral words.

During moral vertical spatial metaphor processing, emotional factors and moral cognition interact. Zhai, Guo, and Lu (2018) used the IAT paradigm and found that participants processed moral emotions significantly faster than moral concepts when processing moral vertical spatial metaphors, reflecting that intuitive emotional processing is a faster automatic process in moral cognition, while moral processing requires rational thinking and reasoning, and emotions can facilitate moral vertical spatial metaphor mapping. Zhu Jinfu, Chen Wei, Pu Minghui, and Feng Shenmei (2018) used event-related potential technology and a semantic priming paradigm to explore the role of disgust emotion in moral vertical spatial metaphor processing. The study found that after moral disgust stimulus priming, participants processing neutral target words presented at the bottom of the screen elicited larger P2 and N400 amplitudes, indicating that moral disgust emotion forms semantic connections with moral spatial metaphors, thereby facilitating individuals' processing of moral vertical spatial metaphors.

### 2.3 Neural Mechanisms of Moral Visual Color Metaphor and the Influence of Moral Emotion

Moral visual color metaphors possess rich cross-cultural background and psychological reality, representing important content in moral metaphor research, primarily involving color and brightness dimensions. Research on the color

dimension has focused on black-white contrast, finding that both background color priming and black-white color word processing tasks demonstrate a "moral is white, immoral is black" metaphorical effect that influences individuals' moral judgments and explicit moral behaviors (Song Shiqing, Zhou Lingli, Chen Hong, 2018). Other studies have verified the psychological reality of moral metaphors on the brightness dimension, showing that individuals' moral cognition and brightness perception mutually influence each other (Yin Rong, Ye Haosheng, 2014). Additionally, participants' perception of light dimmed after committing immoral behavior, but they showed greater preference for items with higher brightness, reflecting that metaphorical consistency and compensation effects also exist in moral brightness metaphor mapping relationships (Chatterjee, 2012). Beyond black-white and brightness metaphors, Gan, Fang, and Ge (2016) also discovered moral color metaphors. Participants spent longer processing green immoral words than moral words, eliciting significant P200, N300, and LPC components in early attention processing, semantic processing, and late moral reasoning evaluation stages. However, some studies hold different views. Yang Jiping, Guo Xiumei, and Wang Xingchao (2017) found that red-white color moral metaphors might not exist, and color words related to moral concepts might only form metaphorical connections in specific contexts.

Research on emotional factors in moral color metaphors remains scarce. Chen Wei, Pu Minghui, Feng Shenmei, and Zhu Jinfu (2016) used a two-word priming paradigm to explore the role of disgust emotion in black-white color moral metaphor processing. The study found that after moral disgust word priming, black neutral words were processed more slowly than white neutral words and elicited larger N1 and N350 amplitudes. Meanwhile, moral disgust words elicited significantly lower LPC amplitudes than non-moral disgust words. Since LPC is closely related to emotional processing, the study concluded that stimuli related to moral color metaphors require more cognitive resources for more refined processing when moral disgust emotion is involved. Notably, this study used neutral words as target stimuli, while previous research found no processing preference differences between black and white neutral words (Yin Rong, Ye Haosheng, 2014), further highlighting the role of disgust emotion in moral color metaphors.

### 2.4 Neural Mechanisms of Moral Tactile Metaphor and the Influence of Moral Emotion

Both Chinese and Western cultures have long employed tactile-based metaphors, particularly using "hard" and "soft" to describe personality traits, such as "absolutely not soft-hearted," "heart of stone," and "hard-hearted." Ackerman, Nocera, and Bargh (2010) found that negotiators sitting in hard chairs showed more rigid, uncompromising attitudes toward their counterparts than those sitting in soft chairs, demonstrating that individuals' tactile perceptual experiences influence higher-level social cognitive processing. Schaefer, Denke, Heinze, and Rotte

(2014) required participants to touch objects with rough or smooth surfaces and observed brain activation patterns while they evaluated social interaction quality through fMRI. The experimental results supported Ackerman et al.' s (2010) view that rough tactile sensations make social interactions more difficult and confrontational. Brain imaging results revealed that compared to touching smooth objects, participants touching rough objects showed activation in the sensorimotor cortex (SI, SII), premotor cortex, hippocampus, and amygdala during moral evaluation stages. These studies collectively demonstrate that individuals can construct social moral concepts through bodily tactile experience, providing neurophysiological evidence for tactile-based moral metaphors.

Since tactile sensations often trigger different emotional feelings, examining emotional factors in moral tactile metaphor processing plays an important role in explaining the internal connection between tactile sensations and moral cognition and revealing the essence of moral tactile metaphor mapping. Schaefer et al. (2018) investigated the influence of emotional factors on moral tactile metaphor processing. In the experiment, participants completed moral judgment questionnaires and emotion scales (PANAS) while sitting on either hard or soft chairs. Results showed that participants sitting on hard wooden chairs made harsher moral judgments, while those on soft chairs experienced more positive emotions. Additionally, fMRI results of participants making moral judgments after touching soft or hard objects revealed that compared to those touching soft objects, participants who touched hard objects showed activation in primary somatosensory cortex SI during resting state and greater involvement of sensorimotor cortex during moral judgment stages.

## 3.1 The Influence of Emotional Factors on Moral Metaphor Mapping

Focusing on the role of moral emotions in moral metaphor processing represents a prominent feature of current moral metaphor research. Behavioral studies have found that emotional factors significantly influence individual moral metaphor processing (Schnall, Haidt, Clore, & Jordan, 2008; also see Peng Ming, Zhang Lei, 2016; Wu Baopei, Zhang Lei, 2012; Xie Xiyao, Luo Yuejia, 2009). Cognitive neuroscience research further confirms that individual emotional experience constitutes an important variable in the relationship between bodily sensorimotor experience and moral cognition. With emotional factors involved, different processing stages of moral metaphors exhibit distinct processing characteristics (Gan, Fang, & Ge, 2016; Wang, Lu, & Lu, 2016), reflecting that moral emotions are not merely accompanying results of moral metaphor processing but also exert more complex influences on the mapping process.

First, with emotional factors involved, the moral metaphor mapping process consumes more cognitive resources, meaning that moral metaphor processing becomes more refined. Second, moral cognition and judgment involve multiple emotional effects. ERP studies have found that in moral metaphor processing, disgust emotion interacts with executive control to influence moral decision-

making and behavioral responses (Chen Wei et al., 2016; Yan Liangshi et al., 2014; Zhu Jinfu et al., 2018). Beyond disgust, guilt and empathy are also considered typical moral emotions. In different moral contexts, individuals' moral behaviors are influenced by different types of moral emotions. Day and Bobocel (2013) found that compared to disgust, pride, and sadness, guilt better explained the bias in participants' cognition of their own body weight after committing immoral behavior, demonstrating the role of guilt emotion in moral metaphor effects. Third, increasing research demonstrates that in moral metaphor processing, emotions influence the mapping process, while bodily perceptual experiences related to moral metaphors also activate brain regions involved in emotional activity. Individuals' moral decision-making and behavior are also influenced by the interaction between emotion and executive control. Tang et al.' s (2017) fMRI study found that in moral cleanliness metaphor processing, bodily cleansing behavior reduced conflicts between emotion and executive control. This result aligns with Ma Jianling, Liu Chang, and Fu Mingqiu (2017), who argued that individuals' processing of cognitive conflict is influenced by emotional factors, reducing attentional resources for executive control and thereby affecting moral behavior. These findings consistently demonstrate that in specific moral contexts, individuals' bodily experience and cognitive processing interact under the influence of emotional experience. Using cognitive neuroscience techniques allows simultaneous examination of the roles these three factors play in the same moral metaphor processing course and their respective processing characteristics, warranting in-depth exploration in future research.

## 3.2 Integrating Moral Emotion-Moral Metaphor Mapping Mechanisms from an Embodied Cognition Perspective

Studying moral metaphors from an embodied cognition perspective can directly verify that different types of moral metaphors possess psychological reality, and it unifies the relationship between emotional factors and moral metaphor mapping into an integrated mechanism for investigation, providing new approaches for moral metaphor research. First, embodied cognition and moral metaphor mapping are essentially consistent. Peng Kaiping and Yu Feng (2012) noted that abstract moral concept processing involves three thinking strategies: representational cognition, metaphorical cognition, and embodied cognition. Metaphorical cognition is based on individuals' bodily perceptual experience, while embodied cognition also involves the interaction between bodily perception and environmental characteristics. The body plays an important role in human cognitive processes, which cannot proceed independently without bodily participation; environment, body, and cognitive operations are mutually embedded relationships, showing that the two approaches share similar principles (Ye Haosheng, 2010; Yang Jiping, Guo Xiumei, 2016). Second, the embodied cognition perspective can enrich understanding of moral metaphor mapping mechanisms. Metaphorical mapping emphasizes the relationship between concrete concepts (including bodily experience) and abstract concepts, while the core of embodied cognition is the role of bodily experience in constructing abstract concepts, provid-

ing explicit explanations for the internal mechanisms of metaphorical mapping. Third, the embodied cognition perspective can integrate moral emotions into moral metaphor mapping mechanisms. Emotional concepts are both abstract concepts that influence the construction of abstract concepts in metaphorical mapping and promote individuals' understanding of metaphors, and they are also embodied, containing rich and concrete bodily perceptual experiences. The embodied cognition perspective connects metaphorical mapping with emotion, further clarifying the role of emotional factors in metaphorical mapping. Therefore, moral embodied cognition and moral metaphors represent different forms of the same moral concept representation. Integrating the relationship between moral emotions and moral metaphor mapping compensates for the previous defect of neglecting bodily perceptual experience in moral psychology research and improves research ecological validity.

Research findings on the cognitive neural mechanisms of moral metaphors also support these views (Denke et al., 2016; Schaefer et al., 2015). fMRI studies have found that the brain' s sensorimotor cortex plays an important role in embodied cognition, while the dorsolateral prefrontal cortex (DLPFC) and temporoparietal junction (TPJ) are closely related to moral cognitive processing, and brain regions responsible for processing emotional information such as the ventromedial prefrontal cortex (VMPFC) and orbitofrontal cortex (OFC) also participate in moral concept processing. Functional connectivity (FC) and other indicators further reveal the important role of emotional factors in this process. From the embodied cognition perspective, we can more comprehensively and deeply analyze the role of moral emotions in moral metaphor mapping processes and their complex neural mechanisms, providing a beneficial supplement to current research.

## 4.1 Expanding Moral Metaphor Mapping Across Different Dimensions and Directions

Existing research has selected relatively narrow perceptual dimensions that do not fully cover the types of moral metaphors. Although taste metaphors, temperature metaphors, and left-right spatial metaphors related to social moral cognition have been verified to possess psychological reality, 极少研究涉及 (very few studies have addressed them) (Ding Yi et al., 2013; Yang Jiping, Guo Xiumei, Wang Xingchao, 2017; Yin Rong, Ye Haosheng, 2014; Rozin, Haidt, & Fincher, 2009; Williams & Bargh, 2008). Moreover, due to relatively singular research methods, no clear conclusions have been reached regarding metaphor mapping processes in complex situations, and future research could systematically enrich research content from cognitive neuroscience perspectives.

The same metaphor type may also be represented through different physical dimensions. For example, existing research on moral purity metaphors has mostly focused on the mapping relationship between bodily cleansing behavior and morality, while Sherman and Clore (2009) found that representing moral purity and moral pollution with white and black could enhance participants'

moral self-image, achieving effects similar to bodily cleansing behavior. This suggests that different physical dimensions in moral metaphor mapping may also interact, such as the mutual influence between vertical and horizontal spatial positions and between spatial position and visual color, which requires further research.

The directionality of metaphorical mapping and its mechanisms also require in-depth investigation. Previous studies have indicated that moral concepts and vertical space have bidirectional mapping relationships, with unbalanced mapping strength in the two different directions. Besides vertical spatial experience influencing moral concept processing, semantic processing of moral concepts can conversely affect vertical spatial cognition, but no clear conclusions have been reached regarding the reverse direction process (Jia Ning, Jiang Gaofang, 2016; Lu Zhongyi et al., 2017). Zhang Fenghua and Ye Hongyan (2016) argued that research results on the directionality of cleanliness metaphor mapping are contradictory, with mapping direction influenced by various factors including priming manipulation methods. However, current research on metaphor mapping directionality has not adequately addressed all metaphor types and lacks direct evidence related to bodily perceptual experience such as neurophysiological indicators. Future research could further verify the bidirectionality of moral metaphor mapping and its specific generation mechanisms and conditions from this perspective.

## 4.2 Enriching and Improving Research Paradigms in Natural, Interactive Social Environments

Most current research controls other factors in laboratory environments and examines moral metaphor processing mechanisms along only one physical dimension, making it difficult to powerfully explain how moral metaphors influence individuals' moral cognition and behavior in more natural, complex social situations and what role moral emotions play in these contexts. Future research should consider more rigorous experimental designs, employing implicit experimental tasks to avoid interference from irrelevant factors. For example, Xie Qing, Yang Qun, and Tian Xuehong (2018) used ERP to examine participants' processing characteristics of immoral behavior during a two-choice oddball task, with the implicit oddball paradigm preventing participants from making responses to maintain moral self-image and satisfy social expectations in explicit tasks. Regarding experimental material compilation, Ding Fengqin, Wang Ximei, and Liu Zhao (2017) argued that moral and immoral stimulus materials selected in previous research had overly explicit moral value attributes, making it difficult to examine participants' true attitudes. Therefore, morally ambiguous stories containing both moral and immoral values should be used to allow participants to make choices in complex situations that highlight environmental characteristics and bodily experience priming. This view aligns with Yan Liangshi et al. (2014), who questioned previous research that simply primed immoral stimuli and could not avoid the influence of social context and

moral emotions on experimental tasks, suggesting that textual materials could be used to examine participants' processing characteristics during metaphorical mapping through implicit methods. However, Wang Yunqiang and Guo Benyu (2017) argued that these stimulus materials are hypothetical scenarios of real social interactions that deviate from real situations, proposing that virtual reality and augmented reality technology could be introduced to improve the simulation degree of real social situations. Future research should fully consider and design reasonable research paradigms and experimental tasks according to the different characteristics of moral metaphors to improve research ecological validity.

Lin Yiqin and Zhang Dandan (2017) proposed using multi-person simultaneous interactive scanning (hyperscanning) technology with fMRI, ERP, and functional near-infrared spectroscopy (fNIRS) to reveal the neural mechanisms of moral cognition and decision-making behavior in social interaction contexts, which can activate more brain regions related to social interpersonal interaction and provide higher ecological validity. fNIRS technology, especially mobile and wearable near-infrared spectrometers, breaks the limitations of laboratory research in cognitive neuroscience, offering higher ecological validity, lower economic costs, and proximity to natural real-world environments (Guo Huan et al., 2016; Ye Peixia, Zhu Ruida, Tang Honghong, Mai Xiaoqin, Liu Chao, 2017; Piper et al., 2014; Zhao & Cooper, 2018), enabling participants to acquire bodily experience and process moral metaphors in real social interaction situations, yielding more reliable research results. Moreover, due to the embodied characteristics of moral metaphors, environmental factors related to physical dimensions such as cleanliness, visual color, spatial position, and temperature all influence moral metaphor mapping processes. Wang Yunqiang and Guo Benyu (2017) proposed constructing a multi-perspective model of hormone-gene-brain-environment-behavior to deeply examine the relationships between brain, moral cognition, decision-making, and behavior from the perspective of interactions among psychological, biological, and environmental factors.

## 4.3 Improving Research Replicability and Cross-Cultural Validity

Research results on moral metaphors are sometimes controversial, such as contradictory findings regarding the influence of bodily cleanliness state on moral judgment (Zhang Fenghua, Ye Hongyan, 2016; Schnall et al., 2008; Zhong et al., 2010). Siev, Zuckerman, and Siev (2018) conducted a meta-analysis of 15 studies related to the "Macbeth effect" and found that the effect was not as significant in replication experiments, perhaps reflecting low cross-cultural validity of moral cleanliness metaphors. However, this result did not fully consider the influence of cultural differences in moral metaphors on participants' moral cognition, as the analyzed data came from 3 different continents with a total of 1746 participants and lacked conceptual validation analysis. As is well known, moral cognition and moral metaphor mapping have obvious cultural

and regional characteristics. Therefore, it is necessary to focus on cross-cultural differences in moral metaphors within Chinese cultural contexts and provide direct evidence from cognitive neuroscience perspectives. For example, the same color may have different meanings in Chinese and Western cultures. Black-white metaphors are prevalent in Western culture, with some scholars arguing they relate to racial prejudice against African Americans in modern Western society. Historically, African Americans with dark skin suffered from racial prejudice and discrimination, placing them in lower social classes and living standards and stereotypically labeling them as "evil" (Alter, Stern, Granot, & Balcetis, 2016). However, while white in traditional Chinese culture has positive, moral metaphorical meanings such as "innocent" and "flawless like white jade," it is also considered to have negative connotations such as "funeral white affairs" and "raising white flags" in specific occasions and folk customs in real life.

Moral cleanliness metaphors also have specific cultural backgrounds. Although cross-cultural research indicates that cleanliness metaphors are universal, Ren Jun and Gao Xiaoxiao (2013) proposed that Western religion' s "original sin" culture prompts individuals to engage in cleansing behaviors to maintain moral purity, whereas in Chinese culture, immoral behavior causes individuals to lose face, leading them to engage in moral covering behaviors to save face. Lee, Tang, Wan, Mai, and Liu (2015) supported this view, finding that East Asian cultural background participants experienced significantly reduced guilt and repentance after face cleansing. Su Yanjie and Sun Fangfang (2014) attributed this phenomenon to the "moderating effect of participants' source countries," arguing that different ethnicities, nationalities, and cultural backgrounds form diverse thinking modes and behavioral responses that influence moral cognition and behavior.

Furthermore, numerous research findings from cognitive linguistics have also found that people using different languages in different cultural regions affect their processing of abstract concepts. Cognitive linguist Boroditsky discovered through field experiments that language influences individuals' spatial and temporal cognition, and that spatial cognition affects temporal cognition. In different cultural contexts, different language expression methods influence individuals' representation of abstract concepts such as time and space, a process achieved through metaphorical mapping. Chinese can express temporal concepts from the vertical spatial dimension, such as "five thousand years up and down," while Hebrew speakers, influenced by right-to-left writing, also show right-to-left characteristics in expressing temporal material concepts. These findings also reveal to some extent the differences in abstract concept metaphorical mapping brought about by cultural and linguistic usage differences, which have important reference significance for moral metaphor research using word stimulus materials.

In view of this, future research should, from a cognitive neuroscience perspective and based on behavioral research results, analyze and compare differences in the neural mechanisms of different types of moral metaphor mapping processes

across different cultural backgrounds. This can improve research replicability and cross-cultural validity and help deeply explore the formation mechanisms of bidirectional moral metaphor mapping. Meanwhile, localized research enables us to better understand Chinese people' s social moral cognition and decision-making behavior within Chinese cultural contexts, thereby inspiring us to develop moral education with Chinese characteristics, actively shape citizens'moral behavior, and create a harmonious, moral social atmosphere.

## References

Chen, W., Pu, M. H., Feng, S. M., & Zhu, J. F. (2016). Temporal characteristics of black and white neutral word processing after disgust priming: Evidence from ERPs. *Chinese Journal of Clinical Psychology*, 24(5), 784-787.

Chen, Y. M., Guo, T. Y., He, L. G., & Yan, L. S. (2014). Analysis of types, rules, and mechanisms of moral metaphors. *Journal of Shenzhen University (Humanities & Social Sciences)*, 31(5), 55-59.

Ding, F. Q., Wang, X. M., & Liu, Z. (2017). The moral concept cleanliness metaphor and its influence on moral judgment. *Psychological Development and Education*, 33(6), 666-674.

Ding, Y., Ji, T. T., Zou, W. Q., Liu, Y., Ran, G. M., & Chen, X. (2013). The metaphorical mapping from physical temperature to social affection: Mechanism and explanation. *Advances in Psychological Science*, 21(6), 1133-1140.

Guo, H., Shen, H. Y., Zan, Y., Zhang, D. H., Cai, T. T., & Zhu, H. L. (2016). Research on two-person simultaneous interactive measurement based on functional near-infrared spectroscopy technology. *Acta Laser Biology Sinica*, 25(06), 523-530.

Jia, N., & Jiang, G. F. (2016). Psychological reality and bidirectional mapping of moral concept vertical spatial metaphors. *Psychological Development and Education*, 32(2), 李健, 王艳, 唐一源. (2011). Spatiotemporal analysis of ERP in moral dilemmas. *Chinese Journal of Biomedical Engineering*, 30(2), 220-

Li, Q. W. (2008). Discussion on "cognitive revolution" and "second-generation cognitive science" . *Acta Psychologica Sinica*, 40(12), 1306-1327.

Li, Z. J., Zhang, J. J., & Qiao, Y. Y. (2018). Divergence in embodied theory: Conceptual metaphor and perceptual symbol view. *Studies in Philosophy of Science and Technology*, 35(2), 45-51.

Lin, Y. Q., & Zhang, D. D. (2017). The role of hyperscanning technology in social cognitive neuroscience. *Applied Psychology*, 23(4), 300-308.

Lu, Z. Y., Jia, L. N., & Zhai, D. X. (2017). Mapping in understanding moral concept vertical spatial metaphors: Bidirectionality and imbalance. *Acta Psychologica Sinica*, 49(2), 186-196.

Luo, Y. J., Li, W. Q., Peng, J. X., & Liu, C. (2013). Cognitive neural mechanisms of moral judgment. *Journal of Southwest University (Social Sciences Edition)*, 39(3), 81–86.

Ma, J. L., Liu, C., & Fu, M. Q. (2017). Cognitive neural mechanisms of emotion influencing conflict processing. *Advances in Psychological Science*, 25(1), 49–58.

Peng, K. P., & Yu, F. (2012). Moral psychophysics: Phenomena, mechanisms, and significance. *Social Sciences in China*, 12, 28–45.

Peng, M., & Zhang, L. (2016). Developmental research on the influence of disgust emotion on moral judgment. *Journal of Psychological Science*, 39(5), 1110–1115.

Ren, J., & Gao, X. X. (2013). What will Chinese people do after immoral behavior? *Journal of Psychological Science*, 36(4), 978–983.

Song, S. Q., Zhou, L. L., & Chen, H. (2018). The influence of black and white background colors on honest behavior. *Journal of Psychological Science*, 41(2), 430–434.

Su, Y. J., & Sun, F. F. (2014). A meta-analysis of moral embodiment. *Journal of East China Normal University (Educational Sciences)*, 32(2), 88–

Wang, Y. Q., & Guo, B. Y. (2017). How the brain establishes moral concepts: Progress and prospects in research on the cognitive neural mechanisms of morality. *Chinese Science Bulletin*, 62(25), 2867–2875.

Wang, Z., & Lu, Z. Y. (2013). The vertical spatial metaphor of moral concepts and its influence on cognition. *Acta Psychologica Sinica*, 45(5), 538–545.

Wu, B. P., & Zhang, L. (2012). The relationship between disgust and moral judgment. *Advances in Psychological Science*, 20(2), 309–316.

Xie, Q., Yang, Q., & Tian, X. H. (2018). Integration and separation effects in moral judgment: Evidence from ERP. *Psychological Exploration*, 38(2), 178–

Xie, X. Y., & Luo, Y. J. (2009). Emotional factors in moral judgment: Exploration from cognitive neuroscience perspective. *Advances in Psychological Science*, 17(6), 1250–1256.

Yan, L. S., Yan, Z. X., Ding, D. Q., Zou, X., & Fan, W. (2014). Temporal characteristics of body cleansing word processing after moral disgust priming: Evidence from ERPs. *Chinese Journal of Clinical Psychology*, 12(1), 32–37.

Yang, J. P., & Guo, X. M. (2016). Research on moral concept metaphors from an embodied perspective. *Psychological Exploration*, 36(5), 387–391.

Yang, J. P., Guo, X. M., & Wang, X. C. (2017). Metaphorical representation of moral concepts: From dimensions of red-white color, left-right position, and oblique font. *Acta Psychologica Sinica*, 49(7), 875–885.

Ye, H. S. (2010). Embodied cognition: A new approach in cognitive psychology. *Advances in Psychological Science*, 18(5), 705–710.

Ye, P. X., Zhu, R. D., Tang, H. H., Mai, X. Q., & Liu, C. (2017). Application of near-infrared optical imaging in social cognitive neuroscience. *Advances in Psychological Science*, 25(5), 731–741.

Yin, R., & Ye, H. S. (2014). Black-white metaphorical representation of moral concepts and its influence on moral cognition. *Acta Psychologica Sinica*, 46(9), 1331–

Zhang, F. H., & Ye, H. Y. (2016). The effect "washed" out: Analysis of factors influencing different directions of cleaning priming on moral judgment. *Journal of Psychological Science*, 39(5), 1236–1241.

Zhu, J. F., Chen, W., Pu, M. H., & Feng, S. M. (2018). Temporal characteristics of vertical spatial metaphor processing after disgust priming. *Chinese Journal of Behavioral Medicine and Brain Science*, 27(3), 266–271.

Ackerman, J. M., Nocera, C. C., & Bargh, J. A. (2010). Incidental haptic sensations influence social judgments and decisions. *Science*, 328(5986), 1712–1715.

Alter, A. L., Stern, C., Granot, Y., & Balcetis, E. (2016). The "bad is black" effect: Why people believe evildoers have darker skin than do-gooders. *Personality and Social Psychology Bulletin*, 42(12),

Chatterjee, A. (2012). Disembodying cognition. *Language and Cognition*, 2012, 2(1), 79–116.

Day, M. V., & Bobocel, D. R. (2013). The weight of a guilty conscience: Subjective body weight as an embodiment of guilt. *PLoS One*, 8(7), e69546.

Denke, C., Rotte, M., Heinze, H. J., & Schaefer, M. (2016). Lying and the subsequent desire for toothpaste: Activity in the somatosensory cortex predicts embodiment of the moral-purity metaphor. *Cerebral Cortex*, 26(2), 477–484.

Dong, P., & Lee, S. W. S. (2017). Embodiment as procedures: Physical cleansing changes goal priming effects. *Journal of Experimental Psychology-General*, 146(4), 592–605.

Gan, T., Fang, W., & Ge, L. (2016). Colours' impact on morality: Evidence from event-related potentials. *Scientific Reports*, 6, 38373.

Hill, P. L., & Lapsley, D. K. (2009). The ups and downs of the moral personality: Why it' s not so black and white. *Journal of Research in Personality*, 43(3), 520–523.

Siev, J., Zuckerman, S., & Siev, J. (2018). The relationship between immorality and cleansing: A meta-analysis of the macbeth effect. *Social Psychology*, 49, 303–309.

Lee, S. W. S., Tang, H., Wan, J., Mai, X., & Liu, C. (2015). A cultural look at moral purity: Wiping the face clean. *Frontiers in Psychology*, 6(577).

Lee, S. W., & Schwarz, N. (2010). Dirty hands and dirty mouths: Embodiment of the moral-purity metaphor is specific to the motor modality involved in moral transgression. *Psychological Science*, 21(10),

Meier, B. P., Sellbom, M., & Wygant, D. B. (2007). Failing to take the moral high ground: Psychopathy and the vertical representation of morality. *Personality and Individual Differences*, 43(4), 757-

Pacilli, M. G., Pagliaro, S., Spaccatini, F., Giovannelli, I., Sacchi, S., & Brambilla, M. (2018). Straight to heaven: Rectitude as spatial representation of morality. *European Journal of Social Psychology*, 48, 663-672.

Piper, S. K., Krueger, A., Koch, S. P., Mehnert, J., Habermehl, C., Steinbrink, J., ···Schmitz, C. H. (2014). A wearable multi-channel fNIRS system for brain imaging in freely moving subjects. *Neuroimage*, 85(SI1), 64-71.

Rozin, P., Haidt, J., & Fincher, K. (2009). From oral to moral. *Science*, 323(5918), 1179-1180.

Schaefer, M., Cherkasskiy, L., Denke, C., Spies, C., Song, H., Malahy, S., Heinz, A., ···Bargh, J. A. (2018). Incidental haptic sensations influence judgment of crimes. *Scientific Reports*, 8(1), 6039.

Schaefer, M., Denke, C., Heinze, H. J., & Rotte, M. (2014). Rough primes and rough conversations: Evidence for a modality-specific basis to mental metaphors. *Social Cognitive and Affective Neuroscience*, 9(11), 1653-1659.

Schaefer, M., Rotte, M., Heinze, H., & Denke, C. (2015). Dirty deeds and dirty bodies: Embodiment of the macbeth effect is mapped topographically onto the somatosensory cortex. *Scientific Reports*, 5(1), 18051.

Schnall, S., Benton, J., & Harvey, S. (2008). With a clean conscience, cleanliness reduces the severity of moral judgments. *Psychological Science*, 19(12), 1219-1222.

Schnall, S., Haidt, J., Clore, G. L., & Jordan, A. H. (2008). Disgust as embodied moral judgment. *Personality and Social Psychology Bulletin*, 34(8), 1096-1109.

Sherman, G. D., & Clore, G. L. (2009). The color of sin: White and black are perceptual symbols of moral purity and pollution. *Psychological Science*, 20(8), 1019-1025.

Tang, H., Lu, X., Su, R., Liang, Z., Mai, X., & Liu, C. (2017). Washing away your sins in the brain: Physical cleaning and priming of cleaning recruit different brain networks after moral threat. *Social Cognitive Affective Neuroscience*, 12(7), 1149-1158.

Wang, H. L., Lu, Y. Q., & Lu, Z. Y. (2016). Moral-up first, immoral-down last: The time course of moral metaphors on a vertical dimension. *Neuroreport*,

27(4), 247-256.

Williams, L. E., & Bargh, J. A. (2008). Experiencing physical warmth promotes interpersonal warmth. *Science*, 322(5901), 606-607.

Yu, Wang, & He, Y. (2016). Spatial subsystem of moral metaphors: A cognitive semantic study. *Metaphor and Symbol*, 31 (4), 195-211.

Zhai, D., Guo, Y., & Lu, Z. (2018). A dual mechanism of cognition and emotion in processing moral-vertical metaphors. *Frontiers in Psychology*, 9, 1554.

Zhao, H., & Cooper, R. J. (2018). Review of recent progress toward a fiberless, whole-scalp diffuse optical tomography system. *Neurophotonics*, 5(0110121).

Zhong, C. B., & Liljenquist, K. (2006). Washing away your sins: Threatened morality and physical cleansing. *Science*, 313(5792), 1451-1452.

Zhong, C., Strejcek, B., & Sivanathan, N. (2010). A clean self can render harsh moral judgment. *Journal of Experimental Social Psychology*, 46(5), 859-862.

*Note: Figure translations are in progress. See original paper for figures.*