

# Are Situation Models Embodied? Relationships Between Situation Models and Embodied Cognition

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## ABSTRACT

This paper focused on the question about whether situation models are embodied in human cognition. The embodied cognition theory could be a potential solution to the grounding problem in cognitive psychology. However, when it is linked to the situation model theory, it became ambiguous about whether the situation models are also embodied. According to the situation model theory, people could simulate things that are implied or not stated in the text as well, but the current evidence for embodied cognition only showed that people would reenact mental simulation while they read a word explicitly. This paper would begin with a review about the embodied cognition theory and situation model theory as well as their behavioral evidence, and then the authors would suggest further way of testing the embodiment of situation models.

**Keywords:** *Situation model, Embodied Cognition, Cognitive Psychology*

## 1. INTRODUCTION

The grounding problem had been troubled cognitive psychologists for decades before the Embodied Cognition theory was introduced to the field. The Embodied Cognition brought a brand-new insight to the solution of the grounding problem which is how do symbols, or knowledge, in human minds get their meaning and connect meaningfully to the outside world? The Embodied Cognition theory suggested that symbols are stored in the modality-specific areas in the brain, and when it is needed, the modality-specific areas would reenact and simulate people's interaction with a particular symbol. For example, when a person reads the word "car", the modality-specific areas in his brain would reenact his memory about car, such as the color of the car, the sound of the car, or the touch of the car [1].

Situation models was suggested decades before the embodied view were introduced, but the relationships between these two ideas did not come in consider until recent years. According to Zwaan, the definition of situation models is that situation models are mental representations of the state of the affairs described in the text rather than the text itself [2]. For example, when we read the sentence *A girl walks through the clock tower at*

*exactly 12 o'clock at noon*, theatrically, we would simulate the scene described in the sentence, which is a girl walking through a clock tower. However, according to the situation model theory, people might also simulate the things beyond the text, for instance, some people might be simulating the bell ringing because it is 12 o'clock at noon. And therefore, the question bears on whether this beyond-the-text-simulation is also embodied in modality specific areas.

## 2. EMBODIED COGNITION AND BEHAVIORAL EVIDENCE

Prior to answer the question about whether situational models are embodied, we first need to examine on the Embodied Cognition theory itself, its antithetical theory, and the behavioral evidence for the embodied theory. As previously described, the embodied theory assumes that knowledges are stored in the modality-specific areas of the human brain [1]. And therefore, modality-specific areas such as the visual or the auditory cortex would go through a reenactment phase according to the previous perceptions.

However, before the embodied theory was introduced, people believed in the amodal theory of human cognition. In the amodal, or the disembodied,

theory, psychologist believed that the central area was responsible for storing concepts and knowledges and played the role of processing the multimodal information. Under the amodal theory, the information that was stored in the central brain areas would be randomly transduced into an amodal representation, such as a feature list, semantic network, or frame [1]. In other words, the amodal representation was largely based on arbitrary information representations, just like what computers do.

As opposed to, the Embodied Cognition theory suggests that the representation of knowledge is based on perception and memories. It claimed that the modality-specific areas are responsible for perceiving the outside information and that information would be stored in the modality-specific areas. Therefore, when people are thinking about cars or other objects, the modality specific areas would re-describe the object by reenacting their perception and interaction with the object, and in this case, the representation of knowledge and information are grounded, no longer arbitrary.

In Pulvermuller et al., experimenters showed that the modality specific activities are engaged when people were just reading about action words, and this kind of modality activities corresponded to the ones that were engaged in actual movements [3]. In this study, the experimenters hypothesized that when people are hearing or reading about actions words related to hand, foot, or mouth actions, they would use the according motor areas of the brain to simulate the actions. Moreover, this study also used the technology of functional localizer to spot the region of interest in the brain during the experiment, which improved the accuracy of the experiment results. The result of this study showed that the motor areas of the brain were also activated when people were reading actions words just like how they were activated when people were engaging in actual movements.

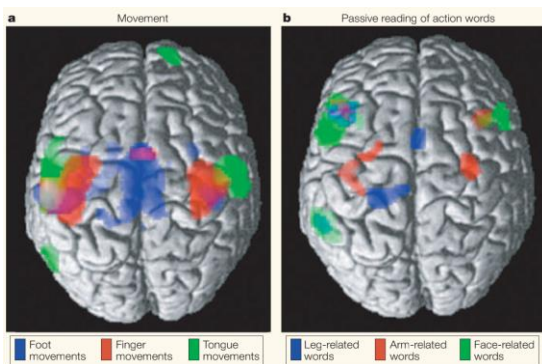


Figure 1 Corresponding Parts Responding to the Stimulation in Pulvermuller et al. 2004

Furthermore, in Willems et al. , the participants were asked to decide whether the word shown on the screen is in English and then press buttons, either yes or no [4]. The experiment showed that it would be faster for the participants to recognize a manual relative word (e.g.,

grab, take, slam...) than a non-manual word (think, wonder, want...), and the non-corresponding lateral hemisphere to the dominant hand would be more stimulated than the other side. Rather than testing the premotor activities, the experiment in this study changed the brain activity of the participants. Because people would activate their lateral brain area when they are pressing the button, and the brain simulation of those manual relative areas would accelerate the action of pressing the button. The result of this study further reinforces the results from the previous studies about embodied cognition.

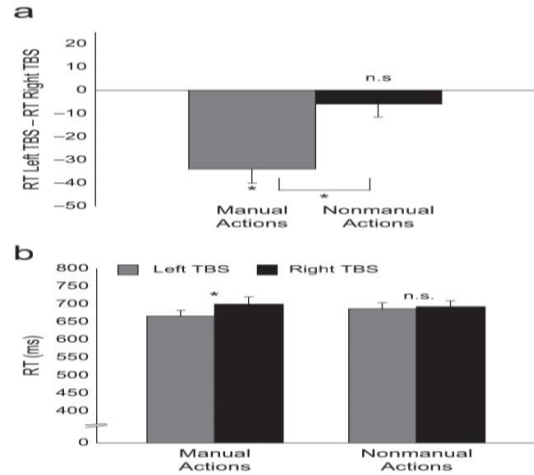


Figure 2 Mean Reaction Time in the Theta-Burst Transcranial Magnetic Stimulation

Table 1. Mean Reaction Times (in Milliseconds) in the Main and Control Experiments

Experiment and stimulus type	Left-hemisphere TBS	Right-hemisphere TBS
Main experiment		
Manual verbs	663.4 (168.8)	697.5 (206.8)
Nonmanual verbs	683.7 (178.9)	689.5 (180.9)
Pseudoverbs	789.3 (175.6)	802.6 (193.0)
Control experiment		
Concrete nouns	606.3 (151.0)	610.5 (172.7)
Nonconcrete nouns	606.4 (153.4)	613.9 (155.1)
Pseudonouns	751.9 (218.6)	787.6 (251.9)

Note: Standard deviations are shown in parentheses. TBS = theta-burst stimulation.

### 3. SITUATION MODELS

Situation models are mental representations of the state of the affairs described in the text rather than the text itself and is the representation of that fragment of the word [5, 6]. In another way speaking, as previously described, the situation model would not only simulate what is described in the text but also what is not, or implied, in the text. Referring to the example A girl walks through the clock tower at exactly 12 o'clock at noon, people might not only simulate a girl walks through the tower, but also simulating a clock on the clock tower ringing.

### **3.1 Behavioral Evidence for Situation Model**

In Zwaan 1995[7], the situation model was specified in five event indices---time, space, causality, protagonist, and intentionality---making up the event-indexing model. In this study, Zwaan and his colleagues proposed that when each story or text is comprehended, the readers would update their situation models according to the five indices in the event indexing model. In order to test the validity of the event indexing model, the experimenters designed various stories that included various verbs, and the job of the participants was to classify the verbs in each story according to the event-indexing model. In the story, it says, “As they [the princesses] were being dragged off [by the dragon], they cried for help.” In this sentence, the action of drag and cry happened on the same time, so they would both belong to the temporal class of the event-indexing model. In contrast, some of the word might not even related at all, such as walking on the street and fighting in the castle. The result of this study provided a firm behavioral evidence for the event-indexing model theory.

Besides, many experiments are made to provide valid behavioral evidence for situated text understanding. In 1988, Morrow & Clark et al [8]. constructed a particular study of how people interpret the verb “*approach*” in different contexts. Participants in the experiment inferred different actions for “The stalking cat is approaching the insect” and “The spaceship is approaching Mars”. The larger the landmark and the farther the distance are, the faster participants judge the speed of the object is, which is strongly consistent with the situated text understanding. This study offers convincing evidence on spatial situations for the situation model. In addition, there are also some perspective evidences to account for it.

To further confirm the situation model theory, Morrow et al. construct three relevant experiment to examine whether readers’ focus is associated with the implicit information in the narrative and whether the protagonist’s perspective is related with the character’s mental and physical location [9]. It turns out that readers adopt the protagonist’s perspective or focus on the protagonist from the narrator’s perspective. To be more specific, they find that readers focus on information that is relevant to the protagonist by implication even if it is not mentioned. Also, the location that the protagonist was thinking about are more accessible and so does the association between the location room and the protagonist’s actions [9]. Therefore, based on these experiments of Morrow and other scientists, which provide profound behavioral evidence for the situation model theory, it can be conclusive that people infer more information than the text itself presents during the text comprehension.

### **4. RELATIONSHIP BETWEEN SITUATION MODEL AND EMBODIED COGNITION**

Situation model and Embodied cognition are both shown in their own behavioral evidences. At the same time, it is also worthy to evaluate whether the situation model is embodied. If it is, the modality-specific areas must be activated without the presence of sensory-motor stuff in the text. From the *LASS* theory, we know that Conceptual processing relies on both language and situated simulation [10]. Since situated simulation is multimodal and modality-specific, however, it still remains unclear whether it is the same for the situation models about the others or stories we are unfamiliar with. To further probe in this question, in 2008, Simmons et al. used fMRI to test the activation of the brain during conceptual processing [11]. Although it involved activation in two regions of the inferior frontal gyrus bilaterally in test phase, this study failed to prove the situation model is embodied for several reasons. It only takes tens or a couple of hundred milliseconds to generate a specific simulation. So, in the late phase of the experiment, which last over 7 seconds, the processing even didn’t involve simulation and simulation did not happen after language processing. But this study does provide a springboard for future exploration on the issue.

Current study moves a step forward on the relation between the embodied cognition and situation model. Previous research has shown that word meaning activates the cortex in a modality-specific way [12]. Moreover, people may make more interpretation of the context beyond the form of it due to the situation model theory. In other words, readers are aware of the intentions of the writer [13]. According to Van Ackeren et al. (2013), the results of the study indicate that the comprehension of indirect requests(IR) sentences and action execution activates cortical motor areas reliably. In this study, participants are asked to do some implication tasks, such as the utterance “It is hot here!”, which implies both action of opening a window and visual scenes about a hot desert. As there is no action words present in the sentence, the readers construct situation models to understand the utterance and the motor simulations are part of the situation model. It turns out that comprehension of IR sentences activates cortical motor areas more than comprehension of sentences devoid of any implicit motor information. Also, it reliably activates substantial portions of the theory of mind network, which involves in inferences making of mental states. Since the situation model is not directly mentioned in this study, it cannot be conclusive that the modality-specific area is stimulated during text understanding. While to some extent, it do provide valid evidence for solving the issue.

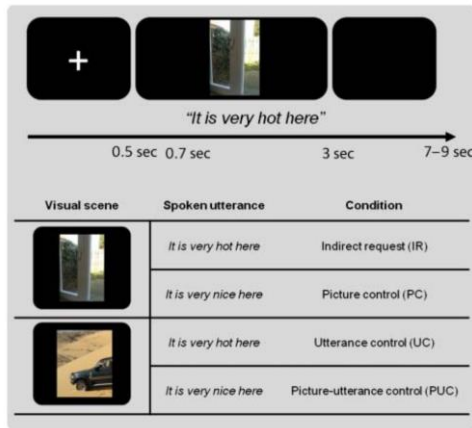


Figure 3 Marcus J. Van Ackeren et al. 2012

## 5. CONCLUSION

In this paper, we generally reviewed the embodied cognition theory and situation model theory with some existing behavioral evidence to support each. Moreover, the issue on the relationship between situation model and embodied cognition is tried to be solved and a few valid evidence are found to directly answer this question. However, some promising methods related with modality-specific area may hopefully make advancement on the question in the future.

Despite a number of papers have provided behavioral evidence for testifying embodied cognition and situation model respectively, it remains unclear about whether situation model is applied in the modality-specific area of the brain. We eventually failed to answer that whether situation model is embodied. But luckily, recent studies are researching more specifically on the overlapping part of the embodiment and situation model. Therefore, to make more effective investigation on this issue, some further approaches are suggested. First, make sure the setting of the utterance does not involve any direct motor-sensory words, which otherwise contradict the situation model (e.g., grasp, catch). Thus, experimenters can generate motor simulation predictably which helps highlighting the related part of situation model and embodiment. Second, crucial modality-specific area should be paid more attention on during the conceptual understanding of the text. Modality-specific areas are broadly tested in the previous studies so that the results of them become meaningless to evaluate on this issue. If the experimenters directly test the modality-specific area during people constructing situation model, whether situation models are embodied may probably turn out to be clearer. However, this could be complicated because the experimenters would need to test the modality activities during situation model construction while avoid implying the participants to construct a situation model.

Looking into the future, experimenters could focus more on the modality specific activities during situation

model creating. But as the current technologies only allows us to test modality specific activities during regular reading or thinking process, maybe the most efficient way would be the elimination method. For example, if a participant is instructed to read the sentence *A girl walks through the clock tower at exactly 12 o'clock at noon*, then his modality specific activities should include motor cortex, which simulates the action of walking. Therefore, if any other modality activities are shown during the process, then he might be constructing a situation model. For example, if the auditory cortex was activated, then he might possibly be thinking about the bell ringing. However, this kind of conclusion would be challenged since it is a deduction rather than a direct evidence.

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