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# RE-enactment or PRE-enactment: Function of Modality-specific Stimulation

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## Abstract

**Over the past two decades, there has been strong empirical evidence suggesting that while many aspects of knowledge of object use are partially determined by previous perceptions-motor experiences, some understanding of tools' function is more flexible under restrictive experimental reconditioning. This paper attempts to examine whether subjects' object knowledge is based on instantiation of prior experience or current body state and the nature of the task(s) asked to be performed. The proposal requires 72 healthy English-speaking subjects who have one of their hands temporarily constricted. The researchers would be then measuring their RTs' difference when the subjects are asked to perform a judgement task. Then, we will predict possible patterns of the data sets and provide a brief theoretical explanation.**

## Keywords

**Embodied cognition; modality specificity; handedness; use of tools.**

## 1. Introduction

Knowledge representation is grounded in the neural mechanisms for perceiving and acting upon entities' real-world referents (1) - this is what cognitive scientists refer as Embodied Cognition (EC), according to which thoughts are implemented in perceptuo-motor simulations located in the brain modality-specific areas (2). Embodied Cognation theory states that whenever we are thinking of a conceivable object (either concrete or abstract), one or several modality-specific brain areas would be activating independent sensual stimulations to instantiate the object or concept. Thus far, a plenty of theoretical studies and empirical papers have provided robust behavioral and neurological evidence for this theory, demonstrating that retrieval of certain knowledge about objects' usage would activate a distributed circuit of property representations in and around the brain's systems for perception, action, and interoception (3); in addition, research has also indicated that people activate perceptual symbols in response to different textual stimuli (4). However, very few scientific literatures have been published to account for why people would run modality-specific stimulations in the very first place (i.e. what is the construct benefits, if any, for peoples' cognition and reaction mechanism to be arranged in such pattern). Despite numerous papers have already explained WHAT is Embodied Cognition theory and HOW it operates, we are still in urgent need to study WHY EC is a better theory in terms of its functionality.

So why exactly would people run stimulations in their brains and instantiate different objects or concepts in modality-specific brain regions? According to traditional theoretical explanation from Pulvermüller et al. (5,6), stimulations are RE-enactment of prior experiences. However, the theoretical base for this assumption is in great dispute amongst scientific community.

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Moreover, this theory has never been truly experimentally tested. Willems et al. (7) have challenged this assumption, suggesting alternatively that EC simulations are PRE-enactments of potential future experiences, so people who run stimulations in their brains could better prepare themselves for the upcoming events. For instance, if a baseball player wants to catch a ball, she would picture herself being at a hypothetical position where she could firmly grasp the ball and readjust her postures to make the best chance reaching that spot. So, how could we tell whether stimulations are best understood as RE-enactments or PRE-enactments of external stimuli?

In previous papers, researchers have tested object representations in subjects with natural left and right handedness, and stroke patients who have permanently lost the use of left or right hand. Inspired by this experimental methodology, our research team want to further investigate whether similar situations would happen to people without severe brain damage by employing similar experimental conditioning. Using the preceding approach, this work will inquire the foundational question of EC: What is the function of modality-specific simulation and why is brain built to run that simulation? Do tool-grasping effects follow subjects' history of object usage or their current capabilities? To answer this question, researchers will test the RTs of subjects (whose hand is physically restricted) when asked to evaluate a tool's daily function.

## 2. Investigation

### 2.1. Experiment

#### 2.1.1. Participants

In this work, researchers plan to recruit 72 healthy native English speakers as the subjects of our study. All subjects have normal or corrected-to-normal visions and no movement disorders. Participants would provide a formal consent in compliance with American Psychological Association ethical standards before conducting the experiment. Participants would report their natural handedness before dividing into different subgroups. Handedness was confirmed by the Edinburgh Handedness Inventory (8). The sample size of each study is quantitatively determined by medium-large effect sizes (ranging from 1.41 to 2.46) calculated from studies performing similar tasks (9). To test the statistical significance, researchers will be performing a power analysis (10) for a mixed factorial ANOVA within group variables, with the estimation that 15-18 participants for each condition is enough for satisfactory power to detect any significant effects.

#### 2.1.2. Materials

Researchers plan to replicate the same experimental material as used by previous studies (9). 96 black-and-white images of familiar tools are presented to subjects as visual stimuli. All of these tools have handles which can be easily grasped. Half of these objects are oriented to the left direction and the other half to the right. All of the tool images are displayed against a white background.

There was a pilot study to verify whether these graspable tools in the images are perceived to be in the intended orientation. Participants in the pilot study need to identify each object and rate each object as either better oriented for a left-handed person or a right-handed person. Two examples of images are presented in Fig.1.

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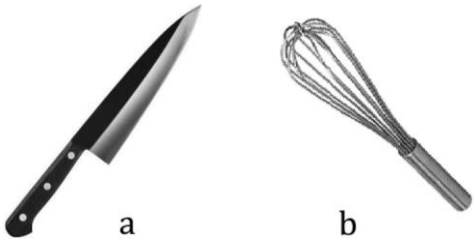


**Fig 1.** Examples of images: (a) a left-oriented tool (b) a right-oriented tool (11).

### 2.1.3. Procedures

After signing the consent, all participants need to complete the EHI test (8), and then randomly divided into two subgroups. In group A, participants' non-dominant hands are demobilized with a medical bandage: left-handed people tie their right hands, and right-handed people tie their left hands. In group B, by contrast, participants' dominant hands are tied up: left-handed people tie their left hands, right-handed people tie their right hands. The bounded hands cannot move properly throughout the experiment.

Then, participants will be instructed to perform a manipulation judgment task (9), in which they are asked to observe the images of tools in random order, and verbally identify, as quickly as possible, the type of grasp action they would employ (i.e., clench or pinch) when using each object for its typical everyday function (see Fig.2 for physical demonstrations). Subjects are instructed to remain silent if they don't know the answer. Researchers choose verbal responses over key press to eliminate the potential influences of manual response mode in conjunction with handedness on RTs.

Participants will first complete several trials to familiarize themselves with the experimental conditioning and procedures, as well as to test if their verbal response is loud and articulate enough to be clearly recorded by experimenters.

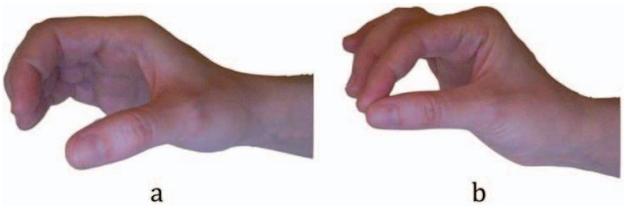


**Fig 2.** Physical demonstrations of two types of grasp options: (a) clench (b) pinch (11).

### 2.1.4. Data Analysis

Researchers will be performing two major inter-and-intra group data analysis.

(a) Is there a significant difference in RTs towards the tools that are oriented to their free hand (the hand that hasn't been tied up) between two groups of subjects?

Researchers will be using this data analysis to determine whether it is their history of object use that affects the object manipulation.

(b) Within two groups, to which side of the oriented tools would the subjects' RTs be noticeably faster?

(1) Do the subjects in Group A respond faster to tools that are faced towards their dominant than their non-dominant hand side?

(2) Do subjects in Group B respond faster to the tools that are faced towards their restrained hand or their free hand side?

The data in group A could be used to verify the conclusion of previous study, that is, whether subjects using their dominant hands or not, could affect RTs in manipulation judgment.

The data in group B would determine whether the current physical state has caused the difference in RTs in manipulation judgements.

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## 2.2. Prediction

P1: If motor simulation is pre-enactment of potential future actions, then the pattern of grasp RTs should follow the subjects' assigned hand restriction: Subjects with their left hand restricted (right hand free) should be faster for tools with their handles pointed to the right, and vice versa.

P2: If motor simulation is RE-enactment of prior tool use (in accord with what is hypothesized by Barsalau et al.), then all subjects should show the natural "righty effect", regardless of which hand has been restricted. They should all respond faster (on average) when the tool handles point to the right — consistent with their HISTORY of tool use.

P0: No clear statistical pattern would be observed.

# 3. Conclusion

In this paper, we have examined the historical development of embodied cognition theory, its purpose, or lack thereof; designed a single-variable experiment to test our hypothesis; and provided corresponding predictions for each possible outcome. The highlight of this study is that we have visualized two possible results with empirically accessible outcomes and removed confounding variables that could potentially obfuscate us from drawing any further conclusions. If we could manage to elucidate the function of embodied cognition, then, for further study, we could research on its applications in clinical, educational, organizational, economic, and other fields that are closely related to humans' cognitive patterns.

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