Action-based Memory is Better than Speech-based Memory in Recognition:
A Near-Infrared Spectroscopy Study

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Introduction

In the present study we examined the neural correlates for incidental learning of three kinds of memory: outer speech (reading aloud), action (gesturing), and inner speech (silent reading). We hypothesized that action-based memory would have a stronger memory trace than speech- and silent reading-based memories because action seems to facilitate memory (Cook, et al., 2010; Cook, et al., 2012) and we hypothesize that these memories will each activate distinct areas of the brain such as the left middle and superior temporal regions i.e., speech and silent reading (Price, et al., 1994).

Method

Participants: Twenty-four university students (all right-handed; 12 females, 12 males).

Materials: We used 60 simple (Object-Particle-Verb) kana-only sentences (e.g.: ࡃ࠿࡛ࣥ࣌). 40 sentences were used in the learning and recognition sessions and the other 20 sentences were used in the recognition session as new items. The particles DE (࡛) and WO (੢) were used in a 1:1 ratio. An additional five sentences were used for practice.

Procedure: The learning sessions contained two tasks: Action and Speech (order counterbalanced across participants). In Action, 20 sentences were presented on a monitor. 10 sentences instructed the participant to gesture (using right-hand only); the other 10 sentences instructed to silently read. In Speech, a different set of 20 sentences were presented. 10 sentences instructed the participant to speak aloud; the other 10 sentences instructed the participant to silently read. Sentences were randomly presented and shown for 5 seconds at a time via a monitor. Action and Speech began with two practice sentences. After the learning session, a recognition session, which the participants had not been informed about, was conducted. Participants were once again presented the 40 sentences from the learning session as well as 20 additional filler (new) sentences which the participant were not shown in the learning session. The participant was asked to report their performance in the learning session via a keypad (i.e., 1. Speech, 2. Action, 3. Silent Reading) but if the participant had not seen the sentence in the learning session (i.e., the fillers), the participant was asked to report “4. New Sentence.” Participants were shown the sentences for a maximum of 10 seconds at a time via a monitor. After the participants made their choice, they were also asked about the confidence of their decision using a 1-6 scale; 6. Extremely Confident to 1. No Confidence. Participants had a maximum of 5 seconds to make this choice. The recognition session began with five practice sentences. After the experiment, participants completed a survey rating each sentence in terms of comprehension, imagineability, frequency seen, frequency done, and criminality.

NIRS data acquisition. A 95-channel NIRS unit (LABNIRS; Shimadzu, Japan) was used to measure brain activity of the participants during the experiment.

Results

Figure 1 shows mean correct recognition rates of the four response types. We conducted one mixed design three-way analysis of variance (ANOVA) with List (1, 2, 3, 4) as a between factor and Response (Speech, Action, Reading, New Sentence) and Sentence Type (DE, WO) as within factors. The result of ANOVA revealed only a main effect of Response, $F(1, 23) = 46.67, p < .001$. Action was recalled significantly more accurately than speech and reading ($p < .05$ for multiple comparison test with Bonferroni correction). Reading and New Sentence were recalled significantly more accurately than Speech ($p < .05$).

Conclusion and Future work

Participants accurately distinguished between performing an action for each sentence and accurately perceived when a new sentence was presented. However, participants did not accurately distinguish between inner and outer speech (i.e., reading aloud and reading silently). The result suggests that the memory traces for action are stronger than other kinds of memories, and this implication will be confirmed by NIRS data analysis.

![Figure 1. Mean correct recognition rates of the four response types.](image-url)