How We Teach Vocabulary Matters: Extending Gesture'S Impact on Word Learning to Reading

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Abstract

The purpose of this study was to examine how learning words with matching and mismatching representational gesture affects subsequent comprehension of these newly-learned words within read sentential contexts. Results did not support our hypothesis that pseudowords learned via text and co-occurring semantically-congruent representational gestures would enhance subsequent identification and processing when reading them in sentential contexts. Implications are discussed.

1 Introduction

Cognitive Load Theory maintains that complex tasks are difficult to execute because they place a heavy demand on cognitive resources (Sweller, 1994). One such complex task is vocabulary learning, which involves associating novel words, which are often composed of arbitrary combinations of speech sounds, with known meanings. As postulated by Dual Coding Theory (DCT; Clark & Paivio, 1991), pairing representational gestures, which convey word meaning visually via form and motion, with corresponding speech can reduce the cognitive load of vocabulary learning. This occurs by splitting the cognitive load between the visual and verbal representation systems, thus allowing improved processing and recollection of newly-learned words.

The Integrated Systems Hypothesis posits that when gesture and speech occur conjointly both are processed bi-directionally and obligatorily (ISH; Kelly et al., 2010). Thus, language comprehension occurs in such a way that information from one modality (speech) cannot be processed without being influenced by information from the other modality (gesture). Behavioral studies have indicated that semantically-congruent gesture that co-occurs with speech enhances comprehension and memory while semantically-incongruent gesture hinders these processes (see Hostetter, 2011 for a meta-analysis).

Although the effects of representational gesture (henceforth, gesture) on spoken language processing and vocabulary learning are well-understood, the impact of gesture on learning vocabulary words presented via text has not yet been investigated. Further, it is unknown how learning words via text and co-occurring gesture affects subsequent reading of these words in sentential contexts. Thus, the purpose of this study was to examine how learning pseudowords (i.e. fake words) presented via text with matching (semantically-congruent) and mismatching (semantically-incongruent) gestures affects subsequent integration of these newly-learned pseudowords into semantically-congruent and semantically-incongruent read sentential contexts. In doing so, it reveals how word learning strategies—specifically, those incorporating gesture—later affect reading comprehension.

In order to investigate the research question, a self-paced reading (SPR) paradigm was employed. SPR paradigms are useful for examining how sentences are processed because they allow participants to determine how long to spend reading each word by pressing a button to reveal each word sequentially (Jegerski, 2014). To determine how pseudowords learned with matching and mismatching gestures are subsequently integrated into read sentential contexts, we manipulated both the semantic match between gestures and definitions at word learning and the semantic congruence of gestures and word definitions relative to sentential contexts during sentence reading. As will be described in further detail, this required a design in which the definitions of learned pseudowords and gestures were each independently semantically-congruent or -incongruent (matching or mismatching) relative to subsequent read sentential contexts.

It was hypothesized that pseudowords learned with matching gestures would result in improved processing and recollection upon subsequent sentential reading exercises, such that:

1) Pseudowords learned with matching gestures would be identified more accurately and more quickly when used in both semantically-congruent and semantically-incongruent sentential contexts than pseudowords learned with mismatching gestures.
2) Pseudowords learned with matching gestures would be processed more quickly during subsequent reading in both semantically-congruent and semantically-incongruent sentential contexts than pseudowords learned with mismatching gestures.

Further, it was hypothesized that the gesture a pseudoword was learned with would influence subsequent comprehension of the word in sentential contexts, such that:

3) Pseudowords learned with matching gestures and read in incongruent contexts, in which both the definition of the pseudoword and the gesture the pseudoword was learned with were semantically-incongruent, would be more slowly identified and would take longer to process than when read in semantically-congruent contexts.
4) Pseudowords learned with mismatching gestures and read in incongruent sentential contexts, in which the definition of the pseudoword was semantically-congruent but the gesture the pseudoword was learned with was semantically-incongruent, would be more slowly identified and would take longer to process than pseudowords read in semantically-incongruent sentential contexts in which the definition was semantically-incongruent and the gesture was semantically-congruent.

2 Methods

2.1 Participants

Thirty-two adult native English speakers (*M* = 19.59 yrs.; *SD* = 2.07 yrs.; 23 females, 9 males) were recruited to participate in the current study for partial course credit. All participants had normal hearing and normal or corrected-to-normal vision. Additionally, all participants were screened for documented speech, language, or learning disabilities. All procedures were approved by the Institutional Review Board at the University of Alabama.

2.2 Procedure

Through a succession of interleaved word learning and SPR blocks, participants learned a total of 96 pseudowords consistent with English phonotactic rules via English definitions preceded by gestures. During word learning blocks, participants viewed the following sequence twice: pseudoword as text; video of gesture either matching or mismatching the pseudoword's meaning; English definition as text; inter-stimulus interval (1000 ms). Participants were instructed that English definitions represented the meanings of pseudowords and that gestures may either match or mismatch the meanings of pseudowords. Within each learning block, two pairs of pseudowords were presented. If one of the pseudowords within the pair was learned with a matching gesture, the other was also, and vice versa (see Figure 1). For example, if participants learned *kroosk – to drink* with a ***drinking*** gesture, they would learn *fesp – to sweep* with a ***sweeping*** gesture. The opposite would occur within a mismatching pair, such that participants would learn *kroosk – to drink* with a ***sweeping*** gesture, and *fesp – to sweep* with a ***drinking*** gesture.

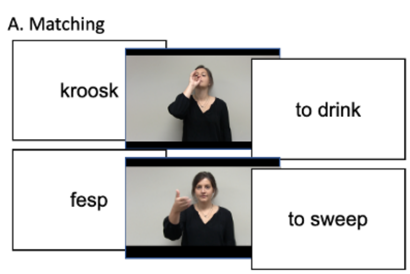

Figure 1: Matching Word Learning Trial

After learning two pairs of pseudowords at a time (a total of four words), participants began a SPR block. During SPR trials (see Figure 2), participants were directed to read a context sentence presented wholesale (e.g., *He was thirsty*). The context sentence was followed by a critical sentence presented one word at a time (e. g., *He/used/the/cup/to/…*) ending with a pseudoword from the previous learning block (e.g. *kroosk*). Participants were instructed to read all stimuli as quickly as possible, proceeding through them by pressing a button. In critical sentences, there were four possible conditions in which congruency of both definitions and gestures associated with pseudowords were varied orthogonally:

1) Semantically-congruent definition within the sentential context, learned with a matching gesture semantically-congruent with the sentential context (definition-congruent, gesture-congruent)
2) Semantically-incongruent definition within the sentential context, learned with a matching gesture semantically-incongruent with the sentential context (definition-incongruent, gesture-incongruent)
3) Semantically-congruent definition within the sentential context, learned with a mismatching gesture semantically-incongruent with the sentential context (definition-congruent, gesture-incongruent)
4) Semantically-incongruent definition within the sentential context, learned with a mismatching gesture semantically-congruent with the sentential context (definition-incongruent, gesture-congruent)

Immediately after reading the pseudoword, participants responded to the pseudoword-sentential congruency probe: "Did the final word fit within the sentence?" In the experimental task, latency for SPR of pseudowords within critical sentences as well as accuracy and latency for correct responses to pseudoword-sentential congruency probes were examined.

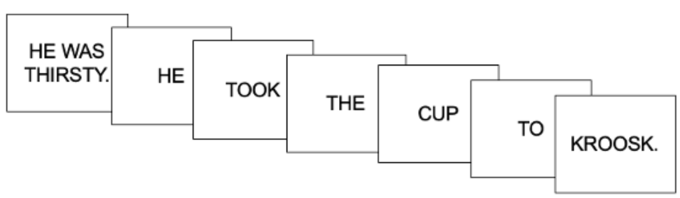

Figure 2: Congruent Sentence Reading Trial

2.3 Stimulus Norming

All stimuli within word learning and sentence reading trials were counterbalanced in congruency and separately randomized in order within blocks. Prior to the experimental task, norming was conducted with native English speakers who did not participate in the experimental task. English definitions representing the meanings of gestures were selected from among those in the same block 77-100% of the time (n=30; M=94%; SD= 4.5%). Additionally, matching gesture-definition pairs were rated as more semantically-similar than mismatching gesture-definition pairs

(n=33; match: M=5.95, SD=1.35; mismatch: M=2.20, SD=1.64; B=-3.76, t=-14.85, p <.001). Finally, critical sentences were completed with the correct English definition with 73-100% accuracy (n=30; M= 88%; SD=7.4%).

3 Results

Prior to analysis, latencies greater than three standard deviations beyond cell means or below 100 ms were trimmed. Latencies for SPR of pseudowords and responses to pseudoword-sentential congruency probes were modeled via linear mixed-effect regression. In all models, the maximal random effect structure justified was implemented.

Contrary to the first hypothesis, results did not indicate increased accuracy on the pseudoword-sentential congruency probe when words were learned with matching gestures compared to when words were learned with mismatching gestures (see Figure 3). Response discrimination analysis using signal detection theory revealed an overall bias to respond that pseudowords were semantically-congruent with critical sentences (B=0.93, z=13.68, p<.001). This bias was reversed when pseudowords were semantically-incongruent with critical sentences (B=-1.61, z=-18.98, p <.001). Crucially, however, response discrimination was not affected by gesture-sentence congruency. Further, there was no difference in reaction time for the pseudoword-sentential congruency probe when words were learned with matching gestures compared to when words were learned with mismatching gestures (B=61.44, SE= 37.34, t= 1.65, p =.10; see Figure 4).

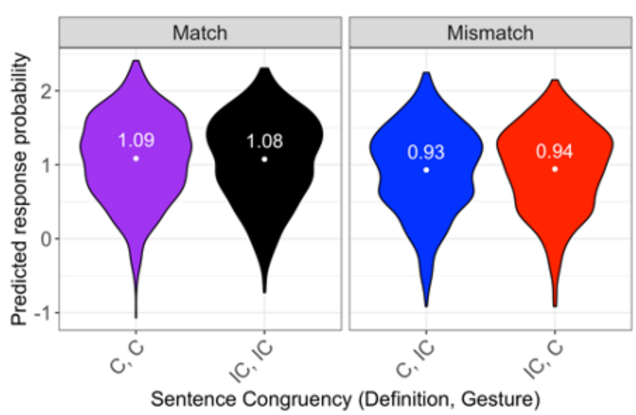

Figure 3: Discrimination on Pseudoword-Sentential Congruency Probe

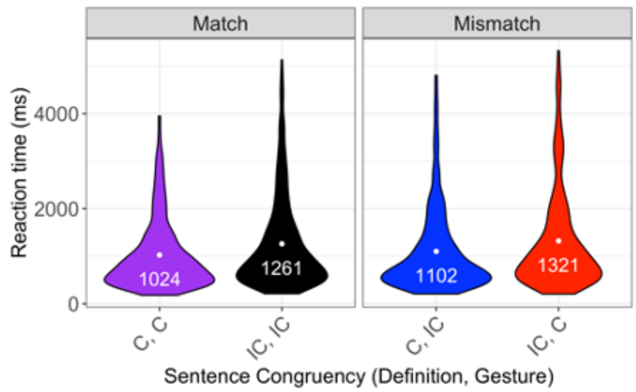

Figure 4: Reaction Time on Pseudoword-Sentential Congruency Probe

Contrary to the second hypothesis, results did not indicate increased SPR latencies when reading pseudowords learned with mismatching gestures compared to reading pseudowords learned with matching gestures (*B*=1.84, *SE*= 2.31, *t*=0.80, *p*=.42; see Figure 5). In alignment with the third hypothesis, when pseudowords were learned with matching gestures, longer reaction times were observed on the pseudoword-sentential congruency probe when pseudowords were read in semantically-incongruent contexts than when pseudowords were read in semantically-congruent contexts (*B*=244.44, *SE*= 61.71, *t*=1.65, *p*<.001; see Figure 4). This was expected because in semantically-congruent contexts, both the definition of the pseudoword and the gesture the pseudoword was learned with match the context of the sentence. These results were not replicated for SPR latencies, which did not differ based on whether a pseudoword, learned with a matching gesture, was read in a semantically-congruent or a semantically-incongruent context (*B*=0.25, *SE*= 4.32, *t*= 0.06, *p* < .96; see Figure 5).

Finally, contrary to the fourth hypothesis, when words were learned with mismatching gestures, longer reaction times on the pseudoword-sentential congruency probe were observed when the definition of the pseudoword was

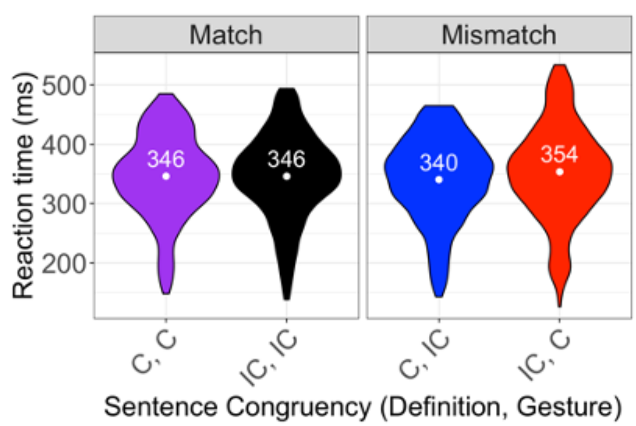

Figure 5: SPR Latency of Pseudowords in Critical Sentences

semantically-incongruent and the gesture the pseudoword was learned with was semantically-congruent with the sentential context, compared to when the definition was semantically-congruent and gesture was semantically-incongruent (*B*=216.53, *SE*=63.79, *t*=3.39, *p*=.002; Figure 4). These results were replicated when investigating SPR latency, such that longer SPR latencies were observed when reading pseudowords learned with mismatching gestures in sentential contexts in which the definition of the pseudoword was semantically-incongruent and the gesture the pseudoword was learned with was semantically-congruent (*B*=9.83, *SE*=3.27, *t*=3.00, *p*=.003; see Figure 5).

4 Discussion

These results do not support our hypothesis that pseudowords learned via text and co-occurring semantically-congruent gestures would enhance subsequent identification and processing when reading them in sentential contexts. Further, they only somewhat support our hypothesis that the gesture a pseudoword was learned with, whether matching or mismatching, would influence subsequent processing of the word in both semantically-congruent and semantically-incongruent sentential contexts. Although results did indicate longer reaction times when participants were identifying pseudowords learned with matching gestures read in semantically-incongruent contexts, this effect was not replicated with longer processing times in SPR blocks. Further, there was not an effect of mismatching gesture on identification or processing speed when reading pseudowords in semantically-congruent and -incongruent sentential contexts. Contrary to the hypothesis, longer reaction times and processing speed were observed when pseudowords were learned with mismatching gestures and read in sentential contexts in which the pseudoword's definition was semantically-incongruent with the sentence rather than when the gesture the pseudoword was learned with was semantically-incongruent with the sentence. This result indicates that, contrary to the hypothesis, the gesture the pseudoword was learned with does not influence sentential processing as much as the definition of the word does.

By not finding increased accuracy or reduced reaction times on the pseudoword-sentential congruency probe, our results are not in alignment with the ISH. The ISH (Kelly et al., 2010) posits that when gesture and speech occur conjointly, both are processed bi-directionally and obligatorily, enhancing memory and comprehension. Our results do not suggest that presenting words as text along with sequential semantically-congruent gesture enhances later memory or comprehension. Further, only the increased reaction times when processing a pseudoword semantically-incongruent with both gesture and definition within a sentence, is in support of DCT (Clark & Paivio, 1991), which maintains that pairing representational gestures with corresponding speech can reduce the cognitive load of vocabulary learning by splitting it between the visual and verbal representation system, enhancing memory and processing. Therefore, pseudowords that are recognized as fully-incongruent should take longer to process (Kelly et al., 2015). To fully support DCT, our results would have needed to indicate increased accuracy on the pseudoword-sentential congruency probe for pseudowords learned with matching gestures, as well as consistent increases in SPR latencies when reading mismatching pseudowords in incongruent contexts, indicating processing deficits.

One reason as to why no consistent effect of semantic match or gesture or definition congruency on processing speed during SPR was observed may be because the directions explicitly stated to proceed through the sentences as quickly as possible. Those directions may have encouraged participants to process pseudowords once they had already left the screen, suggesting our SPR measure may not have reflected this additional processing time. A future study is planned to address this possible confound and to obtain more information as to how learning pseudowords with matching vs. mismatching gestures affects subsequent processing and comprehension. Further, behavioral measures may not be precise enough to reveal subtle differences in word representations that occur when learning words with matching vs. mismatching gestures (Henderson et al., 2011). However, this study can serve as a preliminary example of how SPR paradigms can be used to investigate the effects of word learning strategies on subsequent processing and comprehension of newly-learned words in read sentential contexts.

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