When Hands Speak Louder Than Words: The Role of Gesture in the Communication, Encoding, and Recall of Words in a Novel Second Language

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In the interest of clarifying how gesture facilitates L2 word learning, the current study investigates gesture's influence on three interrelated cognitive processes subserving L2 word learning: communication, encoding, and recall. Individuals unfamiliar with Hungarian learned 20 Hungarian words that were either accompanied or unaccompanied by gestures depicting their referents, and taught the meanings of the words to interlocutors who were also unfamiliar with Hungarian. All participants were then tested for their recall of target words. The results show that gesture facilitates all three cognitive processes, supporting the predictions of McNeill's (2005) growth point theory. Furthermore, the results indicate that gesture production facilitates all of the cognitive processes more effectively than gesture viewing. Overall, the results demonstrate that gesture can serve as an effective cognitive aid for L2 word learning by beginning L2 learners, particularly in task-focused, conversational settings.

Keywords: gesture; vocabulary; discourse

SECOND LANGUAGE (L2) ACQUISITION, like other aspects of human communication, is profoundly multimodal. In both classroom and conversational settings, L2 learners and their interlocutors use *gesture*—meaningful hand movements—in conjunction with the target language to convey information (Adams, 1998; McCafferty, 2002; Sueyoshi & Hardison, 2005). Although previous research has shown that gesture benefits the early stages of L2 acquisition, particularly in the realm of word learning (Gullberg et al., 2010; Kelly, McDevitt, & Esch, 2009; Lazaraton, 2004; Tellier, 2008), it is unclear which of the cognitive processes involved in the early stages of L2 acquisition is affected by gesture. Using a discursive experimental task focused on word learning, the current research investigates the role of gesture in three interrelated cognitive processes essential in the initial stages of L2 acquisition: communication, encoding, and recall. By examining the impact of various types of gestures in this task, it provides insight into the functions that gesture serves in early L2 acquisition, leading to a better understanding of how gesture supplements speech to facilitate L2 learning.

In order to understand how gesture can contribute to L2 acquisition, it is necessary to understand the relationship among gesture, speech, and thought. Based on naturalistic, crosscultural observations of gesture and speech production

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(Efron, 1941; Kendon, 2004), as well as more recent experimental work (Frick–Horbury & Guttentag, 1998; Kita & Özyürek, 2003; Rauscher, Krauss, & Chen, 1996), several models have been proposed to explain the relationship between gesture and language during speech production. One of the most prominent of these models, *growth point theory* (McNeill, 1992, 2005), posits that co-speech gestures (gesticulations) arise from growth points, which are "where new verbal idea unit[s] take form in the stream of the speaker's experience" (McNeill, 2005, p. 82). According to this theory, growth points are conceptual, but are influenced by typological and sociocultural constraints, such as the language spoken and the discourse context. Growth point theory arose within the tradition of Vygotsky (1986), who maintained that language and thought interact dynamically, influencing one another in development. In support of growth point theory, crosslinguistic research has shown that the gestures of speakers of verb-framed languages (e.g., Romance languages) convey manner of motion, and that the gestures of speakers of satellite-framed languages (e.g., Germanic languages) convey path of motion, complementing the motion information that is conveyed via verb phrases in these languages (Özyürek et al., 2005). Growth point theory contrasts with other models in which gesture and language are independent of one another (deRuiter, 2000; Krauss, Chen, & Gottesman, 2000). These models posit that the cognitive representations underlying gesture and speech are separate, and that gesture and speech do not influence one another conceptually. Growth point theory and these alternative models lead to conflicting predictions about the role of gesture in the cognitive processes subserving L2 acquisition. Specifically, growth point theory predicts that gesture should enhance L2 communication, encoding, and recall, whereas the alternative theories outlined above predict that gesture should enhance only communication in the target language.

In addition to growth point theory, McNeill (1992) proposed a taxonomy of gestures that is accepted and used by many researchers regardless of theoretical orientation. This taxonomy contains four basic types of co-speech gestures. *Iconic* gestures convey the physical affordances of concrete entities or actions (e.g., sweeping motions accompanying the word "broom"). *Metaphorical* gestures convey an abstract idea by physically expressing concrete attributes associated with it (e.g., moving the hands apart horizontally to convey length). Iconic and metaphorical gestures are both types of representational gestures, which depict attributes of meaning through their handshape or articulation. *Beat* gestures, on the other hand, are simple rhythmic movements reflecting speech prosody or emphasis (e.g., finger taps produced on stressed syllables of an utterance). Finally, *deictic* gestures direct attention through their handshape, which consists of one or more fingers extended in the direction of a concrete or abstract entity (e.g., pointing to the wrist, where a watch is worn, to indicate the time). McNeill's gesture classification system is ideal for research examining the role of gesture in various cognitive processes because it captures attributes such as communicativeness and representativeness, revealing how gestures are used and what types of information are conveyed through them. This classification system is also ideal for research investigating the functions of gesture within L2 acquisition, given that it captures the universality of co-speech gestures (McNeill, 2005) while providing the flexibility to examine variation in the form, interpretation, and use of gestures stemming from linguistic and cultural influences.

In the context of L2 learning, communication can be defined as the exchange of ideas in or pertinent to the target language. Within this context, co-speech gesture can serve as a nonlinguistic means of communication, supplementing information expressed via the target language. Consistent with this conceptualization, native English speakers produce more deictic and representational gestures when retelling a narrative to L2 English learners than to other native English speakers (Adams, 1998). Similar patterns of gesture use were observed in a classroom-based study in which the teacher spontaneously used representational gestures to convey the meanings of novel vocabulary words to L2 learners (Lazaraton, 2004). Both of these findings indicate that native speakers rely on representational—and perhaps also deictic—gestures to a greater degree when speaking to L2 learners than native interlocutors. As such, they provide evidence that representational and deictic gestures enhance communication between native speakers and L2 learners, and suggest that they may facilitate the cognitively demanding task of L2 acquisition, particularly for beginning learners.

Lantolf (2010) proposed that gesture visually reflects L2 learners' cognition when speaking in—or about—the target language, allowing them to think and communicate more effectively. Several studies examining L2 discourse by learners have provided evidence supporting this claim.

When conversing with native speakers, novice L2 learners often produce representational gestures when they are unable to complete an utterance in the target language. This prompts their interlocutors to suggest appropriate completions, sometimes while producing similar gestures themselves (McCafferty, 2002; Mori & Hayashi, 2006). Similarly, there is evidence from classroom research that L2 learners spontaneously produce representational gestures to convey aspects of L2 word meaning that they cannot express verbally (Smotrova & Lantolf, 2013). This research showed that instructors utilized learners' spontaneous gestures by integrating them into their corrective feedback, and learners reused the gestures in conjunction with corrected target language speech, demonstrating improved understanding. Two other studies conducted in classroom settings showed that L2 learners spontaneously produce representational gestures when using and explaining grammatical forms in the target language to instructors and peers (Lantolf, 2010; van Compernolle & Williams, 2011). Although the gestures of learners may have arisen from the cognitive demands of the L2 learning tasks examined in these studies, social interaction was a part of all of the tasks. Thus, the findings indicate that L2 learners' gestures enhance not only their cognitive processing, but also their communication with interlocutors in and about the target language, and that co-speech gesture may enhance L2 learners' spoken expression in the target language.

In addition to facilitating L2 communication, there is evidence that gesture may enhance L2 acquisition itself, particularly in the realm of word learning. Experimental research has shown that school-aged children learn novel words from an unfamiliar L2 more effectively when the words are presented in conjunction with representational gestures depicting referents than with images portraying referents or as speech alone (Tellier, 2008). Similarly, adults recall L2 figurative phrases (Allen, 1995) as well as L2 verbs (Kelly et al., 2009; Macedonia, Müller, & Friederici, 2010) more effectively when they are presented in conjunction with representational gestures depicting their referents than when they are presented as speech alone. Notably, the studies by Kelly et al. (2009) and Macedonia et al. (2010) showed that words presented with representational gestures that depicted entities other than their referents were learned less effectively than words presented with representative gesture or as speech alone. Moreover, two other studies demonstrated that representational gestures depicting word referents can hinder the acquisition of phonologically similar L2 words (Kelly & Lee, 2012). Taken together, these findings show that that the relationships between the features of gesture and speech affect how L2 words are represented in the mind. In particular, they indicate that representational gestures can facilitate L2 word learning, but only if they depict the referents of phonologically distinct L2 words through their form.

Research on L2 listening comprehension provides additional evidence of how gesture can enhance L2 acquisition. One line of research investigated how effectively people can learn an unfamiliar target language given audiovisual input in the language without translation (Gullberg, Roberts, & Dimroth, 2012; Gullberg et al., 2010). Dutch speakers watched a 7-minute video of a native Mandarin speaker reporting the weather with accompanying gestures, and were afterwards tested for their ability to identify Mandarin phonological, lexical, and syntactic information. The results revealed that participants could recognize and identify the meanings of key Mandarin words that had been accompanied by representational gestures depicting their meanings (Gullberg et al., 2012). Furthermore, participants could readily identify Mandarin phonological and syntactic irregularities inconsistent with the phonological and syntactic information conveyed through the weather report (Gullberg et al., 2010). Another line of research compared the influences of gesture and the face on L2 learners' comprehension of information in a known target language (Sueyoshi & Hardison, 2005). In this work, English as a second language learners of varying levels of proficiency listened to one of three versions of a lecture in English consisting of either speech only, speech and video of the speaker's face, or speech and video of the speaker's face and hands, and answered questions about the lecture's conceptual content afterwards. The results showed that low intermediate L2 learners recalled the most information from the lecture in which both the speaker's face and gestures were visible, and that advanced learners recalled the most information from the lecture in which only the speaker's face was visible. Both groups recalled the least information from the lecture consisting only of speech. Together, the results of these two lines of research on L2 listening comprehension suggest that gesture may be most effective during the early stages of L2 acquisition, when it can enhance comprehension of the structure of the target language as well as information conveyed through it.

As can be seen from the research discussed, previous work on gesture's role in L2 acquisition has been conducted in a variety of settings ranging from naturalistic conversation to classrooms to laboratories, raising the question of how gesture's impact may vary in these environments. In general, research conducted in laboratories tends to focus on the effect of gesture comprehension on L2 word learning, whereas research conducted on classroom learning and naturalistic conversation tends to focus on the effect of gesture production on L2 communication. Moreover, laboratory research often examines L2 acquisition in participants unfamiliar with the target language, whereas classroom and conversational research typically examine L2 acquisition in participants who have been learning the target language for some time. Although research in both types of settings has produced positive results, particularly for representational gestures depicting L2 word referents, it is unclear whether gesture comprehension and production are similarly effective, and whether their effects vary as a function of participants' proficiency in the target language. Furthermore, in the interest of examining the causal relationship between gesture and L2 word learning in the purest possible manner, laboratory paradigms present participants with highly controlled, uniform instruction consisting only of target word and gesture recordings. In contrast, studies of gesture's effect on L2 word learning within classroom and conversational settings investigate the rich, varied interactions between learners and their interlocutors within which L2 acquisition often occurs in real time outside of the laboratory. To determine how gesture affects L2 word learning across these settings, an experimental design is needed that combines the internal validity of the laboratory with the external validity of conversations that occur inside and outside of the L2 classroom. The current study utilizes such a design, providing it with strong internal and external validity while also permitting direct comparisons of the effects of gesture viewing and production on L2 word learning.

Although extant research provides provocative information about the role of representational gesture in L2 communication, encoding, and recall, it raises important questions concerning other types of gestures and two of these cognitive processes. One such question concerns the role of deictic and beat gestures in L2 word learning. Although no research has directly addressed the roles of these gestures in L2 word learning, one study showed that adults recall words from their native language that are accompanied by beat gestures just as well as words accompanied by representational gestures (So, Sim Chen–Hui, & Low Wei–Shan, 2012). This finding suggests that the emphasis conveyed by beat gestures may direct adult L2 learners' attention to target words as effectively as the visual form of representational gesture. Another question that extant research raises is whether gesture affects the storage (encoding) or retrieval (recall) of L2 words from memory. In many previous studies of L2 word learning and listening comprehension, gestures were presented while L2 information was encoded, but performance was measured based on the recall of this information in the absence of gesture (Allen, 1995; Kelly et al., 2009; Macedonia et al., 2010; Sueyoshi & Hardison, 2005; Tellier, 2008). As a result, it is unclear whether the findings of these studies demonstrate that gesture facilitates L2 encoding, recall, or both. By investigating the relationships between speech and all types of gestures produced within a conversational L2 word learning task, as well as the effect of these gestures on L2 word recall, the current study addresses these issues, contributing to the knowledge of how gesture affects L2 acquisition.

THE STUDY

The current study addresses the following two research questions concerning gesture's effect on L2 acquisition:

RQ1. How does gesture affect communication, encoding, and recall in the initial stages of L2 learning?
RQ2. How does gesture's impact on users compare to its impact on viewers in dialogic L2 interactions?

The current study focused on the processes of communication, encoding, and recall because previous work had suggested that production and/or comprehension of certain types of gesture enhances these processes. In the interest of elucidating how gesture's form contributes to its function within L2 acquisition, this study investigated the contribution of three of the most common types of co-speech gestures: representational, beat, and deictic gestures. Because previous work suggests that gesture's impact is greatest during the earliest stages of L2 acquisition (Sueyoshi & Hardison, 2005), and that it is particularly conducive to L2 word learning—one of the first tasks attempted when learning a novel target language (Allen, 1995; Gullberg et al., 2012; Kelly et al., 2009; Tellier, 2008)—the current study focused on individuals unfamiliar with the target language, Hungarian. In particular, Hungarian was chosen as the target language because it is typologically unrelated to all of the languages to which participants had been exposed.

In order to address how gesture affects communication, encoding, and recall in a novel L2, an interactive word teaching and learning task was developed specifically for individuals unfamiliar with Hungarian (see the expanded description in the Procedure section). Because all participants were unfamiliar with Hungarian and this study was conducted in a laboratory, the structure of the experimental teaching and learning task does not directly reflect a classroom environment. Nevertheless, unlike most laboratory studies of L2 word learning, the experimental task was designed to elicit L2-related dialogue between participants. The unique design of the experimental task allowed for investigation and comparison of the effects of gesture on the cognitive processes of interest while maintaining both strong internal and external validity, neither of which would be possible in standard laboratory or classroom studies. Additionally, due to the inclusion of a recall component, the current study permitted investigation of whether gestures produced spontaneously during elicited L2-related dialogue can enhance recall of the target language outside of the immediate L2 learning environment.

To determine whether and how gesture facilitates L2 communication, encoding, and recall, participants' performance in the L2 word learning and recall tasks was quantified and analyzed. The impact of gesture on communication was examined by determining the extent to which gesture accounted for characteristics of elicited L2-related dialogue, and by comparing the characteristics of elicited L2 related dialogue produced in conjunction with gesture with the characteristics of dialogue produced in the absence of gesture. The dialogic characteristics of interest were amount of speech produced, which was measured by counting the total number of words spoken, and interactivity, which was measured by counting the number of conversational turns taken by participants. The effect of gesture on encoding was measured by examining the relationship between gestures and target word repetitions during learning trials. Repetition is thought to reflect the encoding of L2 words given that it engages the phonological loop, a cognitive mechanism specialized for the storage of verbal information in memory (Baddeley, Gathercole, & Papagno, 1998). Indeed, experimental work provides evidence that impairment of the ability to repeat unfamiliar words hinders their acquisition (Baddeley, Papagno, & Vallar, 1988; Papagno, Valentine, & Baddeley, 1991). In light of previous research indicating that gesture production enhances performance in cognitively demanding tasks, including L2 acquisition (McCafferty, 2002; Smotrova & Lantolf, 2013; Tellier, 2008), gesture may serve as a means of expanding the phonological loop and linking it to the visuospatial sketchpad, thereby facilitating L2 word learning. The effect of gesture on recall was measured by examining the relationship between gestures produced in the learning phase and L2 words recalled during the testing phase. By asking participants to recall, rather than simply recognize, the words that they had learned, the task forced participants to actively tap into their mental representations of target words in order to retrieve them from memory, revealing the influence of gesture on the cognitive process of recall.

Based on McNeill's (1992, 2005) growth point theory, it was predicted that representational gesture would facilitate all three major cognitive processes involved in L2 word learning: communication, encoding, and recall. This prediction was based on laboratory work showing superior learning of L2 words presented concurrently with representational gestures depicting their referents (Gullberg et al., 2012; Kelly et al., 2009; Macedonia et al., 2010; Tellier, 2008), as well as classroom and naturalistic research demonstrating that representational gestures facilitate L2 comprehension (Allen, 1995; Lazaraton, 2004; McCafferty, 2002; Smotrova & Lantolf, 2013; van Compernolle & Williams, 2011). Moreover, it was predicted that deictic gesture would facilitate only communication, and beat gesture would facilitate only encoding and recall of L2 words. The predictions for beat gesture were based on research indicating that synchrony between beat gesture and speech enhances audiovisual processing (Hubbard et al., 2008), as well as work demonstrating that adults recall words in their native language accompanied by beat gestures as effectively as words accompanied by representational gestures depicting their referents (So et al., 2012). The predictions for deictic gesture were based on research showing that native speakers use deictic gestures more often when conversing with L2 learners than with native interlocutors (Adams, 1998), as well as work showing that L2 learners use deictic gestures more frequently when speaking the target language than their native language (Gullberg, 1998; Sherman & Nicoladis, 2004).

METHOD

Participants

For the current study, 60 undergraduates were recruited in pairs from the Psychology Department participant pool at the University of California, Santa Cruz, and were granted partial course credit in return for participation. Data from 8 participants (4 pairs) were excluded due to technical issues that arose during sessions or discovery of missing essential data prior to analysis, resulting in a final sample size of 52 participants (26 pairs). Participants consisted of 31 females and 21 males with an average age of 20.15 years ($SD = 1.73$; see Table 1). All participants reported normal hearing and normal or corrected-to-normal vision.

All participants were fluent in English, but only five participants were English monolinguals, reporting no L2 knowledge in any language. Given the impracticality of recruiting only English monolinguals, particularly given that Spanish exposure is commonplace in the locale in which the study was conducted, and given that the English glosses of Hungarian words were simple, common words, participants were not required to be English monolinguals. Though all participants were native English speakers, 23 participants reported bilingualism in another language, with Spanish representing the most popular L2 (13 bilinguals), followed by Cantonese and Tagalog (2 bilinguals each), and Japanese, Hebrew, Mandarin, Hindi, Tamil, and Urdu (1 bilingual each). Nonbilingual participants averaged 3.78 years of L2 study, with Spanish as the most popular L2 (studied by 21), followed by French (studied by 5), Japanese (studied by 2), and German, Italian, Latin, Cantonese, and Korean (studied by 1 each). None of the participants reported knowledge of Hungarian, the target language used in this study (see Table 1).

TABLE 1
Age and L2 Experience of Participants

	Range	Mean (*SD*)
Age	18–28	20.15 (1.73)
# of L2s spoken	0–4	1.17 (0.67)
L2 years spoken	0–22	8.91 (7.58)

Stimuli

The study used 20 Hungarian words. In order to select these words, 15 English speakers who did not participate in the study were asked to rate the concreteness, imageability, and meaningfulness of the English glosses of 80 candidate Hungarian words. These individuals were also asked to gesture in a way that represented the meaning of each English gloss. Hungarian words corresponding to English glosses that received the most consistent ratings and gestures were selected for inclusion in the study (see Appendix A).

Twenty videos of representational gestures depicting referents were created for presentation with each word. Each video showed a fluent Hungarian–English bilingual saying a Hungarian word and its English gloss while reenacting the gesture produced by the greatest number of individuals in the norming session, or while keeping the hands still. Hungarian words and English glosses were presented as text at the bottom of the screen in each video. Although it is possible that presentation of target words as text may have attracted visual attention away from gestures accompanying words, preliminary testing indicated that inclusion of text glosses benefited L2 comprehension due to the dissimilarity of Hungarian and English phonology, canceling out any negative effects of attention diversion from gesture. Furthermore, preliminary testing indicated that in the absence of text glosses, much of participants' attention was directed to auditory decoding of Hungarian phonology, which also detracted from attention directed to gestures accompanying target words.

Procedure

Prior to beginning the learning task, participants signed an informed consent form explaining the purpose and methods of the study. Once they had consented to participate, participants were randomly assigned to play one of two roles in the study: that of Explainer or that of Learner. Both participants were seated at a table across from one another, with Explainers in front of an iMac G4 with a 20-inch screen and headphones (see Figure 1). Explainers were told that 20 Hungarian words and their English glosses would be presented to them via the computer one at a time. They were instructed to teach Learners each word however they thought they would learn it best; their only restriction was that both participants had to remain seated at the table during the learning task. Participants were informed that

FIGURE 1
Configuration of Participants in Learning Phase, Showing Learner (Left) and Explainer (Right)

their speech would be audio recorded during the learning task for later analysis. Participants were told that the study focused on teaching and learning strategies for L2 vocabulary acquisition, hence the audio recording and the unusual setup in which one participant learned each word and then taught it to the other. Explainers were told to summon the experimenter after all of the words had been presented so that Learners could be tested to determine how well they had learned the words.

In each trial of the learning task, a Hungarian word was presented to the Explainer for 2500 ms, and after a 1000 ms interval, its English gloss was presented for 2500 ms. After a 2000 ms interval, the Hungarian word and its English gloss were repeated in the same sequence. Following this, a screen containing text instructing the Explainer to teach the Hungarian word to the Learner was displayed. At this point, the Explainer taught the word to the Learner, after which s/he pressed a key to proceed to the next trial. In half of the trials, words were presented via videos showing a native Hungarian speaker saying them and producing representational gestures depicting their referents while the words were displayed as text at the bottom of the screen. In the other half of the trials, words were presented via videos of the same speaker saying them and keeping the hands still while the words were displayed as text at the bottom of the screen. Word presentation mode was varied within participants, such that different words were presented with and without gesture to each Explainer.

During the learning task, participant pairs were video recorded from behind a one-way mirror, in addition to being audio recorded. This covert video recording, which was approved by the UCSC Institutional Review Board, was employed to ensure that participants were not altering their gestures due to consciousness of being video recorded. A camera oriented perpendicularly to the table captured video of participant pairs, providing a 180° view of both Explainers and Learners with full body visibility (see Figure 1). The screen of the computer on which stimuli were presented to Explainers was oriented perpendicularly to the camera, such that coders were blind to word presentation mode. In order to ensure maximum confidentiality, video of participant pairs captured during the learning phase was viewed only by the experimenter, with a subset of footage viewed by one additional coder for reliability, and was identified only by numbers assigned to each pair.

Following the learning phase of the experiment, Explainers were informed that they would also be tested to determine how well they had learned the words. To ensure that an equivalent amount of time elapsed between the end of the learning task and the beginning of the recall task for both participants, and to prevent Explainers and Learners from affecting one another's word recall, participants were tested simultaneously in separate rooms. During recall trials, each Hungarian word that had been learned during the learning task was presented aurally and visually as text. Participants responded by saying the corresponding English translation or by saying "skip" if they were unable to recall it while their responses were audio recorded. After completing the testing phase, participants were informed that the actual purpose of the experiment was to examine the role of gesture in L2 word learning. They were also informed that they had been video recorded in addition to being audio recorded during the learning task, and were offered the opportunity to have their recordings discarded if they did not wish for them to be analyzed. All participants consented to analysis of their video recordings. Table 2 provides an outline of the independent and dependent variables examined in this study.

Coding

Participants' speech was transcribed and was quantified by counting the total number of words, repetitions of target Hungarian words, and conversational turns produced during learning trials. In order to ensure that only task-focused speech was analyzed, speech was classified into one of two categories. *Task-Focused Speech*, which was analyzed, conveyed the meanings of Hungarian words through definitions, explanations, and mnemonics. *Other Speech*, which was excluded from analysis, conveyed all other information, such as comments about the structure of the experimental task ("I wonder if this is the last one"), the performance of speakers or their interlocutors ("Wow, you're doing a great job"), and matters unrelated to the experimental task ("I'm getting hungry").

Gestures were identified as hand movements that were not self-adaptive (e.g., scratching, pushing oneself backwards from the table) and were produced concurrently with speech. Gestures were individuated from one another on the basis of their stroke, the principal component of gesture that conveys information and is synchronized with speech (McNeill, 1992). Thus, an extension of the hand forward with the palm up that was produced concurrently with the word "to deliver" was coded a single gesture. However, if a similar movement occurred as the first motion of a sequence in which the fingers of the hand subsequently closed and moved in a lateral turning motion concurrently with the word "key," this entire sequence was coded as a single gesture.

In the interest of determining what function(s) co-speech gestures serve in the cognitive processes contributing to L2 word learning, gestures were classified into one of three categories, based on their form: representational, beat, or deictic. *Representational* gestures ($n = 620$; 35% of observed gestures) were defined as gestures depicting meaning conveyed via speech imagistically. Given that only 8% of the representational gestures produced during the learning task ($n = 50$) were metaphorical, and that the meanings of some target words could only be portrayed via metaphorical gestures, these gestures were analyzed jointly with iconic gestures under this classification. *Beat* gestures ($n = 1000$; 57% of observed gestures) were defined as simple, rhythmic gestures reflecting speech prosody or emphasis. *Deictic* gestures ($n = 147$; 8% of observed gestures) were defined as gestures directing attention to a concrete or abstract entity through extended finger(s). In some cases ($n = 127$; 7% of observed gestures), beat gestures

TABLE 2
Independent and Dependent Variables Examined, by Experimental Phase

Independent Variable	Phase	Dependent Variable	DV Type
Interlocutor role (Explainer/Learner)	Learning phase	Representational gesture	Gesture
Interlocutor visibility (visible/nonvisible)		Beat gesture	
		Deictic gesture	
Interlocutor–DV relationship (within/between)		Words spoken	Speech
		Conversational turns	
Word presentation mode (gesture/no gesture)		Target word repetitions	
N/A	Recall phase	Target word recall	Speech

were superimposed on representational gestures, such that representational gestures were held briefly and then moved in a rhythmic, beat-like manner. In these cases, the initial gesture was coded as representational, and subsequent movements were coded as beats.

All speech and gestures were transcribed and coded by a single individual (the author). To establish reliability, a second trained individual independently coded 25% of the gesture data (full sessions of 6 participant pairs). This individual was unaware of the purpose and design of the study, including the research questions, experimental conditions, and predictions. Agreement between the first and second coders was 92% for gesture identification and 90% for gesture categorization ($n = 389$).

For L2 word repetitions, only target words that were pronounced completely and correctly were counted, in order to rule out the possibility that effects derived from false starts, hesitations, or incorrectly encoded words. For L2 word recall, English translations produced by participants in response to Hungarian words during test trials were coded using a binary scheme. Each English translation was scored as 1 if it was the correct translation of the preceding Hungarian word, and was scored as 0 if it was an incorrect translation of the preceding Hungarian word, or if the trial was skipped. Scores for all twenty trials were summed to yield an overall score representing the total number of Hungarian words correctly translated by each participant, which was used to measure L2 word recall.

RESULTS

The study's primary dependent measures are expressed as units of gesture or speech per learning trial, given that trials are the units in which target words are learned. In order to account for differences in rate and duration of speech production, and in order to facilitate comparison with the results of other gesture production studies, analyses were also performed for units of gesture or speech per minute. When they reached significance, the results of these analyses, which were more conservative than analyses per trial, are reported in the endnotes. All analyses have 25 degrees of freedom, and were conducted separately on Explainers and Learners in order to account for any differences in frequency of production resulting from assigned participant role. Due to irregularity in the normality and skewness of most data, all analyses were performed using nonparametric methods, including normally distributed data (i.e., conversational turns).[1]

Communication

To determine the impact of gesture on communication about target words (L2 related discourse), I investigated how gesture affects the amount of speech produced during the learning phase in total words spoken and conversational turns. In my first analysis, I examined the effect of gesture on spoken communication by examining the relationship between gesture and total words spoken, as well as the relationship between gesture and conversational turns produced, both within and between participants. The relationship between participants' own gestures and these speech-related factors was investigated first. For Explainers, overall gesture production accounted for 35% of the variance in the amount of words spoken, and 27% of the variance in the number of conversational turns taken. The relationship between total words spoken and gesture was driven by Explainers' beat gesture production; representational and deictic gesture production failed to account for a significant amount of variance in speech production (see Table 3).[2] However, Explainers' production of each distinct gesture type was unable to account for a significant portion of their conversational turns. For Learners, overall gesture production accounted for 41% of the variance in the amount of words spoken and 36% of the variance in conversational turns taken. This relationship was driven by beat gesture production for both words spoken and turns taken.[3] I next regressed gestures produced by participants onto the total number of words spoken and conversational turns taken by their interlocutors. The results showed that Explainers' gestures accounted for 35% of the variance in the amount of words spoken by Learners, and 53% of the variance in conversational turns taken by Learners.[4] This relationship was driven by beat gesture for both words spoken and turns taken. On the other hand, Learners' overall gestures were unable to account for a significant portion of the variation in the total number of words spoken and conversational turns taken by Explainers, as were their representational, beat, and deictic gestures independently.

In my next analysis, I compared the total amount of speech produced and conversational turns taken in trials in which participants gestured with the amount of speech produced and turns taken in trials in which they did not gesture (see

TABLE 3
Total Words Spoken and Conversational Turns Taken Per Trial, as Accounted for by Representational, Beat, and Deictic Gestures Within and Between Explainers and Learners (Between-Participants Analyses Classified by Participant Speaking)

			Explainer					Learner				
Analysis	Measure	Predictor	*B*	*SE b*	*β*	*t*	*p*	*b*	*SE b*	*β*	*t*	*p*
Within participants	Total words spoken	Constant	20.39	5.00		3.91	.02*	11.37	2.54		5.02	.008**
		Representational gestures	−5.37	5.97	−0.21	−0.90	.38	1.43	2.64	0.10	0.54	.59
		Beat gestures	7.47	2.87	4.70	2.60	.02*	11.62	3.53	0.61	3.29	.003**
		Deictic gestures	32.95	23.72	0.33	1.39	.18	0.76	9.24	0.02	0.08	.94
	Conversational turns	Constant	6.58	1.17		2.66	.07	6.60	1.13		4.16	.02*
		Representational gestures	1.90	1.40	0.33	1.35	.19	1.26	1.18	0.19	1.07	.30
		Beat gestures	1.14	0.67	0.32	1.69	.11	3.49	1.57	0.42	2.23	.04*
		Deictic gestures	0.83	5.57	0.04	0.15	.88	3.46	4.11	0.17	0.84	.41
Between participants	Total words spoken	Constant	28.21	5.18		0.32	.81	9.62	3.10		3.96	.02*
		Representational gestures	3.09	5.39	0.13	0.57	.57	4.96	3.71	0.31	1.34	.19
		Beat gestures	4.58	7.20	0.15	0.64	.53	4.10	1.78	0.42	2.30	.03*
		Deictic gestures	−15.80	18.86	−0.21	−0.84	.41	4.48	14.73	0.07	0.30	.76
	Conversational turns	Constant	8.40	1.14		0.36	.78	5.05	1.13		8.39	.001***
		Representational gestures	1.04	1.19	0.19	0.87	.39	2.10	1.35	0.30	1.56	.13
		Beat gestures	0.78	1.59	0.11	0.49	.63	2.35	0.65	0.55	3.62	.002**
		Deictic gestures	−1.27	4.16	−0.07	−0.30	.76	3.02	5.36	0.11	0.56	.58

Tables 4A and 4B). As in the previous analysis, I first investigated whether participants spoke more during trials in which they gestured. This analysis revealed that both Explainers and Learners produced more speech and took more conversational turns during trials in which they gestured than during trials in which they did not. Comparisons of the amount of words spoken during trials in which Explainers produced and did not produce each individual type of gesture revealed that they spoke more during trials in which they produced representational, beat, and

TABLE 4A
Wilcoxon Signed Rank Tests Comparing Total Words Spoken and Conversational Turns Taken for Trials in Which Participants and Their Interlocutors Produced and Did Not Produce Gestures Within Participants

		Explainer				Learner			
Measure	Gesture Type	Mean (*SD*) w/Gesture	Mean (*SD*) w/o Gesture	*Z*	*p*	Mean (*SD*) w/Gesture	Mean (*SD*) w/o Gesture	*Z*	*p*
Total words spoken	Overall	32.66 (19.18)	21.59 (13.60)	3.82	<.001***	27.88 (26.71)	19.91 (16.52)	2.76	.006**
	Representational	21.22 (23.47)	16.05 (12.71)	3.30	<.001***	37.42 (22.38)	29.25 (16.92)	0.80	.42
	Beat	27.59 (37.00)	21.38 (31.39)	2.58	.01**	37.77 (24.64)	31.27 (20.94)	1.79	.07
	Deictic	15.78 (33.93)	4.88 (14.10)	3.52	<.001***	71.60 (139.75)	9.00 (9.45)	2.70	.007**
Conversational	Overall	6.61 (3.76)	5.32 (2.96)	3.94	<.001***	7.13 (3.35)	5.60 (2.60)	2.91	.004**
	Representational	0.31 (0.23)	0.37 (0.17)	2.15	.03*	0.21 (0.11)	0.23 (0.11)	0.98	.33
	Beat	5.56 (4.12)	8.46 (12.42)	2.81	.005**	7.63 (4.34)	5.66 (2.58)	0.66	.51
	Deictic	5.61 (13.17)	5.83 (3.14)	1.08	.28	5.15 (5.36)	6.52 (2.98)	1.60	.11

TABLE 4B
Wilcoxon Signed Rank Tests Comparing Total Words Spoken and Conversational Turns Taken for Trials in Which Participants and Their Interlocutors Produced and Did Not Produce Gestures Between Participants (Classified by Participant Speaking)

		Explainer				Learner			
Measure	Gesture Type	Mean (*SD*) w/Gesture	Mean (*SD*) w/o Gesture	*Z*	*p*	Mean (*SD*) w/Gesture	Mean (*SD*) w/o Gesture	*Z*	*p*
Total words spoken	Overall	33.69 (27.01)	29.93 (19.79)	1.05	2.92	20.56 (14.08)	16.40 (14.93)	2.54	.01**
	Representational	32.52 (24.10)	31.00 (20.55)	0.75	.45	17.07 (16.23)	3.55 (3.14)	4.27	<.001***
	Beat	45.40 (69.46)	37.50 (64.10)	1.79	.07	21.27 (18.65)	16.29 (13.63)	1.69	.09
	Deictic	86.71 (198.53)	32.92 (18.69)	0.18	.86	19.73 (28.63)	17.80 (11.97)	0.20	.84
Conversational turns	Overall	6.93 (3.69)	5.93 (2.91)	1.98	.05*	6.52 (3.72)	5.25 (2.98)	2.89	.004**
	Representational	0.78 (0.88)	0.31 (0.22)	2.86	.004**	0.16 (0.26)	0.39 (0.40)	2.22	.03*
	Beat	11.54 (12.09)	5.63 (5.89)	1.79	.07	5.86 (5.95)	10.80 (15.65)	1.79	.07
	Deictic	5.39 (10.56)	5.56 (3.17)	2.91	.004**	3.43 (7.30)	6.91 (3.92)	2.91	.004**

deictic gestures than in trials when they did not produce each of these gesture types. Explainers also took more conversational turns during trials in which they produced representational and beat gestures than in trials in which they did not produce these types of gestures, though no difference was found for trials in which they produced deictic gestures. For Learners, these comparisons showed that more speech was produced during trials in which they produced deictic gestures and that there was a nonsignificant trend for them to speak more during trials in which they produced beat gestures, but no difference was found for trials in which they produced representational gestures. No differences in conversational turns were found between trials in which participants produced or failed to produce any of the individual gesture types investigated. Next, I investigated whether participants spoke more during trials in which their interlocutors gestured. The results revealed that Learners spoke more and took more turns during trials in which Explainers gestured than during trials in which they did not. Analysis of individual gesture types revealed that Learners spoke more and took more turns during trials in which Explainers produced representational gestures, and trended toward speaking more and taking more turns during trials in which Explainers produced beat gestures. Explainers, on the other hand, produced equivalent amounts of speech regardless of whether Learners gestured, but took more turns during trials in which Learners gestured than during trials in which they did not gesture. Analysis of individual gesture types revealed that Explainers spoke similarly regardless of whether Learners gestured, but that they took more turns during trials in which Learners produced representational and deictic gestures, and trended toward taking more turns during trials in which Learners produced beat gestures.

In a related analysis, I examined whether Explainers spoke more during trials in which words were presented to them with representational gestures conveying their meanings than in trials in which words were presented to them with text alone. This analysis was conducted to differentiate between the influence of gestures that Explainers viewed in the service of learning the target words and the influence of gestures viewed as feedback from Learners. This comparison revealed that Explainers produced equivalent amounts of speech and conversational turns during trials in which words were presented to them with and without gesture (see Table 5).

Encoding

To determine the impact of gesture on L2 word encoding, I examined how gesture frequency affects repetition of target words in the learning phase. To achieve this goal, I regressed gestures produced by participants onto the number of times that they and their interlocutors repeated the target words during the learning phase. Explainers' overall gesture production per trial accounted for 44% of the variance in the number of times that they repeated target words (see Table 6). Analysis of individual gesture types revealed that this relationship was driven by their beat gesture production; representational and deictic gesture failed to account for a significant portion of Explainers' target word repetition. Learners' overall gesture production per trial accounted for 35% of the variance in their target word repetition. This relationship was driven by their beat gesture; representational gesture trended toward predicting Learners' target word repetition, whereas deictic gesture production failed to account for a significant portion of Learners' target word repetition.[5] In an analysis across participants, Explainers' overall gesture production by trial accounted for 41% of the variance in Learners' target word repetition. This relationship was driven by Explainers' beat gesture; their representational and deictic gesture failed to account for a significant portion of Learners' target word repetition. Learners' overall gesture production, on the other hand, failed to account for a significant portion of the variance

TABLE 5
Comparison of Speech Produced and Word Recall for Target Words Presented to Explainers With and Without Gesture

Speech Characteristic	Gesture	No Gesture	*Z*	*p*
Total words produced	33.54 (19.48)	34.09 (19.17)	1.00	.32
Conversational turns	6.58 (3.22)	6.52 (3.20)	0.08	.94
Target word repetitions	4.25 (1.72)	4.24 (2.03)	0.16	.88
Target word recall	4.27 (2.27)	3.96 (2.42)	0.68	.49

TABLE 6
Target Word Repetitions per Trial, as Accounted for by Representational, Beat, and Deictic Gestures and Speech-Related Factors Within and Between Explainers and Learners (Between-Participants Analyses Classified By Participant Repeating Words)

		Explainer					Learner				
Analysis	Predictor	*b*	*SE b*	*β*	*t*	*p*	*b*	*SE b*	*β*	*t*	*P*
Within participants	Constant	2.96	0.62		3.35	.04*	2.62	0.54		3.96	.02*
	Representational gestures	1.01	0.73	0.30	1.38	.18	1.13	0.57	0.37	2.00	.06
	Beat gestures	0.86	0.35	0.41	2.42	.02*	1.65	0.76	0.42	2.19	.04*
	Deictic gestures	2.57	2.92	0.20	0.88	.39	−0.29	1.98	−0.03	−0.15	.89
Between participants	Constant	4.02	0.62		1.73	.19	2.37	0.61		5.09	.008**
	Representational gestures	1.02	0.47	0.44	2.16	.04*	−0.52	0.72	−0.16	−0.72	.48
	Beat gestures	0.30	0.63	0.10	0.48	.64	0.97	0.35	0.48	2.77	.01**
	Deictic gestures	−0.78	1.66	−0.11	−0.47	.64	4.92	2.88	0.39	1.71	.10

in Explainers' target word repetition. An analysis of individual gesture types revealed that Learners' representational gesture production accounted for a significant portion of Explainers' target word repetition, but that their beat and deictic gesture production was unable to account for it similarly.[6] The final analysis in this set examined whether Explainers were more likely to repeat target words that they learned with accompanying representational gesture than words that they had learned without accompanying gesture. This analysis revealed that Explainers repeated target words that they had learned with and without accompanying gesture with equivalent frequency (see Table 6).

Recall

To determine the impact of gesture on L2 word recall, I investigated how gestures produced in the learning phase affect L2 target word translation in the recall phase, both alone and in conjunction with speech produced in the learning phase. In my first analysis, I regressed the number of gestures that participants produced during the learning phase on the number of target word translations that they produced correctly in the recall test. This analysis revealed that the overall number of gestures that Explainers produced accounted for 44% of the variance in the number of target words that they recalled (see Table 7A). This relationship was driven by beat gesture; deictic gesture showed a trend toward predicting Explainers' recall, whereas representational gesture failed to account for a significant portion of it.[7] For Learners, overall gestures accounted for 28% of the variance in target word recall. This relationship was driven by representational gesture; beat and deictic gesture failed to account for a significant portion of Learners' target word recall.[8] Cross-participant analyses revealed that Explainers' gesture was unable to account for a significant portion of Learners' target word recall, and that Learners' gesture was unable to account for a significant portion of Explainers' target word recall (see Table 5). None of the individual gesture types produced by Explainers or Learners distinctly predicted a significant portion of their interlocutors' target word recall. I also compared

TABLE 7A
Target Words Recalled per Trial, as Accounted for by Gesture and Speech-Related Factors Within Participants

		Explainer					Learner				
Predictor type	Predictor	*b*	*SE b*	*β*	*t*	*p*	*b*	*SE b*	*β*	*t*	*P*
Gesture	Constant	5.29	1.04		5.70	.005**	5.50	0.97		2.89	.06
	Representational gestures	−0.32	1.24	−0.06	−0.26	.80	2.13	1.01	0.41	2.11	.05*
	Beat gestures	1.46	0.60	0.42	2.45	.02*	1.45	1.35	0.22	1.08	.29
	Deictic gestures	9.89	4.93	0.44	2.01	.06	1.16	3.53	0.07	0.33	.75
Speech	Constant	4.73	1.97		5.02	.008**	3.12	1.56		2.88	.06
	Total words spoken	0.16	0.06	0.69	2.60	.02*	−0.02	0.12	−0.05	−0.14	.89
	Target word repetitions	−0.59	0.57	−0.25	−1.03	.32	0.20	0.44	0.12	0.45	.66
	Conversational turns	0.15	0.22	0.15	0.70	.49	0.39	0.35	0.48	1.13	.27

TABLE 7B
Target Words Recalled per Trial, as Accounted for by Gesture and Speech-Related Factors Between Participants (Classified by Participant Recalling Words)

		Explainer					Learner				
Predictor type	Predictor	*b*	*SE b*	*β*	*t*	*p*	*b*	*SE b*	*β*	*t*	*P*
Gesture	Constant	7.26	1.13		0.66	.59	5.12	1.17		2.32	.10
	Representational gestures	0.11	1.18	0.02	0.09	.93	−0.59	1.39	−0.11	−0.42	.68
	Beat gestures	1.69	1.58	0.25	1.07	.30	0.71	0.67	0.21	1.06	.30
	Deictic gestures	1.16	4.13	0.07	0.28	.78	9.64	5.53	0.45	1.74	.10
Speech	Constant	3.62	1.33		7.68	.001***	3.60	2.25		1.52	.24
	Total words spoken	−0.14	0.11	−0.04	−0.14	.89	0.06	0.07	0.26	0.81	.43
	Target word repetitions	−0.65	0.38	−0.37	−1.72	.10	0.22	0.65	0.10	0.34	.73
	Conversational turns	0.80	0.30	0.96	2.71	.01**	0.11	0.25	0.11	0.42	.68

Explainers' recall of target words presented with and without accompanying representational gestures. This analysis indicated that Explainers recalled the meanings of target words equally well regardless of whether they were presented with accompanying gesture (see Tables 7A & 7B).

In order to understand whether speech production during the learning phase affected target word recall, I examined whether total words spoken, target word repetitions, and conversational turns predicted target word recall accuracy. For Explainers, this analysis revealed that, together, the influence of these speech-related factors accounted for 41% of the variance in target word recall (see Table 7A). This relationship was driven by speech production; target word repetitions and conversational turns failed to contribute significantly to target word recall.[9] For Learners, these speech-related factors accounted for 28% of the variance in target word recall. However, when considered distinctly, all of the speech-related factors failed to account for target word recall. In order to gauge the impact of speech-related factors on interlocutors' target word recall, these relationships were also investigated between participants. This analysis showed that Explainers' speech, as quantified via these factors, failed to account for Learners' target word recall, both overall and when considered distinctly. Nevertheless, Learners' speech accounted for 52% of the variance in Explainers' target word recall.[10] This relationship was driven by Learners' conversational turns; speech production and target word repetition failed to contribute significantly to Explainers' target word recall.

In order to determine whether gesture enhanced target word recall above and beyond any facilitative effects of speech, I conducted hierarchical regressions relating participants' speech and gesture production to target word recall. In these regressions, representational, beat, and deictic gestures were entered as predictors of word recall in step 1, and total words produced, target word repetitions, and conversational turns were added in step 2. In my first set of analyses, I regressed Explainers' and Learners' gestures and speech on their own target word recall in this manner. For Explainers, the model including both gestures and speech explained 18% more of the variance in target word recall than the model including only gestures.[11] For Learners, the model including gestures and speech explained 9% more of the variance in target word recall than the model including only gestures (see Table 8A).[12] In my second set of analyses, I regressed Explainers' and Learners' gestures and speech on their interlocutors' target word recall. The model including Learners' gestures and speech explained 45% more of the variance in Explainers' target word recall than the model including only gestures.[13] In contrast, the model including Explainers' gestures and speech explained 4% more of the variance in Learners' target word recall than the model including only gestures (see Table 8B).

DISCUSSION

The current study examined the impact of gesture on three interrelated cognitive processes subserving the initial stages of L2 acquisition: communication, encoding, and recall. Through the means of an interactive word learning task, it examined whether gesture can facilitate these processes, complementing the findings of other studies of gesture in early L2 learning (Gullberg et al., 2010; Kelly et al., 2009; Sueyoshi & Hardison, 2005; Tellier, 2008). This work also represents the first experimental study to directly compare how gesture enactment and gesture

TABLE 8A
Results of Block 2 of Hierarchical Model of Target Word Recall per Trial Within Participants. Speech-Related Factors Added in Block 2 to Gesture-Related Factors Entered in Block 1.

		Explainer					Learner				
Predictor Type	Predictor	*b*	*SE b*	*β*	*t*	*p*	*b*	*SE b*	*β*	*T*	*p*
	Constant	5.57	1.73		3.22	.01**	3.51	1.60		2.19	.04*
Gesture	Representational gestures	0.77	1.30	0.13	0.59	.56	1.77	1.10	0.34	1.61	.12
	Beat gestures	0.88	0.60	0.25	1.46	.16	0.55	1.77	0.08	0.31	.76
	Deictic gestures	7.88	4.64	0.35	1.70	.11	−0.11	3.77	−0.01	−0.03	.98
Speech	Total words spoken	0.16	0.06	0.70	2.52	.02*	−0.02	0.14	−0.07	−0.17	.87
	Target word repetitions	−1.15	0.54	−0.49	−2.15	.05*	−0.06	0.49	−0.04	−0.12	.90
	Conversational turns	0.01	0.22	0.01	0.06	.95	0.37	0.38	0.45	0.97	.34

TABLE 8B
Results of Block 2 of Hierarchical Model of Target Word Recall per Trial Between Participants. Speech-Related Factors Added in Block 2 to Gesture-Related Factors Entered in Block 1. (Classified by Participant Recalling Words)

		Explainer					Learner				
Predictor Type	Predictor	*b*	*SE b*	*β*	*t*	*p*	*b*	*SE b*	*β*	*T*	*p*
	Constant	3.43	1.44		2.37	.03*	3.94	2.31		1.71	.10
Gesture	Representational gestures	−0.25	0.99	−0.05	−0.25	.81	−0.52	1.74	−0.09	−0.30	.77
	Beat gestures	−0.06	1.60	−0.01	−0.04	.97	0.35	0.80	0.10	0.43	.67
	Deictic gestures	−2.00	3.40	−0.12	−0.59	.57	8.43	6.18	0.39	1.36	.19
Speech	Total words spoken	−0.02	0.13	−0.06	−0.16	.87	0.04	0.08	0.19	0.48	.63
	Target word repetitions	−0.62	0.45	−0.35	−1.40	.18	−0.07	0.71	−0.03	−0.09	.93
	Conversational turns	0.87	0.34	1.03	2.54	.02*	0.09	0.29	0.09	0.30	.77

viewing affect L2 word learning and recall. In general, the results indicate that gesture facilitates communication, encoding, and recall of L2 words, and that gesture production enhances these processes more than gesture viewing. These findings provide confirmatory evidence supporting the extension of McNeill's (2005) growth point theory to L2 acquisition (Lantolf, 2010), which posits that gesture and speech interact dynamically through all of the cognitive processes of interest, thereby facilitating L2 acquisition. Together, the findings suggest that gestures produced during conversation, particularly within a structured learning task, facilitate the challenging task of L2 acquisition by enhancing communication, encoding, and recall of the target language.

The first cognitive process involved in L2 acquisition examined in the study was communication, that is, the exchange of ideas in or pertinent to the target language. It focused on communication about the L2, rather than communication in the L2, given that this type of communication is crucial in the early stages of L2 acquisition, when learners lack the vocabulary necessary to discuss linguistic features in the L2 itself. The impact of gesture on communication was investigated by examining the relationship between gesture and speech, as well as by comparing speech produced during trials in which gestures were present or absent. With regard to the relationship between gesture and speech, it was predicted that all types of co-speech gestures would be closely related to the total number of words spoken and conversational turns taken by participants who produced the gestures, which represent verbosity and interactivity, respectively. This prediction was supported by the findings that Explainers' and Learners' gestures accounted for total words spoken, and that Learners' gestures accounted for conversational turns taken by these participants. The prediction was additionally supported by the finding that Explainers' gestures accounted for words spoken and turns taken by Learners. However, when the impact of each gesture type was examined individually, only beat gestures contributed significantly to these discourse-related factors. This finding may be explained by beat gestures' greater dependence on speech than deictic and representational gestures. Although all three gesture types are typically produced concurrently with speech (McNeill, 2005), deictic and representational gestures can communicate meaningfully in the absence of speech vis-à-vis their form, whereas beat gestures cannot because they are noniconic and only occur in conjunction with speech. By conveying emphasis, beat gestures may direct L2 learners' attention to important information about the target language or target word definitions, or may reflect attention that they have already directed to this information. Thus, the relationship between beat gesture production, words spoken, and turns taken suggests that beat gestures may facilitate communication about the target language to a greater degree than representational and deictic gestures.

With regard to the comparison of speech between trials in which gesture was present or absent, it was predicted that participants would speak more during trials in which they gestured than during trials in which they did not gesture. Consistent with this prediction, Explainers produced more total words during trials in which they produced representational, beat, and deictic gestures, and took more conversational turns during trials in which they produced representational and beat gestures. Learners spoke more during trials in which they produced deictic gestures, but they took similar numbers of conversational turns regardless of their production of each individual type of gesture. The greater effect of gesture production on Explainers' than on Learners' speech may be explained by the greater demands on communication from Explainers relative to Learners in the word learning task used in the current study. These greater demands may have amplified the contributions of co-speech gestures to Explainers' verbal communication, producing the observed results. Comparisons of participants' speech during trials in which their interlocutors produced each type of gesture revealed that Learners spoke more and took more turns during trials in which Explainers produced representational gestures. When considered in combination with the relationships observed between Learners' gesture and speech production, this finding suggests that Learners' beat and deictic gestures facilitate their production of dialog pertinent to the target language, but that representational gestures facilitate their comprehension of L2 related dialog. Explainers, on the other hand, took more turns during trials in which Learners produced representational and deictic gestures, but produced similar amounts of speech regardless of Learners' gestures or gestures accompanying word learning. These findings suggest that gesture production enhances Explainers' communication and thought concerning the L2 more than gesture viewing, regardless of whether Learners view gestures when learning words or as feedback from interlocutors.

The second cognitive process involved in L2 acquisition investigated in the study was encoding, that is, the storage of information in memory. To determine the contribution of gesture to the encoding of L2 words, gestures produced by participants were regressed on their repetition of target words during learning trials, given that verbal repetition reflects L2 lexical encoding (Baddeley et al., 1998). Consistent with the predictions, the results showed that beat gestures produced by Explainers and Learners, as well as representational gestures produced by Learners, predicted their target word repetition. These findings indicate that, in addition to their role in communicating L2 related information, beat and representational gestures contribute to the internal processing of this information (McCafferty, 2002; Smotrova & Lantolf, 2013). Moreover, the differential findings for Explainers and Learners provide evidence that beat and representational gestures facilitate L2 word encoding in different ways. In particular, they suggest that beat gestures emphasize key aspects of verbal information concerning the L2, thereby promoting more effective encoding of this information (So et al., 2012), and that representational gestures reflect the visual form of referents, facilitating their association with corresponding L2 words (Hubbard et al., 2008; Kelly et al., 2009; Tellier, 2008). Though it is unclear why Explainers' representational gesture production was not closely related to their target word production, one possibility is that the communicative demands of the experimental task for Explainers may have negated the benefits of representational gestures on their own encoding. If Explainers' attention was focused on communicating the meanings of L2 words to Learners, fewer attentional resources may have remained available for encoding target words. Moreover, Explainers may have focused on conveying the meanings of the target words verbally rather than via gesture, which would explain their production of more beat gestures than representational gestures. In any case, these findings suggest that gesture's ability to attract attention to important attributes of target words may explain its facilitation of L2 word encoding.

To compare the effects of gesture enactment and viewing on L2 word encoding, gestures produced by participants were regressed onto the number of times that their interlocutors repeated the target words. Interestingly, Explainers' overall gestures accounted for more of the variance in Learners' target word repetition than Learners' own gestures, with Explainers' beat gestures in particular contributing to Learners' encoding. These receptive effects demonstrate that beat gesture can direct listeners' attention to important information concerning L2 words, thereby enhancing listeners' encoding in addition to speakers'. Thus, these results provide evidence that beat gesture can serve as a cognitive aid for both speakers and listeners, in addition to its social functions. The results also showed that Learners' overall gestures failed to account for Explainers' target word repetition, but their representational gestures contributed significantly to it. Considered in conjunction with the observation that target words presented to Explainers with representational gestures failed to elicit additional repetition, this finding suggests that Learners' representational gesture served as an effective feedback elicitation device by cueing Explainers to confirm or correct their pronunciation and/or explanation of the target words. Taken together, these findings suggest that viewing representational and beat gestures enhances the encoding of novel L2 words almost as effectively as gesture production, and that each type of gesture serves a distinct but complementary function in early L2 acquisition by virtue of the information that it conveys.

The final cognitive process investigated in the study was recall, that is, the retrieval of information from memory. To determine the contribution of gesture to L2 word recall, the number of gestures produced by participants was regressed on the number of correct target word meanings that they produced during the recall test. The results revealed that Explainers' beat gesture production accounted for their target word recall, whereas Learners' representational gesture production accounted for their target word recall. These results were consistent with the prediction that representational and beat gestures would facilitate L2 word recall. The relationship between Learners' representational gesture production and their target word recall provides evidence suggesting that the form of these gestures facilitated the encoding—and later the recall—of target words by enriching the conceptual links between L2 words and their referents. The finding that Learners' beat gesture production enhanced the encoding, but not the recall, of target words suggests that beat gesture may have helped Learners to store phonological attributes of L2 words and verbal associations between them and referents, but that it was not a useful aid in their retrieval of L2 words. The relationship between Explainers' beat gesture production and their target word recall, on the other hand, suggests that they may have relied mostly on verbal associations that they elucidated when conveying the meanings of target words to Learners in their own recall of target words. These interpretations are supported by speech and hierarchical gesture–speech regressions, which indicate that speech produced by Explainers contributed more to their target word recall than Learners' speech contributed to their target word recall. Unlike gesture production, gesture viewing did not affect L2 word recall for either Explainers or Learners. Learners' conversational turns, on the other hand, facilitated target word recall for Explainers. Considered in conjunction with the results for encoding, these findings suggest that, though the reception of information from gesture may facilitate the encoding of L2 words, it may be insufficient to facilitate recall. Furthermore, the findings provide further evidence suggesting that Explainers' verbal interactions may contribute more to their recall than gesture. Thus, the results of previous work showing that gesture viewing promotes L2 word learning (Kelly et al., 2009; Macedonia et al., 2010; Tellier, 2008) may have derived more from gesture's effect on the encoding, rather than recall, of novel L2 words.

Considered as a whole, the results of this study indicate that representational, deictic, and beat gestures play distinct, yet complementary, roles in three major cognitive processes involved in L2 word learning: communication, encoding, and recall. More specifically, the results suggest that, consistent with the findings of previous laboratory research on L2 word learning (Kelly et al., 2009; Macedonia et al., 2010; So et al., 2012; Tellier, 2008), representational and beat gesture enrich the conceptual representations formed and accessed during the encoding and recall of L2 words by directing—or reflecting—attention to salient features of their meanings. Consistent with research on foreigner-directed speech (Adams, 1998) and L2 listening comprehension (Sueyoshi & Hardison, 2005), the results also indicate that beat and deictic gestures facilitate communication between L2 learners and their interlocutors through a similar process of attention allocation. These findings constitute the first solid evidence that beat gesture contributes to these interrelated cognitive processes involved in L2 word learning, and also indicate that the effects of representational gesture on these processes may be more limited than the results of previous research suggest. Taken together, the results clarify the contributions of each type of co-speech gesture to the communication, encoding, and recall of L2 words, providing a clearer and more detailed picture of the role of gesture in the initial stages of L2 acquisition.

Due to its unique design, this study helps to clarify some of the discrepancies between laboratory and classroom research on L2 acquisition. By examining how L2 words are learned in a conversational yet task-focused setting, the current study permitted direct comparisons of the effects of gesture production and gesture viewing on L2 word learning. Although gesture viewing and gesture production enhanced L2 word encoding comparably, gesture viewing promoted L2 word communication less effectively than gesture production, and it failed to promote L2 word recall. These findings can be explained by the need for listeners to consciously attend to, appropriate, and assimilate gesture in order to take advantage of its cognitive benefits, as opposed to the implicit and automatic benefits of gesture that speakers receive. Furthermore, the finding that beat and deictic gestures, in addition to representational gestures, facilitated the communication, encoding, and recall of L2 words suggests that naturalistic gesture production may be even more effective than directed gesture production for enhancing L2 word learning in laboratory and classroom settings. Because all participants in this study were unfamiliar with Hungarian, the target language, it is unclear whether the results are representative of gesture's impact on L2 word learning in more advanced learners. To address this issue, future research should employ a design similar to that used in the current study with more advanced L2 learners so that the effects of gesture on word learning can be compared between these two populations, providing a clearer picture of how gesture facilitates word learning throughout various stages of L2 development.

The results of this study hold important implications for both laboratory research and classroom applications. Considered in conjunction with work showing that gesture production facilitates L2 acquisition in classroom and naturalistic conversational settings (Adams, 1998; Smotrova & Lantolf, 2013; van Compernolle & Williams, 2011), the findings suggest that encouraging participants to gesture when learning novel L2 words in laboratory settings, as well as in classroom settings, may enhance their acquisition of these words more than simply allowing them to view gestures in conjunction with target words. The relationships between gestures and verbal explanations of L2 word meanings also suggest that the intrinsic variability and interactivity of classroom and conversational settings, which allow for spontaneous verbal exchanges, may be conducive to L2 word learning. Thus, these findings suggest that it may be fruitful to incorporate some interactive, productive tasks into laboratory research examining gesture's effect on L2 word learning, which would allow this research to approximate key aspects of classroom and conversational learning environments. Consistent with previous classroom and conversational L2 research (Lazaraton, 2004; McCafferty, 2002), the study suggests that teachers should use gesture in combination with verbal explanation to convey the meanings of novel L2 words to students. Also, teachers should create structured opportunities for students to use target words in interactions with one another and should encourage students to gesture naturally within these interactions, and to pay attention to the gestures of their interlocutors. It is important to note that, unlike L2 instructional settings, which consist of at least one person with expertise in the target language (the teacher) and at least one person unfamiliar with the target language (the learner), in the current study, neither the Explainer nor the Learner had expertise in the target language. Thus, though the study's design required participants to engage in elicited L2 related dialogue, it is unclear how well the results generalize to instructional L2 settings. Future research should explore this issue by analyzing teachers' and learners' gesture production quantitatively in classroom and conversational settings, particularly for L2 vocabulary learning.

Overall, the results of the current study demonstrate that representational, deictic, and beat gestures work together with speech to enhance communication, encoding, and recall of L2 words by learners unfamiliar with the target language. All types of gestures are produced during all three of these interrelated cognitive processes involved in L2 word learning, and demonstrate that each type of gesture serves a specific purpose within these processes. These results are consistent with growth point theory (McNeill, 1992, 2005) in that they provide evidence that gesture and speech stem from unitary cognitive representations, and that they influence one another dynamically during L2 acquisition. Furthermore, they indicate that, though gesture viewing enhances L2 word learning somewhat, gesture production is more effective and is closely related to speech production, highlighting the importance of active gesturing and verbal explanation in L2 acquisition. These findings indicate that, for beginning L2 learners, gesture production helps to facilitate L2 word learning, serving as a powerful cognitive tool in the labor intensive process of L2 acquisition.

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NOTES

[1] Due to their increased robustness, these analyses are more conservative than parametric analyses, slightly inflating the risk of Type II error (i.e., the chance of failing to reject the null hypothesis when a significant difference exists between two conditions) (Larson–Hall, 2009).

[2] Explainers' overall gestures, $F = 2.48$, $p = .09$, and deictic gestures, $t = 1.95$, $p = .07$, trended toward accounting for the total number of words that they spoke per minute.

[3] Learners' overall gestures, $F = 4.98$, $p = .009$, and beat gestures, $t = 2.89$, $p = .008$, accounted for the number of conversational turns that they took per minute.

[4] Explainers' overall gestures trended toward accounting for the number of conversational turns that Learners took per minute, $F = 2.55$, $p = .08$.

[5] Learners' beat gestures trended toward accounting for the number of times that they repeated target words per minute, $t = 1.78$, $p = .09$.

[6] Learners' overall gestures, $F = 2.62$, $p = .08$, and deictic gestures, $t = 2.26$, $p = .03$, accounted for the number of times that Explainers repeated target words per minute.

[7] Explainers' overall gestures, $F = 2.49$, $p = .09$, and beat gestures, $t = 1.98$, $p = .06$, trended toward accounting for their target word recall per minute.

[8] Learners' representational gestures trended toward accounting for their target word recall per minute, $t = 1.91$, $p = .07$.

[9] Explainers' overall speech-related factors, $F = 4.51$, $p = .01$, including total words spoken, $t = 2.96$, $p = .007$, and target word repetitions, $t = 2.98$, $p = .007$, accounted for their target word recall per minute.

[10] Learners' overall speech-related factors, $F = 3.90$, $p = .02$, including total words spoken, $t = 2.71$, $p = .01$, and target word repetitions, $t = 2.92$, $p = .009$, accounted for Explainers' target word recall per minute.

[11] This model also explained more variance in Explainers' target word recall for overall speech-related factors, $F = 3.31$, $p = .02$, including total words spoken, $t = 2.71$, $p = .01$, and target word repetitions, $t = 2.92$, $p = .009$, per minute.

[12] This model also trended toward explaining more variance in Learners' target word recall for representational gestures per minute, $F = 1.91$, $p = .07$.

[13] This model also explained more variance in Explainers' target word recall as a function of Learners' target word repetitions, $t = 2.46$, $p = .02$, and conversational turns, $t = 3.13$, $p = .006$, per minute.

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APPENDIX A

Hungarian Words and Gestures Presented in the Learning Task (Rating Data Collected in Preexperimental Norming Task)

Hungarian Word	English Gloss	Gesture Description	Concrete	Imageable	Meaningful
bajusz	moustache	Index fingers of both hands trace moustache above upper lip	5.38 (1.60)	5.82 (1.54)	3.07 (2.14)
betegség	illness	Pantomimes coughing, holding fist to mouth	4.96 (2.07)	5.55 (1.48)	5.24 (1.62)
csomo	knot	Pantomimes tying a knot in a string with both hands	4.54 (1.96)	4.50 (1.88)	3.75 (2.01)
hosszu	long	Both hands with fingers pointing up together move apart horizontally	4.67 (1.92)	5.48 (1.53)	3.36 (1.83)
kalapács	hammer	Pantomimes hammering with right hand above left hand held flat with palm oriented up	5.58 (1.93)	6.07 (1.71)	3.35 (1.92)
kefe	brush	Pantomimes brushing hair on both sides of head with right hand	5.56 (1.53)	5.90 (1.44)	3.62 (1.84)
kézbasíteni	to deliver	Both hands move forward from chest and orient upwards together	4.22 (2.04)	5.41 (1.55)	4.38 (2.04)
kulcs	key	Pantomimes turning key in lock with right hand	5.59 (1.87)	6.14 (1.75)	4.34 (2.00)
leforgatni	to record	Pantomimes holding video camera and moving it from left to right with both hands	4.88 (2.09)	5.48 (1.55)	4.07 (1.75)
löni	to shoot	Right hand held with index finger pointing forwards and thumb pointing up; speaker jerks hand up as if shooting	4.38 (2.08)	5.36 (1.89)	4.39 (1.66)
mászni	to climb	Pantomimes climbing ladder by placing hand over hand vertically; hands flat with palms oriented down	4.19 (1.74)	5.50 (1.48)	4.25 (1.86)
megütni	to hit	Pantomimes slapping with right hand	4.52 (2.03)	6.00 (1.44)	4.28 (1.85)
öltözet	clothing	Pinches front of shirt near right shoulder, then pinches front of shirt near left shoulder	4.64 (1.85)	4.85 (1.73)	4.62 (1.93)
óra	watch	Points downward with right hand at wrist of left hand	5.70 (1.46)	6.07 (1.44)	4.97 (1.66)
öröm	joy	Smiles with index fingers of both hands pulling upwards at corners of mouth	4.44 (2.33)	6.00 (1.51)	6.14 (1.62)
seprű	broom	Pantomimes sweeping with fists one above the other	5.54 (1.75)	5.97 (1.80)	3.07 (1.77)
tesgyakorlas	sports	Pantomimes throwing baseball in air and batting it	5.07 (1.86)	6.24 (1.41)	5.00 (1.79)
tréfa	joke	Pantomimes laughing, with right hand pounding table	4.19 (2.15)	4.82 (2.14)	5.29 (1.58)
unott	bored	Places head in right hand, pantomiming yawning	3.85 (2.05)	4.90 (2.01)	3.97 (1.68)
varrni	to sew	Pantomimes manual sewing with needle and thread	4.46 (2.00)	5.66 (1.40)	4.11 (1.79)

APPENDIX B

Descriptive Statistics for Task-Related Gesture and Speech Data

	Rate	Per Trial			Per Minute		
Participant	DV	Range	Mean (*SD*)	Skewness	Range	Mean (*SD*)	Skewness
Explainer	Representational gestures	0–2.85	0.65 (0.72)	1.81	0–1.96	0.57 (0.57)	1.22
	Beat gestures	0–5.75	0.90 (1.16)	3.08	0–0.16	0.04 (0.04)	2.05
	Deictic gestures	0–7.05	1.82 (1.67)	1.40	0–0.21	0.08 (0.06)	0.77
	Total words spoken	0.80–76.45	29.72 (19.22)	0.91	0.93–56.40	26.94 (14.45)	0.40
	Target word repetitions	1.45–10.25	4.89 (2.55)	0.60	1.80–9.46	4.56 (2.06)	0.71
	Conversational turns	2.50–17.20	9.03 (4.25)	0.23	2.92–18.66	8.45 (3.55)	0.73
Learner	Representational gestures	0–3.90	0.36 (0.76)	4.00	0–2.99	0.30 (0.59)	3.73
	Beat gestures	0–8.85	0.74 (1.67)	4.40	0–3.81	0.55 (0.87)	2.41
	Deictic gestures	0–1.15	0.09 (0.23)	3.84	0–0.80	0.08 (0.17)	3.18
	Total words spoken	1.10–44.30	17.36 (11.93)	0.75	1.76–35.04	16.00 (10.05)	0.41
	Target word repetitions	0.10–9.20	3.83 (2.45)	0.51	0.12–11.29	3.68 (2.52)	1.17
	Conversational turns	1.50–21.55	9.14 (5.14)	0.56	2.39–14.21	8.29 (3.62)	−0.16