The Cognitive Load Aspects of Cued Speech in the Learning of a Second Language

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Abstract The purpose of this study is to determine the cognitive acceptance of cued speech in regard to its gestural aspect. Gestures have been applied to language learning situations and shown to be effective when they are coherent with speech. Cued speech has also been used as an alternative choice of sign language for people with hearing problems. Much research supports its effectiveness in improving deaf students' reading ability. Gestures and cued speech have similar learning effectiveness. This study suggests that when coherent cued speech is used for learning new words, students remember more of the new vocabulary and retain the information longer compared to other learning conditions, namely incongruent gestures with speech and repeated speech. However, one of the benefits of using cued speech over gestures is the ability to express all spoken words because it is based on phonemes.

Keywords cued speech · second language · cognitive load theory · visual sign

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Introduction

Background

Cued speech.

Cued speech was developed as an alternative means of communication for people with hearing problems. Dr. Cornett (1967) noticed that many deaf students' reading achievement scores were significantly lower compared to their non-hearing-impaired peers (Karchmer & Mitchell, 2003). He invented cued speech for the purpose of improving deaf students' reading ability and designed it based on phonemes, so it can be expressed with any spoken English words. American Sign Language (ASL), on the other hand, is different from English. ASL does not phonetically represent English words and has a different grammatical structure. Many ASL learners think of English as their nonnative language rather than their native language (Johnson, Liddell, & Erting, 1989). That is why many ASL learners have a difficult time learning English and end up being poor readers (Alegria, 2004; Holt, 1994; Torres & Santana, 2005). However, cued speech is based on phonemes and uses one-hand gestures combined with mouth movements to indicate the meaning of each phoneme. Most studies on cued speech point out that cued speech learners' reading scores are much higher than those of ASL learners, and their scores are just as good as their non-hearing-impaired peers (Alegria, Charlier, & Mattys, 1999; Hage, Alegria, & Périer, 1991; Nicholls & Ling, 1982; Périer, Charlier, Hage, & Alegría, 1990).

The basic assumption of cognitive load theory suggests that the use of two sources of visual information, hand gestures and mouth movements, could overload working memory. The modality effect in cognitive load theory states that if there are two types of visual information presented, then cognitive load would increase because of processing two different types of visual information to one channel rather than using two different channels, audio and visual (Mayer & Moreno, 1998; Tindal-Ford, Chandler, & Sweller, 1997; Sweller, 2005). Therefore, attention is split, which increases cognitive load (Mousavi, Low, & Sweller, 1995; Tindall-Ford et al., 1997). Interestingly, Leybaert & Charlier (1996) point out that cued speech does not overload working memory unnecessarily by comparison with lip reading. Whereas cued speech has two sources of visual information, lip reading has only a single source, but the uncertainty of lip reading actually increases cognitive load for the receiver. The accuracy of cued speech with lip reading is 80% better than lip reading alone in terms of comprehension (Nicholls & Ling, 1982). Cued speech hand gestures enhance the clarity of mouth movements rather than interrupting the understanding of them. Furthermore, hand gestures and positions happen near the mouth. Therefore, the receiver doesn't have to split their attention too much at all. Can we assume then that using an additional visual signal to clarify meaning would not increase cognitive load? If this is true, then why? Feyereisen (2006) suggests the meaningful gestures are not performed to get additional attention, but are integrated naturally with spoken words. Therefore, if cued speech functions as meaningful gestures, then cued speech would not increase cognitive load and would actually enhance communication.

Do all hand gestures improve comprehension of verbal speech? If they differ, then why and how? Kelly, McDevitt, and Esch (2009) researched how gestures influenced learners' comprehension of new language. They report that meaningful gestures enhanced the learning of new words, but meaningless gestures hindered the learning of new words. Based on a meta analysis, Hostetter (2011) reports that co-speech gestures have a very positive effect on communication. Therefore, with co-speech gestures a person can better understand ambiguously presented information (Kelly, Barr, Church, & Lynch, 1999).

Does cued speech have a similar impact to meaningful gestures? The previous study on lip reading and cued speech reported that among deaf people cued speech has an equally positive effect to meaningful gestures. This research focuses on how cued speech affects the learning process of a non-hearing-impaired person who is learning a second language. Many second language learners have trouble differentiating between similar sounds because they are not familiar with all the different phonetics of the new language (Best & Tyler, 2007; Guion, Flege, Akahane-Yamada, & Pruitt, 2000; Strange, Akahane-Yamada, Kubo, Trent, & Nishi, 2001). Furthermore, when cued speech is used for children with cochlear implants, both speech perception and language development improve (Leybaert & LaSasso, 2010). Taking all of this into account, we ask the following question: Can cued speech help a person learn a second language?

Literature Review

Working memory

Working memory has been known for short-term memory since Miller's 1956 article. Two decades later, Baddeley & Hitch (1974) challenged the concept of short-term memory, describing it as an information process that includes receiving and integrating information (Baddeley, 1986). Working memory goes beyond merely holding information; it is instead an actively engaging information process. Braddeley (1986, 2001) addressed four parts of working memory: phonological loop, visuospatial sketchpad, episodic buffer, and central executive. For this research, phonological loop and visuospatial sketchpad are related to language acquisition and gestures.

Phonological loop

Wagner and Torgeson (1987) and Tractenberg (2002) point out that the phonological loop in working memory is deeply interrelated with language learning. Furthermore, other researchers state that one of the main reasons for deaf students' reading scores being lower than those of non-hearing-impaired students is the difficulty of utilizing the spoken part of communication (Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979; Perfetti & Sandak, 2000). The importance of the phonological loop is in controlling the verbal part of communication, and the two main components are a phonological store and an articulatory rehearsal system (Baddeley, 2001). The limitation of the phonological store that it holds sounds for only a few seconds. For its part, the articulatory rehearsal system repeats sounds before they fade away (Baddeley, 2001, 2007). Therefore, the articulatory rehearsal system assists in the processing of verbal information (Smith & Kosslyn, 2007). The classic example of this is when you try to write down someone's phone number or email address. You repeat those numbers in your head before you write down or memorize them.

Visuospatial sketchpad

Smith and Kosslyn (2007) define the visuospatial sketchpad as "the function of integrating spatial, visual and possible kinesthetic information into a unified representation which may be temporarily stored and manipulated." Unlike spoken words, written words and images are processed through the visuospatial sketchpad. We can only process three or four pieces of visual information through the visuospatial sketchpad at a time (Baddeley, 2003). For instance, if you watch a scientific animation with a subtitle, it is not easy to process information not because of the material, but because there are too many visual cues—more than you can process at one time. Processing visual imagery is part of the visuospatial sketchpad's function.

Dual coding

The dual coding assumption explains how we perceive information. It uses two channels: verbal and images (Clark & Paivio, 1991; Paivio, 1990). Based on this assumption, cued speech can be organized as verbal, not visual. If a receiver does not know cued speech, then it would be selected as images and organized as images. However, if the receiver knows cued speech, then it would be selected as images, but it would be organized as verbal because it has verbal meaning. Therefore, cued speech either assists in removing the uncertainty of verbal sounds or overloads working memory because it becomes unnecessary additional visual information. Based on modality theory in cognitive load, when a learner uses two different channels (audio and visual), then cognitive load is reduced (Mayer & Moreno, 1998; Tindall-Ford et al., 1997; Sweller, 2005). In a second language learning situation, cued speech is received on two different channels when a presenter uses both oral and cued speech and a receiver uses audio and visual information processes at the same time. The use of two separate channels in working memory is supposed not to increase unnecessary cognitive load, which is extraneous cognitive load (Sweller, 2005).

Cognitive load theory

Cognitive load happens when a new piece of information is processed by working memory (Chandler & Sweller, 1991; Sweller, 1994, 2005). It includes selecting, organizing, and integrating from sensory memory to long-term memory (Clark, Nguyen, & Sweller, 2011; Ericsson & Kintsch, 1995; Paas, Renkel, & Sweller, 2003). Cognitive load has become a very important topic because of the limitation of working memory (Baddeley, 2002). There are three different types of cognitive load: extraneous, intrinsic, and germane (Sweller, 2003, 2005). Intrinsic cognitive load deals with its own internal complexity of meaning (Sweller, 2005). This concerns whether the basic element of information is difficult to process. Extraneous cognitive load deals with how the presented information either increases or does not increase cognitive load (Sweller, 2003, 2005). For instance, if a PowerPoint slide has similar colors for both background and text, then learners would spend all their attention trying to read the text rather than processing the information. Germane cognitive load is the natural cognitive load when information is being processed. It is a positive cognitive load because it means than the receiver is learning or processing information (Sweller, 2003). Cued speech deals closely with extraneous cognitive load. If cued speech involves unnecessary and confusing hand gestures, then it excessively increases cognitive load, which ends up reducing germane cognitive load. However, if cued speech involves essential and meaningful hand gestures for clarifying information, then it reduces extraneous cognitive load, which makes available more resources for processing information.

Method

Sample and data

Procedure

This research process had four steps. First, a survey question was administered to collect the participants' basic information, such as age, native language, experience with learning Korean. The second step was for them to participate in a Korean vocabulary lesson. There were three different types of instructions and participants were randomly assigned to one of the instruction groups. The lesson was designed to teach 12 Korean words. After the lesson, the participants were asked to take a vocabulary test. The last step was for them to take the same test three weeks later.

Participants

A total of 43 graduate school students were recruited for the study. At the time of the study, they were enrolled in a Human Rehabilitation program. There were 20 female students and 23 male students. Their average age was 29.95 years. There were 15 students from Asia and 28 students from Africa. There were 12 different native languages, with Mongolian and English being the two most common. Their average time of living in Korea was 17.35 months. There were 23 students who had lived in Korea for less than 12 months and six people who had lived in Korea for more than four years. There were 21 students who said they could read Korean; however, this did not indicate their fluency in Korean.

Design

The research design is mixed, consisting of a one-way between-groups analysis of variance (ANOVA), a two-way ANOVA, an independent sample t-test, and analysis of covariance. The study had one independent variable with three different levels (repeated speech [RS], Incongruent gestures with speech [IGS] and cued speech [CS]), and one dependent continuous variable (vocabulary test). Both the IGS and CS groups were taught with cued speech, but only the CS group had cued speech explained to them.

Topic of instruction

The Korean word list came from the Test of Proficiency in Korean (TOPIK), which is the official test for measuring the fluency in Korean for nonnative speakers. The vocabulary words used for this study were chosen from the beginner level. All of the instructions used the same word list, and the Korean words were given with their English equivalents. Students only saw one Korean word with its English equivalent at a time (Figure. 1).

Fig. 1 A sample word lesson

While participants were looking at the screen (Figure, 1), the main instruction was given in English. Spoken Korean was only used for pronouncing the Korean words. The instruction was "The next word is 자전거. 자전거 means Bicycle. 자전거 means Bicycle. Again, the next word is 자전거. 자전거 means Bicycle. 자전거 means Bicycle." Meanwhile, the instructor showed the word in Korean and English on the sketchbook. When the instructor used cued speech (CS) or incongruent gestures with speech (IGS) along with the word (Figure, 2), the instruction was "The next word is 자전거 (CS)/(IGS). 자전거 (CS)/(IGS) means Bicycle. 자전거 (CS)/(IGS) means Bicycle. Again, the next word is 자전거 (CS)/(IGS). 자전거 (CS)/(IGS) means Bicycle. 자전거(CS)/(IGS) means Bicycle." The same instructor taught all three classes. Therefore, besides the use of IGS or CS, all instructional conditions were the same.

Survey questions

The survey was divided into two parts: pre-survey and post-survey. The pre-survey had two components. The first collected the participant's background information, such as age, gender, nationality, native language, length of time lived in Korea. The second part collected information about the participants' language ability and interest in learning Korean, such as ability to read Korean, Korean language course(s) taken, and general interest in learning/using Korean, gestures, or sign language. The post-survey collected the participants' ratings of the test and the instruction.

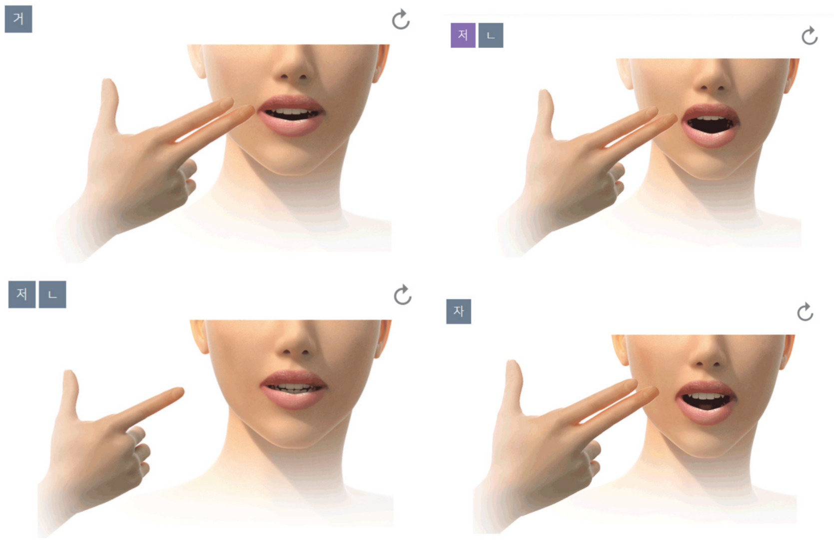

Fig. 2 Sample cued speech for 자전거

Research questions

1. Is there a difference in learning outcomes among participants who are exposed to repeated speech (RS), incongruent gestures with speech (IGS), and cued speech (CS)?
2. Is there a difference in learning outcomes based on participants' prior knowledge of Korean?
3. Is there a difference in the effect of different instructions on students' learning outcomes?
4. Is there a difference in learning outcomes after three weeks among participants who are exposed to repeated speech (RS), incongruent gestures with speech (IGS), and cued speech (CS)?
5. Is there a difference in their ratings of the test and the instruction among participants who are exposed to repeated speech (RS), incongruent gestures with speech (IGS), and cued speech (CS)? If there is, then how does it affect the participants' learning outcomes?

Results

First research question

A one-way between-group analysis of variance (ANOVA) was conducted. The reliability of the vocabulary test was tested and the Cronbach's alpha was .859, which was higher than the recommendation (α =.7). Levene's test was conducted to assess the equality of variances. The significance value was .742, which does not violate the assumption of homogeneity of variance. A one-way ANOVA was conducted to explore different outcomes among RS, IGS, or CS

(Table 1). Participants were randomly assigned to one of the three groups, and there were no statistically significant differences at the $\alpha > .05$ level in assessment scores for the three instructional groups [$F(2, 41) = 2.253$, $\rho = .118$].

Table 1 The first test: Descriptive analysis of the three different instructional groups

	n	M	SD
Repeated Speech	13	8.62	3.06
Incongruent Gestures with Speech	13	7	3.54
Cued Speech	18	9.5	3.15

However, when an independent samples t-test was conducted to compare the tests for the Incongruent Gestures with Speech group and the cued speech group, there was a statistically significant difference in the scores for IGS (M = 7, SD = 3.53) and CS [M = 9.5, SD = 3.15; $t(38) = -2.07$, $\rho = .047$]. The significance of the differences in the means was large because the effect size was .129 (Cohen, 1988).

Second and third research questions: Prior knowledge

A two-way between-groups analysis of variance (ANOVA) was conducted to explore the interaction effects of prior knowledge and different types of instruction with the vocabulary test. There was a statistically significant effect for prior knowledge [$F(2, 37) = 31.364$, $\rho = .0005$] and the effect size was large (partial eta squared = .459). However, the interaction effect with different types of instruction [$F(2, 37) = 2.401$, $\rho = .105$] was not statistically significant.

Fourth research question: After three weeks

The second test was conducted three weeks later. In order to answer the second question, a one-way between-groups analysis of variance (ANOVA) was conducted (Table 2). Levene's test was conducted to assess the equality of variances, and the value of significance was .917, which does not violate the assumption of homogeneity of variance. The analysis showed that there was a statistically significant difference at the $\alpha < .05$ level in the second assessment scores for the three different instructional groups [$F(2, 37) = 4.445$, $\rho = .019$]. The magnitude of the differences in the means was very large because the effect size was .217 (Cohen, 1988).

Table 2 The second test: Descriptive analysis of the three different instructional groups

	n	M	SD
Repeated Speech	12	6.33	2.84
Incongruent Gestures with Speech	13	5.69	3.25
Cued Speech	16	8.93	3.32

Fifth research question: Test and instruction rating report

After the vocabulary test, the participants rated the test difficulty level and the instruction. The test rating scale ranged from 1 (very hard) to 7 (very easy). The instruction rating scale also ranged from 1 (not interested) to 7 (very interested). This analysis was divided into three groups according to the three types of instruction (RS, IGS, and CS). A one-way ANOVA was conducted to explore the difference of test difficulty among the three groups. The test indicated that there was no statistically significant difference at the $\alpha > .05$ level in the test difficulty rating for the three groups [$F(2, 39) = .261$, $\rho = .772$]. Another one-way ANOVA was conducted for the rating of the instruction. This test also indicated that there was no statistically significant difference at the $\alpha > .05$ level in the ratings of the instruction for the three different groups.

Discussion

Kelly et al. (2009) report that congruent gestures enhanced learning of a second language. Meaningful gestures are semantically integrated with words (Marstaller & Burianová, 2013). This research demonstrated that learners who understood what cued speech was received higher scores on learning new words compared to the learners who did not know what cued speech was when it was presented: incongruent gestures ($M = 7$, $SD = 3.53$), cued speech [$M = 9.5$, $SD = 3.15$; $t(38) = -2.07$, $\rho = .047$]. This result suggests that cued speech functions as meaningful gestures and that cued speech is part of the semantic content rather than a separate claim on the receiver's attention. Furthermore, the cued speech group retained the learned information much better than the incongruent gestures group when they were tested three weeks later [$F(2, 37) = 4.445$, $\rho = .019$]. This finding supports the hypothesis that people learn and remember a new language better when it is taught with meaningful gestures because the gestures are synchronized with the new words (Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001; Feyereisen, 2006).

There was no difference between the repeated speech condition and cued speech in the test conducted immediately after the instruction. Kelly et al. (2009) used four different settings: speech, repeated speech, incongruent gestures, and congruent gestures. They reported that there were differences between speech & incongruent gestures vs. repeated speech and congruent gestures in the test immediately after the instruction. Repeated speech and congruent gestures were statistically different when the test was given two weeks later. This study did not include the speech condition because it would have had the same result as the incongruent gestures group. Interestingly enough, the cued speech group got better scores three weeks later than the repeated speech group. From this result it can be safely assumed that repeated speech and cued speech/meaningful gestures generate similar learning experiences immediately following the instruction, but cued speech/meaningful gestures result in information being retained more effectively than with repeated speech. Other researchers have reported that learners remembered more items when gestures were used compared to learners who learned the items without gestures (Goldin-Meadow et al., 2001; Wagner, Nusbaum, & Goldin-Meadow, 2004). The reason for this is that spatial patterns help people remember better (Wagner et al., 2004). Gestures related to speech increase the dual task capability in working memory (Cook, Yip, & Goldin-Meadow, 2012). Wagner points out that the dual task paradigm occurs when two types of information come into working memory that support each other rather than causing confusion or competing with each other in the brain's processing of the information.

Conclusion

Meaningful gestures can be a very useful tool in learning a second language; however, it has its own limitation. It is difficult to create meaningful gestures. There is an almost infinite number of ways, and everyone could come up with their own way to create and interpret gestures. There are more than 171,476 words in the latest Oxford English dictionary (How many, 2017). Can we come up with at least 10,000 signs and remember all of these visual signals? How about cued speech? Cued speech is developed based on phonemes, which is similar to spoken language (LaSasso, 2010). When Cornett (1967) developed cued speech, he used eight hand shapes and four hand placements. And cued speech can be learned in a short period of time—one week or a few weeks (Cornett & Daisey, 2001). Using cued speech is more natural and practical compared to developing thousands of meaningful visual signals. Could it be a new way of learning a second language?

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