



The Effect of Modality Type on Cognitive Processing of L2 Single Words

Vahid Rahmani Doqaruni^{1*}

¹University of Gonabad, Iran

Abstract The main purpose of the present study is to find out which type of modality (i.e., reading, listening, or reading while listening) affects second language (L2) learners' cognitive processing of single words more efficiently. In order to achieve the aim of the present study, a semantic decision task was employed. In this task, participants saw a pair of words presented one after the other and were asked to decide whether or not the target word was affectively related to the preceding word. The participants were 150 Iranian EFL learners who were randomly assigned to three equal groups (each consisting of 50 participants), namely, reading, listening, and reading while listening. The data showed that the type of modality has a significant effect on the cognitive processing of single words in L2 education. More specifically, it was found that multimodality (i.e., reading while listening) is more effective than single modality (i.e., listening or reading) in the cognitive processing of L2 single words.

Keywords: *Type of modality, Multimodality, Cognitive processing, Semantic decision task, Iranian EFL learners*

1. Introduction

Different disciplines have used the term “multimodality” in different ways to accomplish their purposes. However, “it is commonly used to refer to the different resources used by participants to accomplish social actions” (Lilja, 2023, p. 206). In the field of second/foreign language (L2) education, these resources can be oral, such as word, phrase, and clause; aural, such as tone, stress, and intonation; visual, such as gesture, gaze, and movement; written, such as text, transcript, and passage; and even pictorial, such as illustration, drawing, and picture. All of these resources operate in collaboration with the lexical and grammatical knowledge of L2 learners to produce a mutually reinforcing complex of cues to meaning (Hardison & Pennington, 2021).

Language learning and teaching are essentially multimodal activities. Several studies have shown that L2 learners not only use speech but also employ body movements and facial gestures to convey and comprehend the message and enhance learning opportunities (e.g., Eskildsen & Wagner, 2013; Garcia-Gamez & Macizo, 2019; Huang et al., 2019; Li & Somlak, 2019; Macedonia & Klimesch, 2014; Macedonia & Knosche, 2011; Morett, 2014, 2018; Smotrova, 2017; Tai & Khabbazzbashi, 2019). Written information can also

*Corresponding Author:
Vahid Rahmani Doqaruni
rahmani@gonabad.ac.ir

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help listeners comprehend when they are not able to fully interpret information from the audio channel, as is the case in many L2 contexts. Due to the importance of multimodality in increasing learning efficiency in L2 education, nowadays much of the material presented to L2 learners as input has become available in both written and aural formats. Most, if not all, course books include both aural and written versions of the same texts, and graded readers come along with CDs that include the spoken versions of the texts. This makes L2 input available in three modes: reading, listening, and reading while listening. So, to fully understand language learning and teaching processes, it is necessary to consider and investigate these different single modalities (i.e., reading and listening) and multimodal forms (i.e., reading while listening).

Many previous studies have explored the effect of these different single modalities and multimodal forms on L2 vocabulary learning. In this way, previous research has shown that L2 words can be learned incidentally through reading (e.g., Pigada & Schmitt, 2006; Waring & Takaki, 2003). Similarly, it has been shown that L2 words can be incidentally learned through listening (Brown et al., 2008; van Zeeland & Schmitt, 2013; Vidal, 2011). Likewise, research has shown that reading while listening can also have positive effects on incidental vocabulary learning (Brown et al., 2008; Webb & Chang, 2012). Comparisons of the extent to which these three different modalities result in incidental vocabulary learning have shown that reading while listening is more effective than reading (Webb & Chang, 2012), and listening is the least effective one (Brown et al., 2008). Comparing the effects of L2 input modalities is of considerable importance because it has been argued that L2 lexical development is dependent on vocabulary learning through these modalities (Laufer, 2003; Nation, 2013; Webb & Nation, 2017), so it is necessary to find out how much each modality results in learning.

However, one question that remains to be explored is how these three different single modalities and multimodal forms are cognitively processed. There is great value in examining this issue because previous relevant theories, including the dual-coding theory (Paivio, 1986) and the cognitive theory of multimedia learning (Mayer, 2001), have suggested that the human brain processes information through separate modalities, namely, auditory and visual. However, to the best of my knowledge, no previous study has ever attempted to test the credibility of such theories on multimodality by designing relevant cognitive tasks. This is surprising because previous research has shown that cognitive processing plays an important role in L2 learners' minds and it can be influenced by different factors such as linguistic affection (Rahmani Doqaruni, 2021a), semantic relatedness (Rahmani Doqaruni, 2021b, 2022), learners' age (Rahmani Doqaruni, 2023), and mode of presentation (Rahmani Doqaruni, in press). So, in line with previous research, exploring the effect of type of modality (either single modality or multimodality) on the cognitive processing of linguistic stimuli is of particular interest. Thus, the main purpose of the present study is to find out which type of modality (i.e., reading, listening, or reading while listening) affects L2 learners' cognitive processing of single words more efficiently. In order to achieve the main purpose of the present study, the following research question was asked:

Are there statistically significant differences between different types of modalities (i.e., reading, listening, and reading while listening) considering the cognitive processing of L2 single words by EFL learners?

2. Theoretical Framework

The cognitive theory of multimedia learning (Mayer, 2001) has gained particular attention in the field of L2 education (Liu et al., 2018; Xu, 2010). This theory is based on three other theories. First, the Dual-Coding Theory (Paivio, 1986) which states that language learners process information through two channels of sensory memory, namely, auditory and visual. Second, the Generative Theory (Mayer, 2001) which contends that learning is a process consisting of the following procedures: selecting auditory and visual information from sensory memory, forming auditory and visual representations, organizing the representations in the working memory, and integrating new knowledge with prior knowledge. Third, the Cognitive Load Theory (Sweller, 1988) which warns that the working memory and cognitive channels are limited in processing information and can be overloaded in case there is extra input.

The cognitive theory of multimedia learning hypothesized a series of principles based on the assumptions proposed in these three theories. First, the modality principle which states that when the input is presented through auditory and visual channels simultaneously, students go through the following steps for processing the information: 1) both auditory and visual channels are stimulated; 2) auditory and visual representations of the input are formed; 3) cognitive connections between the representations are constructed; 4) the connected representations are integrated into long-term memory; 5) and finally, higher learning efficiency is achieved (Mayer, 2014). Second, the redundancy principle which contends that learners experience cognitive overload if extra multimedia input is imposed on a single channel. The learners' attention splits between different modalities, and consequently, processing information becomes difficult, which results in lower learning efficiency (Moreno & Mayer, 2002). Third, the coherence principle which asserts that learners are distracted if there is irrelevant or unnecessary multimedia input. This leads to disrupted information processing, and as a result, learning efficiency is reduced (Mayer & Moreno, 2003).

Different studies have attempted to investigate the effects of learning L2 single words through different modalities. Brown et al. (2008) used graded readers to compare the differences in vocabulary learning through reading, listening, and reading while listening. It was found that reading while listening was the most effective modality in increasing vocabulary knowledge, and listening was the least effective one. Both immediate and delayed posttests showed that participants followed a similar pattern in gaining more knowledge of the target vocabulary, which was through reading while listening, reading, and listening, respectively. The data further showed that the scores in the reading while listening and reading conditions were significantly greater than the listening condition.

Vidal (2011) was interested in comparing incidental learning of L2 single words through different modalities of reading and listening. The participants, who were first-year university students studying English for specific purposes, were divided into two groups. One group read three short academic texts, while the other listened to three short lectures. In order to control for any interfering variables, the texts and lectures covered the same content and were of a similar length. Participants in the reading group demonstrated more vocabulary knowledge gains in comparison to the listening group in both immediate and delayed posttests.

Webb and Chang (2012) compared reading and reading while listening modalities to find out which one was more effective in incidental learning of single words by EFL learners. The participants were asked to read or read and listen to the same text several times. Two tests were administered to find out which group performed better in learning two sets of 50 words. The results showed that the participants in the reading while listening group outperformed their counterparts in the reading group as they learned significantly more words incidentally.

Lin and Yu (2017) compared the effects of four conditions on vocabulary learning of eighth-grade students: text only, text plus picture, text plus sound, and text and sound plus picture. Their results revealed that the multimodality of text plus sound resulted in achieving the best scores in the immediate posttest, while the multimodality of text and sound plus picture resulted in achieving the best scores in the delayed posttest.

Teng (2018) tried to find out the effects of reading and reading while listening to a graded reader, considering the four aspects of L2 vocabulary knowledge, i.e., form recognition, grammar recognition, meaning recall, and collocation recognition. The participants were Chinese second-year EFL students studying at a university in China. The findings showed that the participants in the reading while listening group outperformed the participants in the reading group on all four vocabulary knowledge tests. This study is of particular importance as it shows that the modality of input may have an effect on different aspects of word knowledge.

Feng and Webb (2020) compared incidental learning of single words by Chinese learners studying EFL at a university in China through three different conditions: watching a TV program in L2, reading the transcript of the same TV program, and listening to the audio of the same TV program. The findings revealed that the participants had significant gains in L2 vocabulary knowledge in all learning

conditions. However, no significant differences were found between the three modalities, which indicates that each of them contributed equally to vocabulary knowledge gains.

As reviewing the literature shows, the most effective modality for learning individual words is reading while listening. While these studies are of great value as they help to gain a deeper insight into the effect of different modalities on vocabulary knowledge in L2 education, they are limited in the sense that they have only focused on learning purposes. In this way, the present study aims to move this strand of research one step further by designing a new methodology through which the effect of different modalities on EFL learners' cognitive processing of single words is investigated.

3. Methodology

3.1. Participants

The participants were students in the Department of English Language and Literature at the University of Gonabad, northeastern Iran. They were all majoring in English language teaching and English language and literature and were recruited for the study through invitation. In order to ensure that the participants in the study had similar EFL proficiency, a modified paper-based proficiency test of TOEFL (consisting of only structure, written expression, and reading comprehension sections) was taken from 215 students. The cut-off score was set at 520, which indicates that the participant has at least an intermediate proficiency level. Following the test results, 179 students (128 female and 51 male) were selected. They were then randomly assigned to three equal groups (each consisting of 50 participants), namely, reading, listening, and reading while listening. So, for the actual experiment, the data of 150 participants (106 female and 44 male) were used.

The participants were between 18 to 25 years old. They reported either normal vision or corrected to normal vision using glasses. All participants were born and lived in Iran at the time of the experiment and spoke Persian as their native language. They reported using Persian on an everyday basis in both formal and informal contexts, with English being spoken mostly in educational contexts. All participants were aware of the voluntary nature of the study and gave informed consent to participate in the study.

3.2. Stimuli

The aim of the present study was to investigate the effect of different types of modalities (i.e., reading, listening, and reading while listening) on EFL learners' cognitive processing of L2 linguistic stimuli, which were single words. In order to achieve the aim of the present study, a prime word (a noun) preceded the target word (an adjective). This resulted in congruent noun-adjective dyads, e.g., *Hug-Friendly* (positive prime, positive target) or *Cemetery-Depressed* (negative prime, negative target). In this way, meaningful noun-adjective dyads in the present study consisted of either a positive or a negative prime noun followed by an affectively congruent target adjective. Meanwhile, unrelated noun-adjective dyads were constructed by preceding target adjectives with unrelated prime nouns (positive condition: *Hell-Friendly*; negative condition: *Reward-Depressed*). In other words, the noun-adjective dyads that were unrelated in meaning consisted of either a positive or a negative prime noun that was affectively incongruent with the following target adjective.

Following the mentioned procedure, a set of 60 English nouns (30 positive, 30 negative) and 30 English adjectives (15 positive, 15 negative) were paired into 60 noun-adjective dyads in this study. Half of the noun-adjective pairs were affectively related, and half were affectively unrelated. The noun-adjective dyads used in the present study were adopted and adapted from Jonczyk (2016). According to Jonczyk (2016), the prime nouns and target adjectives were matched regarding the variables of valence, arousal, concreteness, frequency, and word length.

3.3. Procedure

3.3.1. Data Collection

A semantic decision task was employed in the present study. In this task, participants see a pair of words presented one after each other and are asked to decide whether or not the target word is affectively

related to the preceding word. In order to design and perform the task, PsychoPy (Peirce, 2007, 2009), version 3, was used.

Participants were seated in a comfortable chair 100 cm away from a laptop monitor in a quiet room. The participants of the reading group were asked to read a sequence of two words appearing on the screen (first, a noun and then, an adjective) and decide upon the presentation of the second word, whether the word pair was affectively related by pressing an appropriate button on the keyboard (right arrow for yes and left arrow for no). Each noun-adjective dyad was preceded by a fixation point that lasted 2000 ms. Subsequently, a prime noun was presented for 1000 ms in the center of the screen, followed by a target adjective. The target adjective stayed on the screen until the participant responded, but no longer than 2000 ms. The same procedure was followed by the other two groups (i.e., listening and reading while listening), with the only difference being the presentation modality, which was either through listening or reading while listening.

The whole experimental session consisted of 60 trials presented in a randomized order in white letters (font Times New Roman, size 20) over a grey background. The whole data-gathering process took almost 5 minutes for each participant.

3.3.2. Data Analysis

SPSS (version 24) was used to analyze the data. Descriptive statistics of the measures were calculated for reaction time (RT) to determine the effect of different modalities on the cognitive processing of L2 single words. In addition, a one-way ANOVA test was used to find out whether the difference between the three modality groups was statistically significant. Furthermore, an LSD post-hoc test was run to reveal where the possible difference among the modality groups might lie.

4. Results

Table 1 shows the means and standard deviations of RTs (in milliseconds) for different conditions of prime-target in three different modalities. As the data reveals, the reading while listening group outperformed the other two groups with respect to their cognitive processing of L2 single words as they showed the fastest RT in all conditions in comparison to the other two groups ($M=1.003$, $SD=.10$). The reading group was the second one in this respect ($M=1.382$, $SD=.14$) and the listening group had the slowest RT ($M=1.613$, $SD=.10$).

Table 1
Means and Standard Deviations of RTs for Different Modalities

| | Listening | | Reading | | Reading While Listening | |
|-------------------|-----------|-----|---------|-----|-------------------------|-----|
| | RT(ms) | SD | RT(ms) | SD | RT(ms) | SD |
| Positive-Positive | 1.517 | .10 | 1.276 | .13 | .849 | .10 |
| Positive-Negative | 1.789 | .11 | 1.484 | .14 | 1.067 | .10 |
| Negative-Positive | 1.712 | .11 | 1.520 | .15 | 1.112 | .11 |
| Negative-Negative | 1.436 | .10 | 1.251 | .14 | .986 | .12 |
| Total Mean | 1.613 | .10 | 1.382 | .14 | 1.003 | .10 |

In order to test whether the difference among the groups was significant, a one-way ANOVA test was used. As Table 2 shows, there was a statistically significant difference in the EFL learners' cognitive processing of single words with respect to the modality used, with $F(2, 147)=13.144$, $p=.000$.

Table 2
One-Way ANOVA

| | Sum of Squares | df | Mean Square | F | Sig. |
|----------------|----------------|-----|-------------|--------|------|
| Between Groups | 11797.453 | 2 | 5898.727 | 13.144 | .000 |
| Within Groups | 65968.840 | 147 | 448.768 | | |
| Total | 77766.293 | 149 | | | |

As Table 3 shows, the LSD post hoc test indicates that the statistically significant difference lies between reading while listening group and the other two modalities (i.e., listening and reading). However, the data did not show any other statistically significant differences between the groups.

Table 3
LSD Post-Hoc Test

| | | Mean Difference | Std. Error | Sig. | 95% Confidence Interval | |
|-------------------------|-------------------------|-----------------|------------|------|-------------------------|-------------|
| | | | | | Lower Bound | Upper Bound |
| Listening | Reading | -6.240 | 4.237 | .143 | -14.61 | 2.13 |
| | Reading While Listening | -21.140* | 4.237 | .000 | -29.51 | -12.77 |
| Reading | Listening | 6.240 | 4.237 | .143 | -2.13 | 14.61 |
| | Reading While Listening | -14.900* | 4.237 | .001 | -23.27 | -6.53 |
| Reading While Listening | Listening | 21.140* | 4.237 | .000 | 12.77 | 29.51 |
| | Reading | 14.900* | 4.237 | .001 | 6.53 | 23.27 |

*The mean difference is significant at the 0.05 level.

5. Discussion

The data showed that the type of modality has a significant effect on the cognitive processing of L2 single words. According to the data, the learners in the reading while listening group had the fastest RT with respect to their cognitive processing of linguistic stimuli in comparison to their counterparts in the listening and reading groups. Moreover, the follow-up post hoc test showed that the significant difference among the groups lies between the reading while listening group and the other two groups (i.e., the listening and reading groups). So, the results underscore the notion that multimodality has a positive effect on the cognitive processing of single words in L2 education.

The results of the present study suggest that participants in the reading while listening group may have linked both the written and auditory word forms to the meaning representation faster than either of them alone. This finding is in line with previous research as it has been shown that having access to both written and auditory word forms facilitates learning (e.g., Hu, 2008; Ricketts et al., 2009; Rosenthal & Ehri, 2008) and a bimodal presentation, such as text and sound, results in better recognition memory (e.g., Bird & Williams, 2002). As Winke et al. (2010, p. 79) point out, “essentially, it appears that more input is better, leading to the increased depth of processing since learners utilize different input modes differently, and these input modes reinforce one another”.

The findings also support Mayer’s (2001) cognitive theory of multimedia learning. This theory argues that the human brain processes information through two separate channels, namely, auditory and visual. The former is responsible for processing auditory information (e.g., spoken words, music, and sound), and the latter is responsible for processing visual information (e.g., text, picture, and video). According to this theory, the brain makes use of the two channels to encode and store information in order to form mental constructs. So, when a particular stimulus is represented through different modalities, a coherent mental image is formed in the brain, which leads to more efficient learning (Dubois & Vial, 2000). Thus, putting learners in multimodal environments paves the way for parallel information processing, which leads to stronger mental representations of information and hence promotes cognitive processing (Mayer, 2001). In fact, previous research has shown that dual modalities are far superior to single modalities (Abraham, 2008; Akbulut, 2007; Al-Seghayer, 2001; Rassaei, 2018; Yun, 2011). On the same ground, considering the results of the present study, it can be argued that the participants who were exposed to dual modalities (i.e., reading while listening) outperformed those participants who had access to only one single modality (i.e., listening or reading) with respect to cognitive processing of L2 single words.

It has also been argued that multimodality enhances listening comprehension and reading comprehension. Considering the former, it has been shown that using both visual and auditory channels at the same time, such as reading while listening in the present study, helps learners to construct connections among different multimodality representations of the listening content more efficiently

(e.g., Chang et al., 2011; Chen et al., 2012). In addition, textual content may lead learners to pay more attention to the auditory content (Chen & Chang, 2011) and consequently enhance their comprehension by providing textual support. Considering the latter, Kozan et al. (2015) found that adding auditory material to the reading material facilitated learners' comprehension because working memory is directly connected to the auditory channel. So, as it has been shown that multimodality has positive effects on listening and reading comprehension, it might be argued, in the same way, that these effects have enhanced the participants' cognitive processing of linguistic stimuli in the reading while listening group.

Further support for the results of the present study comes from the concept of "emotioncy". Emotioncy (emotion + frequency) is defined as sense-provoking emotions with respect to particular words, which can affect cognition (Pishghadam et al., 2013). It has been argued that emotioncy can relativize different aspects of human's cognition (Pishghadam & Abbasnejad, 2017a, 2017b). According to Pishghadam et al. (2013), the relativization of cognition is due to the frequency of sensory experience, which awakens emotioncy through the senses. In this way, the senses play an important role in emotioncy as they are the modalities through which the people connect with the outside world. These combinations of senses (i.e., multisensory) enhance the learning experience (Shayesteh et al., 2019).

The findings of the present study showed that the concept of emotioncy can be employed in the realm of multimodality as well. Pishghadam et al. (2013) asserted that the level of emotioncy is influenced by the number of senses involved in a particular task. For example, the number of senses involved in the task of vocabulary learning (such as hearing, seeing, etc.) impacts vocabulary learning and retention. This is in line with Pishghadam's (2015) hierarchy of emotioncy, ranging from involvement (auditory, visual, and kinesthetic) to involvement (inner and arch), which emphasizes the emotions evoked by different senses. In fact, emotioncy introduces the ways (e.g., visually or auditory) through which individuals experience the world, which consequently shape and affect their cognition. So, it can be argued that higher levels of emotioncy, which cover more senses, can result in stronger cognitive processing of linguistic stimuli. In other words, when language users have higher levels of emotioncy for specific words, they will be more involved in the cognitive processing of that particular linguistic stimuli. This might be the reason why the participants of the reading while listening group (i.e., the multimodal group) in the present study processed linguistic stimuli more effectively as they experienced a higher level of emotioncy in comparison to the other single modality groups (i.e., listening and reading).

The aim of the present study was to investigate the effect of type of modality (i.e., reading, listening, or reading while listening) on EFL learners' cognitive processing of linguistic stimuli. The data showed that the type of modality has a significant effect on the cognitive processing of single words in L2 education. More specifically, it was found that multimodality (i.e., reading while listening) is more effective than single modality (i.e., listening or reading) in the cognitive processing of single words.

The findings of the present study have immediate pedagogical implications. The positive role of multimodality in the classroom environment implies that language teachers can exploit multimodality to both diversify the material in their language class and facilitate their cognitive processing. For example, the teacher can use songs with transcriptions and clips from movies and series in the teaching of vocabulary and grammar to enhance the learning experience. These multimodalities provide contextualized language input tied to real-life situations, which, as shown by the findings in this study, can result in more effective cognitive processing of linguistic stimuli. As Teng (2023, p. 752) points out, "the design of multimedia instruction can stimulate learners' cognitive processes. The visual and verbal information processing system enables people to build visual and verbal cues and then retrieve relevant stored information from memory to activate knowledge for learning". Moreover, as using multimedia technologies has become widespread for presenting authentic input and there is a growing interest in using such technologies by young L2 learners, presenting input through multimodality helps L2 learners have access to real language and accelerates their cognitive processing.

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