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A Canonical Correlation Analysis: Learning Preferences and Sensory-Specific English Learning Material Stimuli

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Abstract/Izvleček The study investigated the relationship between sensory-specific English learning material stimuli and sensory learning preferences. The study involved 53 English as a foreign language participants. Participants were provided with different sensory-specific English learning material stimuli to analyse their overall comprehension. A canonical correlation analysis was used to analyse the collected data statistically. Auditory learning preference was significantly related to adaptive English learning stimuli (paper texts with sound, images with captions, and sound with images). The canonical correlation coefficient of .665 indicated 44.2% of the variance in English learning was determined by learners with auditory learning preferences and adaptive learning materials.

Kanonično-korelacijska analiza: učne preference in senzorično specifični dražljaji učne snovi angleščine

Študija je preučevala razmerje med senzorično specifičnimi dražljaji učnega gradiva za angleščino in senzoričnimi učnimi preferencami. Vključevala je 53 udeležencev angleščine kot tujega jezika, ki so prejeli različne senzorično specifične dražljaje učnega gradiva za angleščino, da bi analizirali njihovo splošno razumevanje. Za statistično analizo zbranih podatkov je bila uporabljena kanonično-korelacijska analiza. Preferenca slušnega učenja je bila pomembno povezana s prilagodljivimi dražljaji za učenje angleščine (besedila na papirju z zvokom, slike z napisi in zvok s slikami). Kanonični korelacijski koeficient 0,665 je pokazal, da so 44,2 % variance pri učenju angleščine določili učenci s slušnimi učnimi preferencami in prilagodljivimi učnimi gradivi.

Keywords:
sensory-specific English learning material stimuli; sensory learning preferences; the canonical correlation analysis; adaptive learning material stimuli; auditory learning preference

Ključne besede:
Senzorično specifični dražljaji učne snovi angleščine, Kanonično-korelacijska analiza, prilagoditveni dražljaji učne snovi, preferenca slušnega učenja

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Introduction

Sensory learning preferences differ for each student (Aslaksen and Lorås, 2018; Rogowsky et al., 2015; Hayashi and Cherry, 2004; Reid, 1987), most often with different ways of perceiving, thinking, memorizing, and solving problems (Shepard-Carey, 2020; Golon, 2017; Keefe, 1987; Messick, 1976; Allport, 1973). Students are directly exposed to these stimuli in EFL materials, which are crucial for optimizing learning (Tomlinson 2008; Kozhevnikov 2007). Language learning is also an individualized, complex process. Different individuals perceive and respond to learning materials differently (Chen, 2019; Hsu, 2016; Lee, Yeung and Ip, 2016; Hedayati and Foomani, 2015). Hence, studying sensory preferences and sensory-specific stimuli could improve the learning of English.

Peacock (2001) and Luchow and Shepherd (1981) concluded that non-visual sensory modalities applied to visually related tasks do not enhance learning. Since the learning aim is to be completed visually, other sensory modalities might interfere with the meshing hypothesis.

Studies have also shown that if stimuli match learners' learning preferences, students can learn more effectively (Montero Perez, Peters, and Desmet, 2018; Keefe, 1991). The meshing hypothesis suggests adapting learning stimuli to learner preferences. Therefore, previous studies should be examined further. Research is needed to determine whether sensory-specific learning materials foster learners with different sensory preferences. To provide suitable language learning material stimulation, teachers must first understand their learners' learning preferences (Cohen, 2003).

Once teachers are aware of students' learning preferences, they can adapt their pedagogy and themselves to best suit the learning styles of their students (Gilbert, 2000). To cater to student learning differences, teachers should also consider individual learning differences when planning and designing their lessons, according to Fenrich (2006). Chen (2009), and Rezler and Rezmovic (1981) argued that Taiwan senior high schools ignore or omit these types of preliminary learning preferences among students. In light of this, the authors suggest that considering the relationship between sensory-specific language learning material stimuli, personal sensory learning preferences, and their impact on learning outcomes, language learners can improve students' English comprehension.

The correlation between personal preferences and stimuli used in learning materials remains unresolved. The learning process must be facilitated by both learning materials and pedagogical methods, as suggested by Rao (2011). Learning can be facilitated to enhance learners' comprehension. As a result of the findings, sensory-specific materials were emphasized as an important tool for bridging the learning gap between expectations and reality.

This study aimed to identify the relationship between sensory-specific learning materials and learner preferences in the learning of English. Using English language learning materials, the study investigated how sensory stimulation affects learning preferences.

Literature review

Humans' sensory perceptual learning modality

Since people are innately able to perceive things, we learn, get to know, and experience things primarily through our senses (Barth et al., 2012). In sensory perception, stimuli from the living world are recognized, organized, and interpreted in a variety of ways. Humans can perceive virtually every sense through their senses, Conscious awareness is present in some senses, while subconscious awareness is present in others, including visual, auditory, tactile, kinaesthetic, olfactory, taste, proprioception, and vestibular senses. It is through these that humans explore the world and discover its challenges and opportunities (Keefe, 1987).

To explain the concept that learners have differentiated learning preferences, Keffe (1979) classes each learner's learning style into three different categories and conceptualizes the individual styles into cognitive, affective, physiological, and physical perspectives. Cognitive learning focuses on how learners perceive the world. There appears to be a correlation between how learners perceive and process information and how they will process it. Affective perspectives emphasize how learners feel while they are learning, while physiological and physical perspectives emphasize how students respond to stimuli. Contrary to this, Cronbach and Snow (1977) proposed Aptitude-Treatment Interaction (ATI), indicating that when the educational materials are delivered to the student, teaching strategies can compensate for the learning results that are induced by individual differences (Thang, Nambiar, Wong, Jaafar, and Amir, 2015).

According to significant research, primates are capable of learning, especially through sensory integrations, since the Anterior Rhinal Cortex regulates multiple functions of this region (Goulet and Murray, 2001; Murray and Mishkin, 1985). DCT (Dual Coding Theory) of Paivio (1986) and Baddeley's (1998) working memory theory explain how humans incorporate, understand, process, store, extract, and use stimuli. In both theories, the mind of a human is defined clearly. Visual aids appear to play a significant role in learning, so they are used to integrate text and images into learning materials, ensuring student learning outcomes are promoted by how learning materials are presented and how they interact with student learning. Based on DCT theory, learning is not only about texts, but also how they are delivered to accommodate learners' individual needs and, above all, to induce positive outcomes.

Effects of sensory-specific learning material stimuli on learners with different sensory learning preferences

Learners perceive learning stimuli differently (Ehrman and Leaver, 2003; Oxford, 1993; Riding and Cheema, 1991; Felder and Silverman, 1988; Keefe, 1987; Messick, 1976; Allport, 1937). In the literature review, learning style, learning preference, or cognitive style were terms used by many researchers (Hederich-Martínez and Camargo-Uribe, 2016; Ehrman and Leaver, 2003; Littlemore, 2001; Merriam and Caffarella; 1999; Riding and Agrell, 1997; Tinajero and Páramo, 1997; Kinsella, 1996; Reid, 1984; Oxford, 1993; Jamieson, 1992; Riding and Cheema, 1991; Oxford, 1990). Learning styles have not been sufficiently verified. Throughout this article, the term "learning preference" is used in reference to Reid (1984).

Cronbach and Snow (1977) proposed Aptitude-Treatment Interaction (ATI) theory, claiming that when learning aptitude and teaching instruction are matched, optimal learning results will be generated (Pashler et al., 2008). Hence, learning stimuli should match learners' preferred learning styles. Such a match between learning stimuli and learning styles might increase students' chances of learning (Ferrero et al., 2016; Gleichgerrcht et al., 2015; Dandy and Bendersky, 2014; Howard-Jones, 2014; Dekker et al., 2012; Tabatabaei and Mashayekhi, 2012; Gilakjani, 2012; Riener and Willingham, 2010; Mulalic, Shah and Ahmad, 2009; Wintergerst, DeCapua and Verna, 2003).

The meshing hypothesis theory has been supported without any concrete evidence by several studies (Chew, 2016; Willingham et al., 2015; Pashler et al., 2008; Kozhevnikov, 2007; Coffield et al., 2004; Calvert et al., 2000). Bicer (2014) also found no statistically significant correlation between learning achievement and learning style preferences. Wright and Zhang (2009) also wrote a review regarding how public speaking training stimulates generalization of speech patterns. Considering that different training tasks have different effects on generalization, there is no simple way to predict a given task's generalisation pattern since there is no simple rule that can be used. Based on what has been discussed above, different sensory stimuli should be considered for individuals with various learning styles.

Since there are many types of learning styles, it is impossible to consider every single one, and it is highly unlikely that learning preferences will be remembered for each individual. It is undeniable that understanding learners' learning styles enhances classroom experience (Hames and Baker, 2015), but it is impossible to solve all the problems associated with learning foreign languages.

Studies conducted by Constantinidou and Baker (2002), Massa and Mayer (2007), Cook, Thompson, Thomas, and Thomas (2009) also claim that learning outcomes were not affected by differences in material stimuli. As with Massa and Mayer (2006), the Verbalizer-Visualizer Questionnaire (VVQ) experiment in this study confirmed the findings that there was insufficient evidence of significant differences between learners' learning abilities, regardless of learning style. According to the researchers, the findings of the study did not support the meshing hypothesis that better learning outcomes can be achieved through providing learning materials that correspond to students' learning preferences. However, the results contradict the meshing hypothesis; thus, the performance of the participants needs to be discussed further. A study by Fahim and Samadian (2011) concludes that experienced learners are much more flexible when it comes to sensory perception, while inexperienced learners tend to be the opposite. There has been insufficient discussion about sensory preference, so more empirical studies are required to clarify its effects

Purpose of the study

A canonical correlation analysis was used to investigate to what extent sensory English learning materials might influence the performance of EFL learners. Learners' learning preferences and sensory stimuli in learning materials have not been conclusively linked.

To gain a better understanding of how learning preferences affect English learning materials, this empirical study investigated the relationship between visual input (paper texts; images with captions), visual and auditory input (paper texts with sound; images with captions and sound; sound with images) and auditory input (sound), with the following research questions:

(1) What is the canonical correlation between learning preferences and sensory-specific English learning material stimuli?

(2) Is the meshing hypothesis supported or rejected by the findings?

Research methodology

Experimental design and procedure

It was a quasi-experimental design. Figure 1, Research Procedure, shows that the experiment lasted six weeks. Each week, different English learning material stimuli were provided to participants. Paper texts (visual stimuli) were used in the first week. The second week included paper texts with sound (a combination of visual and auditory stimuli). Week 3 used images with captions (visual stimuli), while week 4 used images with captions and sound (visual and auditory stimuli). The study involved the administration of sounds (auditory stimuli) and sounds with images (visual and auditory stimuli) during weeks 5 and 6. Following individual sensory-specific stimuli, each participant took about 20-30 minutes to assess their understanding of the English learning material. The students had to answer multiple-choice questions about sensory-specific stimuli as part of each English comprehension test.

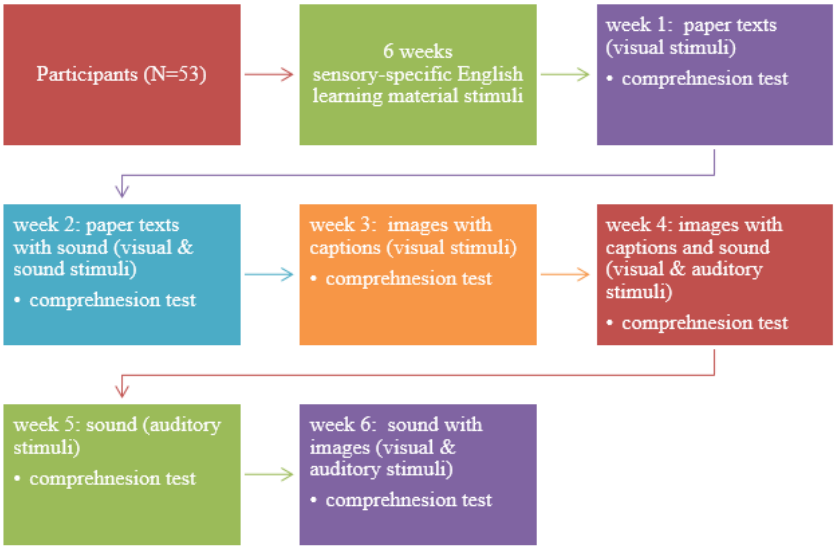

Figure 1. Research procedure

Participants

There were 53 participants in this study, 36 females and 17 males, who were vocational high school English majors in Northern Taiwan, aged 16-17. Six sensory-specific learning exercises guided them to engage and then answer multiple-choice questions related to the stimuli. Participants completed a self-report questionnaire to determine their learning preferences. They were not informed of their learning preferences before the experiment, and neither were the researchers.

The 53 participants in the quasi-experiment were classified as having four learning preferences: 8 visual learners, 27 auditory learners, 15 haptic learners and 3 kinaesthetic learners. It is also possible for someone's learning preferences to change over time (Reid, 1987). Student learning preferences were assessed using a self-report questionnaire. It is, however, important to note that the learning preference of an individual is relative rather than absolute. Therefore, canonical correlation analysis was used. Based on the canonical coefficients, auditory learners and adaptive learning material stimuli demonstrated a significant relationship in learning preferences. Therefore, the present study provided an in-depth description of auditory learners. The rest did not show a significant relationship after the intervention.

Analytical methods

A canonical correlation analysis was used to assess the relationship between sensory-specific English learning materials and learners' learning preferences. To better understand their relationship, the absolute values of the canonical loadings of the ranked variables were also calculated.

Data collection - Sensory-specific English learning material stimuli design

Sensory-specific English learning material was selected based on three criteria. First, learners need to identify the kinds of English learning material they are interested in, as well as select words appropriate to their word proficiency level. To avoid potential cognitive overload, participants should not be provided with material that is too long or difficult. Thirdly, it was essential that the materials be presented visually (paper texts; images with captions), visually and auditorily (paper texts with sound; images with captions and sound; sound with images) and auditorily (sound). We chose a series of American clips online. During a Taiwanese family's two years in the US, these American clips discuss culture shock. Because the main characters are also Taiwanese, this creates a connection with the learners, allowing for a discussion of cultural differences. Based on these criteria, the authors selected sensory-specific learning material stimuli.

English comprehension assessment

The English learning comprehension questions were administered following each sensory-specific stimulus activity to assess a participant's understanding related to the stimuli. A total of eight multiple-choice comprehension questions were used in each experiment regarding the sense-specific English learning material (see Appendix A for samples of multiple-choice comprehension questions in the experiment).

7. The father mentioned, "I have grown to love it like the daughter we wished Evan had been." What did he mean?
(A) Evan had a sister.
(B) Evan was his daughter.
(C) Evan had a daughter.
(D) Evan had been expected to be a daughter but it was on the contrary.

8. What did the mother's brother do?
(A) He does nothing.
(B) He sells furniture.
(C) He owns a restaurant.
(D) He is still a student.

Example 1: Samples of multiple choice comprehension questions in the experiment

One point was awarded for each multiple-choice comprehension question, so there would be an overall score of eight points for each stimulus test. The authors developed eight English comprehension tests for each learning series. Additionally, the test items were verified by experienced English teachers and professors with expertise in education and over ten years of teaching experience. For each item to bear the same level of difficulty during the English comprehension assessments, the difficulty index of each item was calculated statistically prior to the experiment to achieve consistent item discrimination. It was decided to omit those test items that were inappropriate for the test. In general, the difficulty index (DIF I) is 0.67 while the discrimination index (DI) is 0.46.

To make the statistical analysis comparable, the scores were added, counted, and normalised so that they could be compared. Taking the example of a participant who received four points on one sensory-specific learning activity and five in another, the participant would get 56.25 normalised scores as a result of both learning activities. A canonical correlation analysis was then performed on the scores to determine the correlation between the two (sensory-specific learning material stimuli and learning preference).

Self-report learning preference questionnaire

Adapted self-report questionnaires were administered after treatment to answer the second research question. To assess participants' learning preferences, a Likert Scale questionnaire (strongly agree = 5 points, agree = 4 points, undecided = 3 points, disagree = 2 points and strongly disagree = 1 point) and a True-or-False questionnaire were provided. A learning preference question that scored high was classified as indicating a preference for that type of learning.

There exist cultural differences among different countries (Joy and Kolb, 2009). Reid (1984) was used as a reference for the development of the self-report learning preference questionnaire according to cultural differences. For example, Asian students tend to be introverted, making it difficult to learn more about them. To facilitate their expression, the questionnaire was translated into their native language. A final step involved summarizing results from research questions one and two in order to support or reject the meshing hypothesis.

The scores on the adapted learning preference questionnaire were also normalised to determine the specific sensory preferences of learners. Learning preferences change over time, since they are not fixed (Reid, 1987).

Learning preferences, however, are not necessarily absolute since each individual does not belong to the same category of learning preferences.

Experimental results

(1) What is the canonical correlation between learning preferences and sensory-specific English learning material stimuli?

Table 1 shows that the canonical factor accounting for learning preferences ($\chi 1$) explained 44.2% of the total variance ($\eta 1$), the canonical factor explaining sensory-specific English learning material stimuli ($\varrho 2$=.442), and $\eta 1$ explaining 8.469% of the variance in sensory-specific English learning material stimuli.

There was a 44.2% overlap between learning preferences and sensory-specific English learning material stimuli: i.e., assessing the canonical factors ($\chi 1$ and $\eta 1$) alongside the four learning preferences subscales revealed that the four subscales of learning preferences accounted for 8.469% of the total variance in the six domains of sensory-specific English learning material stimuli.

It appears that the pair of canonical coefficients demonstrate an important relationship between auditory learners ($\chi 1$=.947) and adaptive learning material stimuli in the learning preferences: that is, paper texts with sound ($\eta 1$=.468), images with captions ($\eta 1$=.568), and sound with images ($\eta 1$=.496). These factors suggest that a significant relationship exists between these stimuli. Adaptive English learning material stimuli result in positive structural coefficients, which indicate students with auditory preference had better learning outcomes. For the rest, no significant relationship was observed after the intervention: visual learners ($\chi 1$=-.529), haptic learners ($\chi 1$=-.114) and kinaesthetic learners ($\chi 1$=-.482).

Table 1. Canonical correlation of learning styles and adaptive learning materials

X variables	**Canonical variables** χ_1	**Y variables**	**Canonical variables** η_1
visual learners	-0.529	paper texts	0.071
auditory learners	0.947	paper texts with sound	0.468
haptic learners	-0.114	images with captions	0.568
kinesthetic learners	-0.482	images with captions and sound	-0.512
		sound	-0.447
		sound with images	0.496
percent variance dependent	21.944	percent variance dependent	8.469
		ϱ^2	0.442
		Canonical correlation	0.665*

*p<.05

(2) Is the meshing hypothesis supported or rejected by the findings?

Figure 2 gives the ranked variables from the canonical solution as well as the absolute value of their canonical loadings in the canonical solution. According to statistical analysis of the results, auditory learners did not outperform when exposed to corresponding auditory sound stimuli. Contrary to what was expected, they did a better job when using visual aids. Thus, the present study has rejected the meshing hypothesis by demonstrating that an individual's preferred learning preference does not necessarily help predict their performance under the influence of their preferred sensory-specific stimuli. Rather than disadvantaging students who have different preferences when it comes to learning English, there is a need for them to have a choice of multiple materials that can help them meet their learning needs.

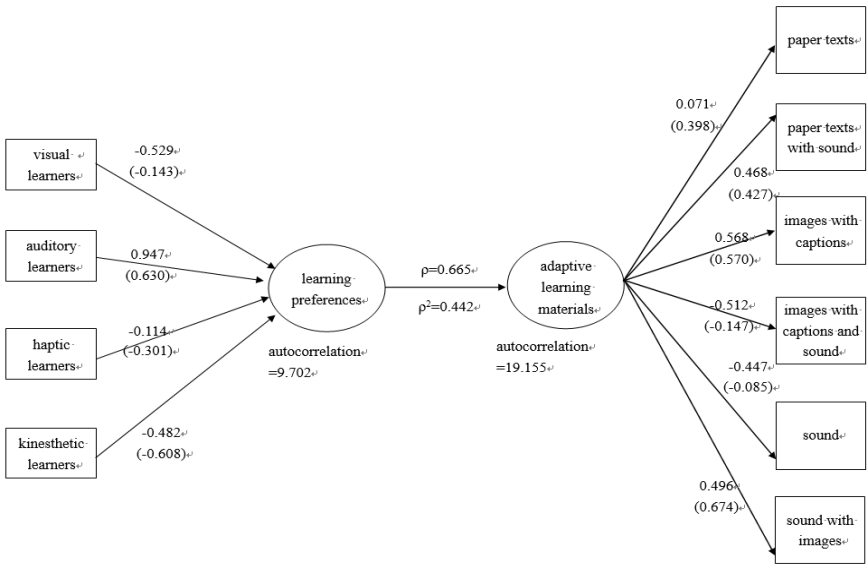

Figure 2. The ranked variables in the canonical solution and absolute value of their canonical loadings

Discussion

In this study, learners with specific learning preferences did not necessarily perform better with sensory learning materials (Krätzig and Arbuthnott, 2006). In the present study, auditory learners had greater success with visual aids.

According to the findings of the current study, the answer to the first research question was that sound ($\eta 1$=-.447) did not promote learning outcomes for auditory learners based on these outcomes. Instead, auditory learners benefit from scaffolding materials presented visually. This may be a result of auditory learners paying more attention to sensory-specific English learning material stimuli with which they are less familiar. This study also found that images with captions and sound had a negative canonical correlation with auditory learners. A high cognitive load might impede auditory learners' ability to learn effectively. There were also minor explanations for auditory preference learners in paper texts ($\eta 1$=.071). Sensory preferences still play a significant role in the development of an individual learner. Lastly, sensory-specific English learning material stimuli were negatively correlated with canonical correlations. Based on these findings, it can be deduced that auditory learners may be most influenced by sensory-specific stimuli associated with English learning materials. Regarding the answer to the second research question, the results showed that this was quite the opposite of what was predicted by the meshing hypothesis: learners do not necessarily perform better when they are under the influence of the corresponding learning material stimuli.

Conclusions and future work

According to previous research, it is commonly believed that learning preference determines learning performance. The meshing hypothesis holds that successful learning would occur under sensory-specific stimuli (Dobson, 2009; Reid, 1995; Gilley and French, 1976). However the results of various studies indicate that learners' performance differs between stimuli when exposed to different sensory modalities (Mahdjoubi and Akplotsyi, 2012). Moreover, learning preferences are also subject to change over time (Reid, 1987). Learners' preferences for learning affect their autonomy as individuals (Khojastenejad and Pishkar, 2015). Consequently, learning preferences remain an issue in language learning settings. Additionally, learning a foreign language may be affected by multiple variables, such as the impact of digital technology stimuli on cognitive load (Martin, 2012), and the relationship between learning preference and retention (Armstrong et al., 2021).

The present study aimed to identify how sensory-specific English learning material stimuli affected learners' performance and to test the hypothesis that meshing motivates learners to improve their performance. Identifying the strengths and weaknesses of a wide range of individual learners is essential for language instructors to recognize and better understand learners (Ortega et al., 2018; Tuan, 2011). Being flexible in pedagogy does assist learners in developing the ability to deal with different learning stimuli. However, learning preferences are not a panacea. As reminders and tools, they serve to clarify how learning outcomes are assessed (Armstrong, 2000). Additionally, since learners have different learning preferences, the way learning materials are presented matters greatly; therefore, it is crucial to consider the learning preferences of each learner during the design phase of teaching materials since students differ in the way they learn and think in different circumstances (Pashler et al., 2008; Sternberg et al., 2008). In this study, the results showed that auditory learners learned best under adaptive English learning material stimuli, likely because they were more prudent when using visual aids, with which they were not proficient, but which compensated for their poor proficiency. It is possible to predict which pedagogy will produce the best results when teachers understand their learners' learning preferences (Hames and Baker, 2015; Omrod, 2008; Pashler et al., 2008).It is strongly advised to be cautious when dealing with learners' individual learning preferences and to handle them with respect. It was considered inappropriate in the current study to label learners according to their learning preferences. To encourage greater retention, instructors should provide learners with a variety of learning material stimuli. Using sensory-specific English learning material stimuli does not necessarily lead to greater proficiency in language skills among learners with corresponding learning preferences, according to the present study. When teaching learners with different learning preferences, it is recommended to be open minded. To accommodate learners with very different learning characteristics, teachers should provide a variety of stimulus designs instead of emphasizing an individual's preferences. Therefore, English learning material design could support learners in learning English if viewed from multiple perspectives.Only 53 participants were recruited because of constraints on time, space, and manpower. Given the small number of participants, it was not possible to generalize the findings. The gender difference must also be examined to see if any significant differences exist.

To obtain further empirical conclusions, a larger sample size and a variety of nationalities should be included. It is recommended that the experiment be extended to further analyse how different types of sensory stimuli affect different types of learners with distinct learning preferences.

Furthermore, Taiwanese classes generally consist of a mix of students with varying levels of proficiency. In fact, structured pedagogy does have a great impact on students with low proficiency. However, highly proficient individuals may experience quite the opposite (Freebody and Tirre, 1985). In the future, researchers could also consider the learners' various proficiency levels. When designing a study, it is also important to consider a learner with a different cultural background who has specific characteristics. The findings of this study are in line with those of a previous study that did not endorse the meshing hypothesis (Rogowsky et al., 2015).

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