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Improving Implicit Learning and Explicit Instruction of Adult and Child Learners of Chinese

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Doctor of Philosophy

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ABSTRACT

Improving Implicit Learning and Explicit Instruction of
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This study explored the main effects and interaction effects of implicit learning and explicit instructional approaches on the language acquisition of beginning adult and child learners of Chinese and analyzed the successful adult and child learners' learning styles in their information processing time, second language acquisition techniques, and cognitive strategies. Volunteers from Brigham Young University and Wasatch Elementary School were randomly assigned to either an Explicit Instruction Treatment (EIT) or an Implicit Learning Treatment (ILT). Following the treatment, the participants completed an online survey and a vocabulary application test. Results from a 2 x 2 factorial ANOVA indicated that adults performed significantly better than children on the listening and vocabulary tests scores (F (1, 135) =158.901, p<.001), and the EIT was significantly more effective than the ILT. There was no interaction between maturity and treatment factors. Results from a 3 x 2 factorial MANOVA indicated that in the Learning Phase, adults in the high and mid performance groups spent significantly longer processing information than those in the low performance group, and adults in the EIT also spent a longer time than those in the ILT. Results from the stepwise regression showed that for successful adult and child learners, Phonological Processing was the most frequently used second language strategy for both adults and children, which was strongly correlated with their vocabulary application test scores. Guessing was the most popular cognitive strategy. Successful children spent significantly less time than the low performing children in the Testing Phase.

Keywords: instructional technology, implicit learning, explicit instruction, second language acquisition, cognitive strategies, information processing

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Chapter 1: Background and Introduction to the Problem

There are a number of reasons why learning a second language can be considered difficult—pronunciation is difficult, the grammar is different, the writing symbols are complicated, and most importantly, the meaning of a sentence cannot be comprehended. For many people, it takes a long time to acquire a new language, and some never progress beyond the most basic levels. This outcome is not surprising, given the complexity of language learning. As people learn a new language, even when learning the smallest element such as a few vocabulary words, their brains are subconsciously comparing and contrasting the meanings, sounds, and symbols. This very complex process requires significant attention to a myriad of linguistic features, in their native language as well as the new language. If learners fail to distinguish the differences between the two languages or if they cannot grasp the meaning, acquisition may be hindered or even come to a halt.

During recent decades, many researchers have sought instructional theories that can optimize second language (L2) learning and help learners reach target levels of proficiency in the least amount of time. These researchers have conducted numerous experimental and quasi-experimental effects-of-instruction studies in the classroom, hoping that new approaches can enhance second language acquisition (SLA). Some SLA approaches have been shown to be effective and have been implemented in the classroom for many years. More rigorous research on the combination effects of various approaches and on learners' implicit learning and frequency of exposure, however, has yet to be conducted.

Many researchers have particularly focused on comparing whether explicitly teaching the key points or guiding students to acquire the language rules by themselves is more effective. While significant progress has been made in understanding the effectiveness of various aspects of these pedagogical strategies, several important questions remain: which of the above approaches is more effective in the classroom? What is each mental process like for learners using these two strategies? Can researchers trace the second language strategies that learners employed in each pedagogical approach? Can the strategies common to the most successful learners be drilled in the classroom?

Computer assisted language learning (CALL) offers the tools to answer some of these questions. With the advent of computer technology, language course designers are able to present various instructional strategies that simulate L2 environments. Using analytical software, researchers can readily track and analyze learner behavior and assess learning outcomes more precisely. These tools, used in conjunction with learner reflection protocols, may allow greater insight into both, helping SLA researchers to understand why one pedagogical strategy (or combination of strategies) might be preferred over others.

This study utilized CALL technology to combine various effective SLA techniques within two parallel online programs, compared the learning effects of both programs, and analyzed learning behavior as well as the learners' mental processes. It was hoped that the findings of this study would provide empirical evidence for L2 acquisition theories and offer an alternative tool to enhance future SLA research.

Introduction to the Problem

Many SLA researchers have investigated the question of which pedagogical approaches can maximize L2 learning effects and shorten the learning process. These researchers focused on comparing two or more instructional approaches, claiming that the learning effect of one approach is significantly greater than the other(s). However, while explaining why one instructional strategy outperforms another, most researchers appeal to the SLA theories that support their hypothesis. In other words, explanations for why a certain approach works are largely theoretical and sometimes circular.

The failure to include learners' mental records in the research could be ascribed to two major difficulties. First, researchers struggle to create a true control condition in their experiments. They cannot exclude all the factors that cause learners to apply implicit[1] learning strategies to complete their tasks. If the treatment of implicit learning cannot be operationally defined as different from the treatment of explicit learning, it is almost impossible to claim that the experiment is valid. Second, data on implicit learning is difficult to obtain. It is time consuming and expensive to create and implement instruments to explicate the learning process. Most rely on recruiting large numbers of proctors to conduct introspective studies and analyze the resulting qualitative data.

Because of these two obstructions, SLA studies rarely collect learners' mental records in their studies. However, implicit learning is an important, if not essential, aspect of language acquisition. SLA theories maintain that learning occurs subconsciously in learners' minds when they obtain instruction (Krashen, 1981; Krashen and Terrell, 1983). If these mental records can be correctly captured through the computer, interpreted by researchers and fully understood by the instructional designers, each SLA instructional effect can be put into a taxonomy that is beneficial for future SLA studies.

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[1] Implicit means capable of being understood from something else through perception or things unexpressed in an incidental manner without awareness of what has been learned. An implicit approach encourages learners to decode meaning through observation and urges the learners to accumulate different hypothesis-testing experiences in many incidental situations.

Statement of Purpose

The purpose of this study was to explore the main effects and interaction effects of two instructional approaches on the language learning outcome of adults and children in an attempt to understand the learning behaviors and thinking processes involved in each treatment. This study also explored whether certain learning strategies and instructional approaches could promote the best L2 learning outcomes.

Terms and Definitions

The following definitions clarify important terms used in this study.

Implicit Learning Approach. Implicit means capable of being understood from something else through perception or things unexpressed in an incidental manner without awareness of what has been learned. Implicit learning is usually defined as the acquisition of knowledge that is independent of conscious attempts to learn, and that occurs without awareness of the acquired knowledge (Jiménez, Vaquero, & Lupiáñez, 2006). In this study, an implicit learning approach was implemented in the animation treatment which encourages learners to subconsciously decode meaning through observation and urges the learners to accumulate different hypothesis-testing experiences in many incidental situations (Smith, 1975). Elements of this approach were implemented in this study as the Implicit Learning Treatment or ILT.

Explicit Instruction Approach. Explicit is defined as fully revealed or expressed without vagueness, implication, or ambiguity. Explicit instruction or form-focused approaches in SLA environments refer to teaching vocabulary items and the grammar patterns directly (Omaggio-Hadley; 1993 Doughty, 2003). In this study, explicit instruction was implemented in the text treatment, which can directly teach grammar patterns, parts of speech, or word for word translations. Elements of this approach were implemented in this study as the Explicit Instruction Treatment or EIT.

Language Learning vs. Language Acquisition. Acquisition denotes the subconscious nature of learning processes. Learning refers to the act or experience of one gaining knowledge or skill. As opposed to the acquired knowledge, learned language knowledge might be that which is explicitly taught but not necessarily mastered. Krashen (1985), in his monitor theory, asserted that "language *acquisition* is very similar to the process children use in acquiring first and second languages … conscious language *learning*, on the other hand, is thought to be helped a great deal by error correction and the presentation of explicit rules." He further theorized that "consciously learned" language knowledge is different from "unconsciously acquired" knowledge in that only the acquired knowledge can be retained in long-term memory and be naturally applied in daily language.

Strategies. Two types of strategies are assessed in this study—SLA and cognitive. SLA strategies refer to "Phonological Processing Strategy," "Meaning-Based Strategy," and "Syntactical Strategy" and they are applied when learners map linguistic form with meaning. Cognitive strategies are the mental strategies that learners apply to learn more successfully. In this study, they refer to "Elimination," "Guessing," "Noticing," "Repetition," and "Prediction." They are employed by learners to solve problems during the processes of information integration.

Phonological Processing Strategy. Phonological Processing Strategy is an auditory technique that involves discriminating differences in phoneme. The phonological system of a language includes an inventory of sounds and their features, and rules that specify how sounds interact with each other. In this study, Phonological Processing Strategy is measured when learners focus on distinguishing the features of sounds or analyzing their rules of interaction.

Meaning-Based Strategy. Meaning-Based Strategy is a skill to decode the meanings from natural and artificial languages. In this study, Meaning-Based Strategy is measured when learners focus on relating their thoughts to referents or signifying the meanings of symbols.

Syntactical Strategy. Syntax is the study of the formation of sentences and the relationship of their component parts. In this study, Syntactical Strategy is measured when learners focus on analyzing word order or grammar rules in a foreign sentence.

Elimination Strategy. Elimination is the act of putting an end to, getting rid of something, or removing something from consideration. In this study, Elimination Strategy is measured when learners ignore or exclude an unwanted element.

Guessing Strategy. Guessing is the act of forming an opinion from little or no evidence. In this study, the Guessing Strategy is measured when learners believe that they made a decision based on intuition or took an action without thinking. It may also imply that learners implicitly made an inference from the hypothesis test, but they did not know why they made that decision and did not have any confidence about the outcome of their prediction.

Noticing Strategy. Noticing means to perceive things with attention. In this study, Noticing Strategy is measured when learners pay attention to distinctive features of things.

Repetition Strategy. Repetition means to make, do, perform, go through or experience the same thing multiple times. In this study, Repetition Strategy is measured when learners try the same action multiple times to confirm their hypotheses.

Prediction. Prediction means to foretell on the basis of observation, experience, or scientific reason. In this study, the Prediction Strategy is measured when learners tell about something in advance of its occurrence by means of special knowledge or inference.

Performance groups. In this study, the performance groups are categorized based on their performances on the listening comprehension tests and the vocabulary application tests. In each treatment, the relative top one-third of students belongs to the high performance group. The mid-ranked one-third and low ranked one-third students belong to the mid and low performance groups, respectively. Adults and children are separately analyzed.

Overview of the Study

This study used parallel online SLA programs to teach beginning-level students basic Chinese and compared their learning processes and outcomes. Programs covered and tested identical L2 content. One program was based on explicit teaching strategies and the other engaged all students to decode meaning by themselves. Both programs were administered to randomly selected college students and sixth graders. Information processing time and the listening test scores for all participants were recorded by the programs. The learners' self-evaluation of cognitive and SLA strategies and learning attitude were collected through an online survey using the Qualtrics online system. A vocabulary test was also conducted during the survey. The duration of the entire experiment was up to 57 minutes (i.e., 37 minutes for the program and 10 to 20 minutes for the survey).

The online programs of this study were designed under the assumptions of two pedagogical theories: an implicit learning approach (animation approach that requires learners to observe a series of events and decode meanings from clues) and an explicit instructions approach (text approach that provides salient comparison between languages such as word-by-word translation and grammar explanation). The Implicit Learning Treatment (ILT) asked students to observe a series of events and decipher L2 word meanings from limited sets of clues. The presentation modalities for this approach included text, audio, and animation. The Explicit Instruction Treatment (EIT) introduced syntactic structure by marking equivalent meaning of English and Chinese and their corresponding grammatical parts of speech with the same color. The media of presentation for this approach included text and audio.

In this research, only students who had never been exposed to Chinese language instruction were eligible to participate. Both versions of the program were pilot-tested by randomly selected sample participants from their representing population. A mean score of 80% on both listening tests was achieved. A *Think-Aloud Protocol* was also conducted during the pilot test for each test-taker to evaluate task difficulty and to generate online survey questions for SLA techniques and cognitive strategies. Randomly selected students from Brigham Young University (BYU) and Wasatch Elementary School (Wasatch) sixth grade were randomly assigned into one of the two treatments—ILT and EIT.

Research Questions

To explore the above issues, the following research questions were addressed:

1. What are the main effects and interaction effects of two instructional approaches (Implicit Learning Treatment and Explicit Instruction Treatment) on the language learning outcome of adults and children as implemented in a multimedia language learning environment?
2. Which learning strategies are used and which behaviors are exhibited by the most successful adult and child learners?

Constructs of the Study

The dependent variables of this study include two listening tests, one vocabulary test, information processing speed, and learning strategies.

Vocabulary recognition and grammar decoding. The scores of two listening comprehension tests implicated the recognition of the meanings and the acoustic features of 29 chunks of L2 sounds. The score of the vocabulary application test reflected the understanding of the grammar category of each of the 29 words and their relations to other words.

Information processing speed. The information processing speed of this study refers to learners' reaction time for each event in the Learning, Practice, and Testing Phases. Information processing time or decision-making time is defined by the mean “time span” between any two clicks of events among “Listen,” “Previous,” “Next,” “Start Practicing,” and “Begin Test” buttons. It is hypothesized that learners need a certain amount of time to decide which pieces of information to attend to and the degree to which they want to build connections among the selected pieces of information and the existing knowledge. It is also hypothesized that learners need time to decide which action they may perform will best help confirm their linguistic/cognitive hypotheses and identify the route to retrieve the newly integrated information.

Learning strategies. The naturally developed learning strategies of this study include three SLA strategies—Phonological Processing Strategy, Meaning-Based Strategy, and Syntactical Strategy, as well as five cognitive strategies—Elimination, Guessing, Noticing, Repetition, and Prediction. It is hypothesized that learners in different developmental stages will prefer to choose one over the others from these strategies to solve linguistic and cognitive problems while processing new information.

Topical Areas that Inform the Language Acquisition and Learning

To effectively explore the impact of different instructional approaches on second language acquisition, certain assumptions and limitations should be stated.

Equal level of difficulty of materials. This study assumed that the level of difficulty of the selected language learning materials[2] and the material presentation strategies (e.g., the amount of contents and instructional sequence) for the target learners of both treatments were equally designed and had met the requirement of the input hypothesis, " *i* +1" (Krashen, 1985). That is, the learners should be able to integrate new information into their conceptual categories in a comprehensible environment.

Cognitive development and the critical period. Many researchers have observed that infants and children in various areas of the world go through similar first language acquisition stages (Liberman, 2011). Likewise, people acquire a second language through various developmental stages. Depending on cognitive maturation, cultural background, and amount of exposure to the new language, the speed of progress through the acquisition stages varies.

Piaget (1983) proposed a theory of cognitive development, describing the ways in which characteristics are constructed that relate to specific types of thinking and how these change over time. He proposed that there is a concrete operational stage between ages seven and eleven. In this stage, children can think abstractly and make logical decisions about concrete phenomena

[2] The language content selected for both treatments was identical (Appendix 1).

(i.e., discriminate the attributes of objects and categorize them into conceptual nodes or exemplars). Piaget also proposed that there is a formal operational stage between the age of 11 and adulthood. Children can perform inductive and deductive reasoning in this critical period. Once children have developed the reasoning (i.e., inductive and deductive) skills, they are assumed to be able to compare two language forms directly, just like adults acquiring their second language (L2). The implication of these issues is such that children at age 11 or 12, in the critical period, are ideally suited for this research. They are still children according to Piaget yet they are old enough to provide useful data for this research.

Based on theoretical assumptions, children at the age of 11 or 12 may either apply a first language acquisition strategy (children acquiring L1) to map L2 forms with their primitive concepts or they may apply a second language acquisition strategy (adults acquiring L2) to compare two language forms directly.

H_1: This research hypothesizes that if children in the Explicit Instruction Treatment (EIT) outperform the children in the Implicit Learning Treatment (ILT) on the listening comprehension tests and the vocabulary application test, then this may indicate that children apply the adults' L2 acquisition strategy to map two language forms directly.

Meaningful learning. This study assumed that the design of the test could also measure the construct of "meaningful learning." Meaningful learning is defined as "relating the new material non-arbitrarily and substantively to a learner's cognitive structure and that the material learned be potentially meaningful to him or her—namely, relatable to his or her structure of knowledge on a non-arbitrary and non-verbatim basis" (Ausubel, 1978, p.41). Meaningful learning is also reflected in the ability to apply the elements of what was taught to new situations, which enables researchers to measure learning outcomes by using problem-solving tasks (Mayer & Wittrock, 1996). In this research, the vocabulary test served as a problem-solving task measuring tool to determine whether learners have the ability to decompose complete sentences into meaningful word chunks, analyze the grammar patterns, and create L2 sentences based on newly learned phonological and syntactical knowledge.

Based on the assumptions above, this research hypothesizes that, if the participants can incorporate meaningful learning on the problem-solving task, they will be able to perform well in the vocabulary test.

H_2: If the participants in the EIT group, which promotes the Explicit Learning Treatment, outperform the participants in the ILT group, which promotes the Implicit Instruction Treatment, then it may indicate that the Explicit Instruction Treatment more effectively allows for learners to apply what was taught to new situations.

Information processing. Baddeley and Hitch (1974) proposed that in the central executive control system (one of the sub-systems in our working memory), there are constraints that require people to make decisions about which pieces of information to pay attention to and the degree to which they need to build connections among the selected pieces of information and the existing knowledge. There is only a limited amount of processing capacity available when substantial new information is presented. This study defined the time span between two consecutive clicks as the needed information processing time (in the Learning and Practice Phases) and decision making time (in the Testing Phase).

Information processing or decision-making time may be a predictor of high learning performance.

H_3: Given the above proposition, this study hypothesizes that adult and child participants in different performance groups (i.e., high: successful, mid; moderate, low: slow), and under different treatments (i.e., implicit vs. explicit, or animation vs. text), will require a different amount of time to process new information and make decisions in various learning phases.

Problem solving. As per the previous assumption, children acquire their first language through various developmental stages; and in each stage, children employ different learning strategies (i.e., SLA—Phonological Processing, Meaning-Based; Cognitive—Elimination, Guessing Strategies, etc.) to solve linguistic and cognitive problems. Ellis and Larsen-Freeman's (2009) analysis indicated that while communicating with each other, people tend to choose the exemplar from several concurrent competing cues, prefabricate sequences of utterances, and select an effective and efficient way to retrieve data.

This research assumed that various learning strategies (i.e., SLA and cognitive strategies) are simultaneously competing cues, and that learners in various developmental stages select one strategy over the others while facing a problem-solving task when learning a new language.

H_4: This research hypothesizes that adult and child participants in different performance groups and under different treatments will have a preference in selecting those competing cues (i.e., SLA and cognitive strategies). SLA strategies or cognitive strategies may be good predictors of a learner's high performance.

Chapter 2: Review of the Literature

Introduction

Many SLA researchers have been seeking pedagogical approaches that can maximize second-language learning effects and shorten the L2 acquisition process. They believe that multifaceted learning activities such as Communicative or Task-based Language Teaching approaches will provide L2 learners with opportunities to practice and integrate L2 knowledge into long-term memory (Long, 1985). This belief has been mostly sustained through research and thus has been practiced for many years. Nevertheless, despite all the research, L2 acquisition still remains slow, inefficient and difficult for most people.

One of the major reasons for L2 acquisition inefficiency may be that while assessing learning outcomes, researchers have never been able to observe what is happening in learners' minds and record the reasoning processes they employ, analyze how concepts are formed or organized, and actually diagnose what causes the various errors that learners actually make. Hence, many questions remain unresolved, including: Which types of various learning strategies work better for successful students? How precisely and proactively L2 learners should engage in using cognitive strategies? If there were a method or program that could simulate L2 learners' natural thinking processes, provide an active L2 learning environment, and be equipped with an accurate mental behavior assessment tool, researchers could perhaps provide useful solutions to the problem of inefficient L2 acquisition.

This chapter will discuss several important principles related to the second language acquisition issue mentioned above and will include:

1. Primary assumptions about language acquisition
2. The process of connecting form with meaning
3. The value of meaningful repetition
4. Cognitive development and L1/L2 acquisition
5. Similarities and differences between adults' and children's acquisition
6. The implication of information processing
7. The Brain Studies of Linguistic Strategy Emergence

The above principles discuss how language and linguistic concepts are formed through developmental stages and examine the assumption about how adults and children utilize different form-meaning mapping strategies to develop their second language.

The discussion in the following sections will explore the various assumptions of rationalist and empiricist views of language acquisition and examine evolving theories of language and thought from several psychologists and psycholinguists. It will also investigate various theories that explain the connection between form and meaning, as well as discuss the role of memory in information processing, compare and contrast L1 and L2 acquisition mechanisms between adults and children. Finally, it will provide evidence from empirical studies that supports a proposed sequence of emerging linguistic strategies.

Primary Assumptions about Language Acquisition

What is the nature of language acquisition? Various studies of language acquisition theory have attempted to categorize several theoretical perspectives ranging from rationalist views to empiricist positions with other theories classified somewhere between the two (Ellis, 1985). The rationalists believe that human beings have genetic faculties for acquiring language, thus, they are innately capable of developing linguistic systems (Chomsky, 1965). On the other hand, the empiricists believe that learners' experience of language learning is more important than their innate capacity to acquire language. Hence, the empiricists argue that learning is a manifestation of external forces acting upon the organism rather than an acquisition of a language through internal biological mechanisms (Larsen-Freeman, 1991).

Based on stimulus-response (S-R) theory, the behavior is regarded as a response to stimuli, whether it is observable or implicit. The behavior is also assumed to occur in associative chains that are caused by the repeated connection of a stimulus with a response (Hilgard, 1962). Therefore, the question arises as to whether or not language learning is an unobservable mental behavior triggered by a series of "linguistic" stimuli. Skinner (1957) believed that by observing participants' reactions in extensive stimulus and response (S-R) conditions, the causal relationship of verbal behavior could be generalized. However, this viewpoint was critically challenged.

This process of evolving theories is common. Based on Kuhn's (1970) *The Structure of Scientific Revolutions*, a typical paradigm is followed by a period of aberration (challenging of popular theory), then crisis with all theories (the decline of the flourishing paradigm), and finally, a new paradigm. This cycle proves true not only in the field of natural science, but also in psycholinguistic discipline. Prevailing paradigms may be polarized between empiricist and rationalist positions but more likely a more accurate language-acquisition theory will be located somewhere between the two. In striving to derive a better language acquisition theory, the following questions must be asked: How do children acquire their first language? Do they have innate capacity to deduce rules as Chomsky theorized? Could children self-generate a language without being stimulated? What is the inner-language development process like?

After considering these issues, many developmental psychologists and educational psychologists have noted the close relationship between language acquisition and early cognitive development. They have also collected data and categorized language development stages, analyzed form-meaning coordination mechanisms, postulated "thought" shaping processes, and proposed instructional strategies that might meet children's needs in various development stages. The following sections will discuss several developmental psychologists', psycholinguist's and educational psychologists' efforts on describing cognitive (language/thought) developmental stages more in depth.

The views of early developmental psychologists and psycholinguists. Various psychologists explored the phenomena of children using language during developmental stages in the twentieth century. Renowned developmental psychologists (also known as constructivists) such as Piaget (cognitive constructivist) and Vygotsky (social constructivist) both discussed how children employ "language" to operate "thoughts" and forming "thought" through communication (Atherton, 2011). As summarized by Vygotsky, Piaget proposed that children formulate their first language through a series of "thought" development processes: (1) the earliest form of thought is autism, which refers to a state when children have not developed the means to interact with others; (2) later comes egocentric thought, which occurs when children have difficulty taking the viewpoints of others; (3) and then the last, logical reasoning, which is when children demonstrate intelligence through manipulating symbols related to concrete objects (Vygotsky, 1986).

In response to Piaget's views, Vygotsky surmised that the purpose of egocentric thought is to communicate, that is, to convey meaning to others. To verify his hypothesis, Vygotsky conducted several experiments on different age groups of children. He found that when faced with obstacles, school children tend to examine situations in silence. When he and his team asked children what they were thinking about, their answers were very close to the thinking-aloud of the preschool children they had observed when faced with the same situations (1986, p. 17).

Vygotsky also found that in difficult situations the coefficient of egocentric speech almost doubled, in comparison with his figure for preschool children not facing obstructions. Vygotsky discovered that a disruption in the smooth flow of activity is an important stimulus for egocentric speech. The impediments in an automatic activity make pre-school children aware of that activity; the egocentric speech becomes an expression of that process of becoming aware (p. 16). Vygotsky concluded that the same mental operations that pre-school children carry out through egocentric speech are relegated to soundless inner speech in school-aged children; he also concluded that egocentric speech helps preschoolers raise awareness levels in the search for solutions to problems. When children reach the age of seven or eight and develop a desire to communicate with others, "egocentric speech" diminishes and turns into soundless egocentric "thought" (p. 18).

Psycholinguist, Frank Smith also affirmed this "thought" formulating process:

> No one has even seen or measured a "thought". . . . when we "think" we could simply be listening to sub-vocalized "inner" speech. . . . Initially adults talk to children in order to control children's behavior. In due course children learn to talk to themselves in order to control their own behavior. And eventually children suppress the sound of their own voices while they are still talking to themselves—and this is "thought" (Smith, 1975, p. 108).

Smith's observation conformed to those of Vygotsky who noted that school children suppress their egocentric speech when they have developed sufficient control over how they direct their attention. The think-aloud behavior of children (proposed by Vygotsky), or the vocalized inner speech (proposed by Smith), is eventually set aside and becomes inner speech, which is perceived as "thought."

If "thought" is developed through the process as Piaget, Vygotsky, and Smith suggested, another question may arise: how do little children organize information, sort out (visual and aural) messages, store them in proper places, and retrieve this egocentric speech? Children must receive enough inputs/stimuli to imitate the sounds and connect meaning to the sounds they hear. Vygotsky (1986, pp. 5-7) explained that the smallest unit of verbal thought is "meaning." In order to decode "meaning" from a complex language (sound) system, children must simplify the information to make it understandable. He further explained that when children cannot understand a new word, it is not because of the utterance of the word but because the meaning of the word is incomprehensible. To grasp the meaning of the sound, children must determine what information to attend to and what information to ignore.

Smith (1975) also found that deliberately relating new experiences to the already known can help children make sense of new concepts and experiences as these are encountered. He speculated that when children try to understand the world, they tend to seek the clue(s) that can help them verify hypotheses about the unfamiliar things (e.g., sounds, objects, or concepts). Smith further explained that understanding the meaning of the sounds is crucial to children at the very beginning stage. The sounds of the language are constructed out of acoustic "distinctive features" similar to the visual "distinctive features" of writing (p. 61). While receiving new information, children have to select among a limited set of alternatives (e.g., sound and meaning that are already known) to answer their cognitive questions. If children fail to verify their hypotheses on the unknown sounds, they may be inundated with "noise." On the contrary, if children can identify the acoustic feature of each sound, they are more likely to comprehend the whole speech without difficulty (p. 45).

According to Smith (1975), the ability to relate new experiences to those already known is built upon three characteristics of cognitive structure:

1. A system of categories
2. A set of distinctive features
3. Network of interrelations among categories

The system of categories, as proposed by Vygotsky and discussed by Smith, becomes the means whereby learners classify objects according to whether they are to be regarded as the same or different from something they have already encountered. This system of categories enables people to "abstract" notions by making a decision to treat one kind of object differently from another. For example, people decide to treat textbooks differently from notebooks. Abstraction in this case occurs when people are able to ignore the differences they perceive in the covers of books and take into account various similarities with respect to the content of the books. Categories that have names are often referred to as "concepts," but categories do not necessarily need a name. For example, people may sense the differences between two types of flowers, but they may not know their names. Similarly, infants may distinguish classes of objects from each other long before they know their names. In any case, a cognitive category must be perceived before a name is given. Thus, a word such as "quantum" is meaningless to children unless they have a category in their cognitive structure to attach the name to (p. 15).

Once a category has been perceived, then sets of distinctive features or attributes are used by the learner to allocate objects or events into particular categories. The patterns for organizing objects according to features must be based on some combination of attributes that are particular to the objects in that category and separate them from others. People can discriminate between desks and chairs because they possess in their cognitive structure a list of distinctive features or properties that are conceptual and may not be visible. Objects (or events) can be classified to categories on the basis of any recognizable attributes. For example, color, shape, weight, size, texture, smell, and taste are all properties of a person's perception of an onion (p. 16).

A network of interrelations among the categories themselves ensures that the lists of distinctive features make sense. All objects that can fall within one particular category have something in common. In addition, there are many kinds of interrelations between categories. Learners may not just want to distinguish between objects, but may also desire to know the relations among them. As the system of categories becomes more intricate, the richness of interrelations between categories increases. For example, Lucky is a poodle, a dog, a pet, a mammal, a vertebrate, and an animal. It has four legs and chews bones. It can be white, fluffy, and friendly (p.17). Some category interrelations in a cognitive network are illustrated in Figure 1.

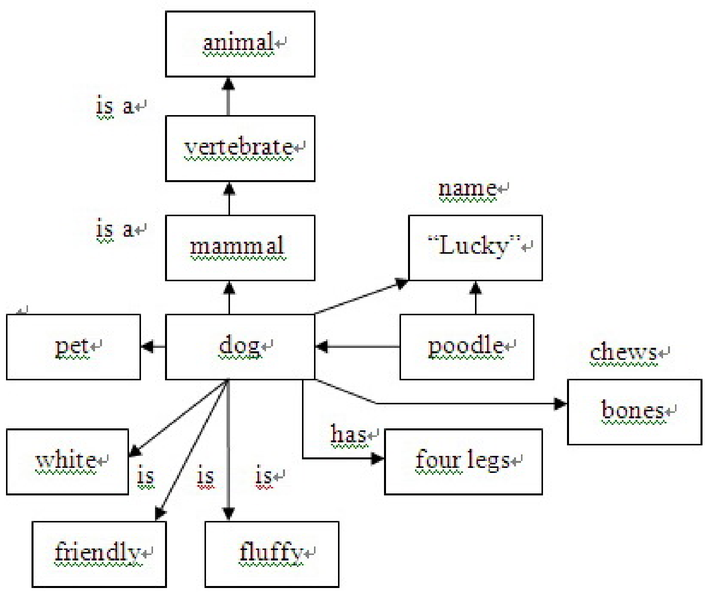

Figure 1. Example of a cognitive network, adapted from Smith. (1975, p. 24)

The above three characteristics of cognitive structure enable children to identify the attributes of new objects/concepts and allocate them to the already known categories.

Viewpoint from educational psychology. Ausubel (1978) held a view that was similar to previous developmental psychologists. Besides observing inner language evolving processes between preschoolers and school children, he analyzed how children formulate and assimilate concepts with careful explanations. Ausubel scrutinized meaningful learning processes by categorizing them into three types (Quinn, 1988). The first type is representational learning, which consists of the learning of single words or what is represented by them. The second type is concept learning, which consists of the learning of objects, events, situations, or properties that possess common critical attributes and are designated by some sign or symbol. The first step of concept learning is concept formation, which is manifested in young children, while the second step of concept learning is concept assimilation, which is seen in school children or adults. The third type is propositional learning, which consists of the learning of the meaning of sentences that contain composite ideas.

In representational learning, children need to equate the meaning of arbitrary sounds /symbols with their referent (i.e., object, event, or concept) and memorize it for later reference. When children first receive information, they find certain attributes of things and assign each of them with meaning. This involves establishing representational equivalence between first-order symbols and concrete images. Ausubel (1978) described the substantial role of this naming process:

> Representational learning is meaningful because such propositions of representational equivalence can be non-arbitrarily related as exemplars to a generalization present in almost

> everyone's cognitive structure at about the first year of life—that everything has a name and that the name signifies whatever its referent means to the particular learner. (p. 39)

When infants can recognize the acoustic feature of sounds, they are able to equate the representation of the symbols/signal (of sounds) to their referent. When infants grow older, they start to acquire more complex learning strategies.

Concept learning occurs after representational learning. When the first-order symbols start to represent concepts (i.e., objects, events, situations, or properties that possess common critical attributes and are designated by some sign or symbol), they become concept names and are equated in meaning with abstract cognitive content. Ausubel (1978) compared the processes of concept formation between different ages of children and found that, for example, the word "dog" to a toddler could be an image of his own pet; but to a preschooler, it represents the attributes of a dog-image elicited from his/her empirical experience with dogs. He clarified that depending on children's personal experiences with the "dog," the attributes of "dog" in his/her concept are elicited through successive, various affective and attitudinal encounters and different phases of hypothesis generation, confirmation, and generalization with the concept of "dog." These personal reactions comprise the connotative meaning of "dog" in children's minds (p. 53). Along with concept formation, Ausubel noted that concept assimilation can help older children and adults use new combinations of already existing relevant concepts to accelerate the process of defining the attributes of newer concepts (p. 56).

Propositional learning happens when children group the attributes of new concepts into the existing categories and when children modify (e.g., extend, elaborate, or qualify) the concept if they find another attribute to add on. Ausubel categorized these processes as subordinate and super-ordinate propositional learning. In another category, when children cannot relate logical proposition to specific super-ordinate or subordinate ideas but can relate it to a broad background of relevant content in their cognitive structure, combinational propositional learning occurs (pp. 39, 57-59).

Ausubel's (1978) meaningful learning indicates that children learn to signify a referent in the early developmental stage. As children gain knowledge and learning experiences, they apply different cognitive strategies to accelerate meaning-mapping processes and thus are able to use more general or more specific symbols (terms) to define a concept. They can recognize or assign a symbol (meaning) to its referent using one-on-one concept mapping or determine a concept's multiple connotations. When children obtain enough knowledge, they can decide to choose one or some of the meanings of a symbol to signify the referent according to the context. This acquisition process is complicated and takes a long time to complete. Compared with Piaget's definition of language/thought development, Ausubel's meaningful learning framework —representational learning, concept learning, and propositional learning play an operative role in thinking rather than merely a communicative role.

The Process of Connecting Form with Meaning

The psychologists mentioned above all stated that there are distinguishing features between each developmental stage when children's cognitive structure is shaped by language and thought. Ausubel's explanation, as discussed above, constitutes an important elaboration of symbol and referent as proposed by earlier scholars such as Peirce and de Saussure, and further developed by Vygotsky. The early 20^{th} century philosopher, Charles Sanders Peirce attempted to analyze how people create and interpret meaning through forms (i.e., words, images, sounds, odors, flavors, acts, or objects) of the sign. He declared that the forms of the sign have no intrinsic meaning unless people give the forms meaning. Linguist Ferdinand de Saussure further dissected the sign into signifier and signified. He explained that the signifier is the material form of the sign (which can be seen, heard, touched smelt, or tasted), whereas the signified is a mental construct (notion) that represents the things in the world. Instead of "sign," another philosopher, Susanne Langer used the term "symbol" to represent the concept in the mind (Chandler, 2009).

Ogden and Richards (1923, p. 30-31) believed that meaning is assigned when our thought selects a symbol to signify the referent. If not influenced by emotion, diplomatic purpose, or any other distractions, the relationship among symbol, thought, and referent can be described using tri-part semiotics that was developed by Ogden and Richards. The relationships among the three parts—symbol, thought, and referent—can be represented by a triangle as shown in Figure 2.

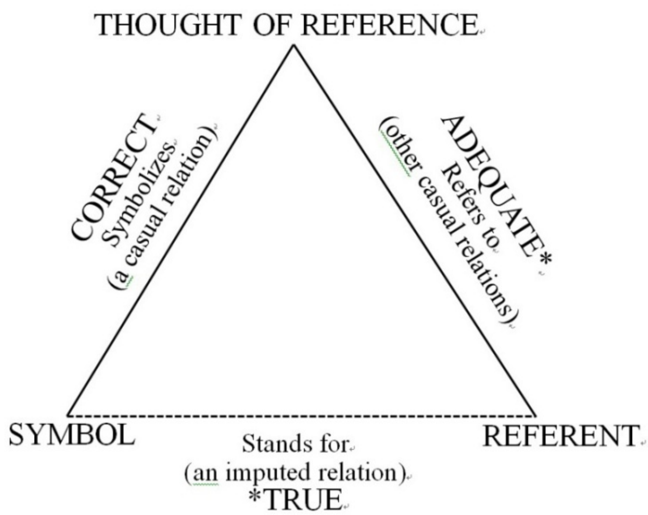

Figure 2. Tri-part semiotics, adapted from Ogden & Richards. (1923, p. 30)

First, there is a correct causal relationship between thought and symbol. When we talk, our thought constantly evaluates the situation—how much knowledge we have about the assigned symbol and referent, whether the social-cultural context is appropriate, and what expectation we have on the listener, etc. When we listen, our thought also evaluates the situation—how much we know about the symbol and referent and what assumption we have on the speaker's intention (Ogden & Richards, 1923, p. 30).

Next, there is an adequate causal relationship between thought and referent. When we think of something, we are influenced by many factors—how much we know about the symbol and the history of the referent (event or concept), and whether we have seen the referent, etc.

Finally, there is a true imputed relationship between symbol and referent. For example, when people talk about dog, the symbol (dog) does not represent the referent (dog). It does not mean that the symbol (dog) cannot refer to the referent (dog), but the symbol (dog) is just one of the many meanings of the referent (dog). The one-on-one relationship between the symbol (dog) and the referent (dog) simplifies the communication processes. That is, when we communicate, we simplify the meaning-depicting process and choose the most pertinent symbol from many of the alternatives to represent the meaning of the referent in the specific context (Ogden & Richards, 1923, p. 31).

To Ogden and Richards (1923), there is a causal relation between thought and symbol, and between thought and referent. Take the interaction between an adult and an eight-year-old child as an example. When an adult talks about Napoleon, he/she needs to have certain knowledge (e.g., history or personal experience) about the referent (Napoleon), and he/she needs to affirm that the symbol (Napoleon) he/she uses can correctly represent his/her thought and adequately refer to the referent (Napoleon). Before the adult introduces this new concept (Napoleon), he/she needs to estimate what the comprehension level and reaction the eight-year-old might have. Also, when the eight-year-old first encounters the symbol (hears about Napoleon), he/she needs to make a connection between this new symbol (Napoleon) and the referent (something relates to Napoleon in his/her experience) by observing how the adult uses the symbol (Napoleon).

Richards and Ogden illustrated the relationship among thought, symbol, and referent and clearly explained the techniques of symbol-selection in talking and listening situations. Nevertheless, talking is a rather complex task. When we talk, we continuously select, organize, and predict the symbols we are using to represent what we think and all of this happens within the blink of an eye. The inter-relationship among thought, symbol, and referent may be analyzed, but all the possible information-organizing and decision-making processes cannot simply be predicted/traced because these complicated information selections and retrieval processes take place within such a short time. Smith (1975) also discussed this phenomenon:

> Certainly language does not exhaust the possibilities about all the different ways in which aspects of our thought may be organized. Words are the observable peaks rising from unexplored ranges of thought. (p. 23)

Similarly, when we listen, we continuously observe, predict, and hypothesize the relation among the symbol, referent, and the speaker's intention (thought) according to our experience. Smith further explores this language comprehension process:

> Language comprehension . . . is a matter of predicting what the language producer will say or write . . . the process by which we make sense of the world in general—relating the unfamiliar to the already known—is all we need to make sense of language. (p. 92)

Talking and listening involves an intricate mental process of form-meaning (symbol-referent) mapping. This process evolves as we accumulate experiences in our head and acquire the ability to organize, compress, and retrieve the information more efficiently. When we grow up, all these mental processes become implicit and happen rapidly; however, it is difficult to elaborate all the decision-making processes whether in talking, listening, or contemplating situations.

The Value of Meaningful Repetition

Communication involves a wide range of cognition. With respect to the speaking and listening skills discussed above, Ogden and Richards (1923) have explained that as people communicate with each other, they take into account the social-cultural context in which the communication is taking place. Ogden and Richards found that the speakers determine utterances based on the understanding of the listeners' comprehension level and intention, the knowledge of the referents and the symbols, and the understanding of the relationship between the referents and the symbols. From the productive perspective, a recent study of usage-based cognitive linguists showed that language is a complex adaptive system. When people talk, the language structures emerge from intertwined patterns of experience, social interaction, and cognitive mechanisms, and the patterns of use deeply affect how people acquire, use, and change language (Beckner, Blythe, Bybee, Christiansen, Croft, Ellis, Holland, Ke, Larsen-Freeman, & Schoenemann, 2009, pp. 1-2). Human social interaction facilitates the concept formation processes and shapes the personal preference of language use. According to Ellis and Larsen-Freeman (2009), communication involves the full scope of cognition, including:

> . . . he remembering of utterances and episodes, the categorization of experience, the determination of patterns among and between stimuli, the generalization of conceptual schema and prototypes from exemplars, and the use of cognitive models, metaphors, analogies, and images in thinking. (p. 91)

Ellis' and Larsen-Freeman's analysis indicated that while communicating with each other, people tend to choose the exemplar from the several co-occurred competing cues, prefabricate sequence of utterances, and select an effective and efficient way to retrieve data. Bush, Melby, and Lewis (2010) also showed that language is a system of connections between stored exemplars. The exemplars are chunks of phonological/syntactical constituents perceived as meaningful units (e.g., concepts, words, sequences of words, structural patterns, etc.) and stored in the categories in the cognitive structure. They have high frequency in collocation and have conventionalized sequences, such as idioms, slangs, verbal phrases, etc. (Bybee, 2006). The exemplars enforce form-meaning mapping processes—during perception as the process of decoding form into meaning and during production as the process of encoding meaning into form (Tode, 2008). Learners perceive frequent sequences of language (exemplars) in input and abstract rules from the sequences, step-by-step (Ellis, 1996). Gradually, the pattern that governs a set of different expressions of the same construction is generalized. Nonetheless, abstraction does not occur until learners encounter a large number of exemplars of the same construction. That is to say, learners need a myriad of exposures before they can induce rules. Frequency is a key determinant of language learning (Tode, 2008).

There are two kinds of frequencies that influence data storage and retrieval—token frequency and type frequency. Token frequency describes how often special terms or specific concepts appear in the input. It refers to the number of time learners encounter the same item (Bybee, 1995; Yamaoka, 2005). In this kind of encounter, the repetition increases the strength of the connections between the relevant feature units and the category unit (Ellis, 2002, p. 166). When evaluating whether a succeeding entity belongs to the same category, learners retrieve the memories, assess the similarity to the new entity, and admit the entity to the category if the entities are similar (Ellis, 2002, p. 147). With high token frequency, this same-item re-evaluating process can strengthen and store units of the form-meaning composite (exemplars) without forming relations with other expressions. In other words, "high-frequency sequences become more entrenched in their morpho-syntactic structure and resist restructuring on the basis of productive patterns that might otherwise occur" (Bybee, 2006). In other words, token frequency can regularize the particular item and make it easier to access (Bybee, 1995).

Type frequency is how many different lexical items can be applied to a certain rule or construction. It refers to the number of distinct lexical items that can be replaced in a given slot in a construction (Ellis, 2002). Type frequency facilitates abstraction (Bybee 1995; Ellis 2002; Yamaoka, 2005). Different items of the same construction are linked together in memory, and the general rule of form-meaning mapping among them is extracted. When type frequency is increased, the pattern is strengthened. When the pattern is entrenched, the probability that it be applied to new items is higher (Bybee, 1995).

Based on the connectionist's architecture, cognition is a network of interrelated conceptual nodes. It is through exposure to large amounts of input that learners implicitly learn that the connection between some of these nodes may somewhat increase or decrease (Hulstijn, 2003). Adults have the capacity to do several things simultaneously and can concentrate on completing challenging tasks because they have accumulated enough token and type frequency to process the lower levels of information automatically. Children, however, have limited capacity to process lower level information since they have not yet accumulated enough conceptual nodes (or exemplars) in their cognitive structure. Thus, the question arises as to whether or not this process of automation can be simulated through providing enough exposures on encountering token and type frequency.

Unfortunately, the issue concerned with how many exemplars are required to be encountered for a structure to be consolidated has yet to be explored. Ellis (2002) noticed that in the recent trend, a developmental sequence—from formula, through low-scope pattern, to construction—is proposed as a useful starting point to investigate the emergence of constructions and the ways in which type and token frequency affect the productivity of patterns (p. 145). At the beginning phase of L2 acquisition, it is possible to simulate an environment that investigates the cross effects between exemplar-based models of learning sequence and the amount of exposure (on both token and type frequency). For the L2 learners, the preexisting conceptual information and problem-solving skills can help accelerate form-meaning mapping processes. If the learning task can focus on providing an environment that allows beginning L2 learners to use the preexisting conceptual information to compare two non-arbitrary competing cues containing the combination of low-scope L2 phonological, morphological, and syntactical rules, then the learners can observe the "opposition" between two new exemplars and formulate cognitive questions. If limited sets of alternatives can be provided in a sequential manner, learners will have the opportunity to generalize the meanings of individual lexical items from the cues and extract the syntactical/phonological patterns through different types of encountering. They can strengthen the linkage between L2 forms and their meanings and re-organize the information in their cognitive systems.

Cognitive Development and L1/L2 Acquisition

A view that is increasing in popularity is that language acquisition is built upon cognition (Clark, 2004). Some researchers have found that children at the age of 12 months start to identify, distinguish, and memorize objects and events without using language. The work of other researchers concurs with this observation, causing them to claim that children categorize what they know before learning a language, and only later begin to use language to map the meaning of things in constructing new categories. In other words, cognition and language interact in a cyclical way as children mature (Bloom, 2000). Other researchers have concluded that children construct multifaceted representations of experience, which are based not only on representations connected to particular words for encoding experience, but also on their cognitive development, for classifying, grouping, and remembering the information (Clark, 2004, p. 472).

The first group of researchers observed that infants in the first 12 months begin to organize what they know about entities and events before they understand the language. For example, in a comprehension task designed for 15 to 18 month old infants, an adult asked each child to put a toy mouse *in* or *on* a box. The infants always put the toy mouse in the box regardless of what instruction was given. When the box was set lying on its side, the infants always turned it to face upwards. While asking infants to put the mouse on the box, the experimenter always received the same response: the box was turned opening upwards and the toy mouse was placed inside. This study showed that infants have developed some strategies to sort out the spatial relation and know that the vertical objects are oriented with top up (opening upwards), and smaller objects go inside containers and stand on supporting surfaces (2004, p. 473).

Another group of researchers observed that when infants aged between 10 and 12 months start to pay more attention to phonological distinctions in the surrounding language, they stop applying the strategies they used when they were six to eight months old. This implies that the conceptual information that is not needed for speaking is often ignored when children start to apply linguistic representations to manage their thoughts. However, this does not mean that infants lose their earlier discriminative ability. On the contrary, evidence in the experiments that investigated infants' speech perception showed that when infants acquire the phonology of another language, they still need this ability to sort out the information (p. 474). Therefore, when language is accessible to infants, they start to map linguistic forms and structures onto the relevant conceptual representations. Because languages differ, the representational forms of each concept will affect how children develop and perceive each language. If we take the experiment on comprehension tasks in the previous paragraph as an example: Infants start to construct similar cognitive representations of spatial relations, yet when learning their own languages, they follow different paths to map language forms onto the previous acquired cognitive notions.

Clark (2004) noticed that while mapping spatial terms onto conceptual categories, children from different language backgrounds perceive the same notions differently. For example, the English language maps *in* onto containment and maps *on* onto support and attachment. Finnish is the opposite and maps the suffix *–ssa* ‘*in*’ onto containment and attachment and maps the suffix -*lla* ‘on’ onto support. Dutch maps three prepositions individually—*in* for containment, *op* for support, and *aan* for attachment. On the contrary, Spanish maps the same preposition, *en*, onto all three spatial notions. The linguistic terms for the three spatial relations in English, Finnish, Dutch, and Spanish relationship are compared in Figure 3.

Why do children of different languages map linguistic forms onto the same conceptual domain differently? What processes have children gone through when they pick up their first language to match (or build) their conceptual framework? According to Bloom (2000), children develop discriminative ability before they can use a language to map the meaning. After the sounds of words become meaningful, children start to use language to signify each concept. They observe, hypothesize, examine, and connect sounds

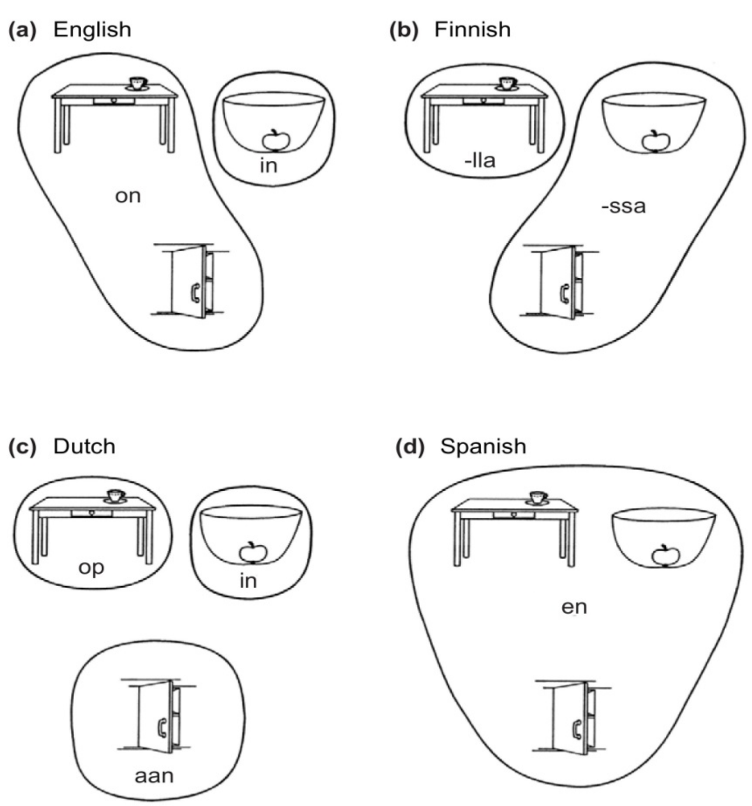

Figure 3. Comparison of form-meaning mapping among English, Finnish, Dutch, and Spanish, adapted from Clark. (2004, pp. 474)

to their corresponding meanings and memorize the proper occasion to say the words correctly (Smith, 1975). While children become very used to thinking in a language and ignore the primitive conceptual information, this discriminative ability is still available and can be invoked under certain situations (Clark, 2004, p. 474).

With those ideas in mind, another question arises as to whether or not children go through the same concept mapping processes in an L2 language as they do in their native language. There are two hypotheses in this study. The first assumption is that when children learn their first language, they use their discriminative ability to map the forms (i.e., sounds, symbols) with meanings; and likewise, since this discriminative ability does not disappear, when children learn their second language, they use the same ability to map the L2 forms with meanings. Based on Clark's (2004) study, the conceptual information that is not needed for speaking is often ignored. Therefore, the second assumption is that when children map the L2 forms with meanings, they may ignore the primitive discriminative ability but directly map the L2 forms (text and sound) onto the L1 forms. The two assumptions of this study are illustrated in Figure 4.

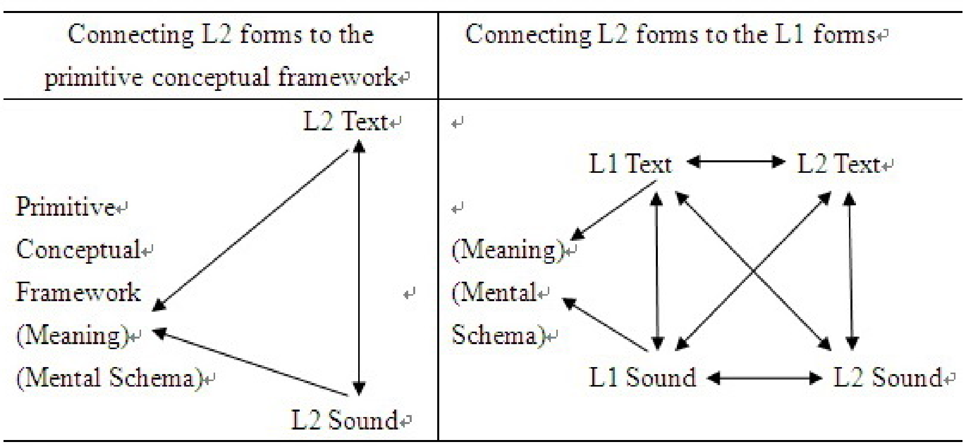

Figure 4. Two form-meaning mapping assumptions between L1 and L2.

The experiment that forms the essential aspect of this current study examined whether it is more effective to map the L2 forms onto the primitive conceptual framework (implicit approach: animation) or if it is more efficient to directly map the L2 forms onto the L1 forms (explicit approach) when learning a second language.

Comparisons of Adults' and Children's Acquisition

Various researchers have found that both first language acquisition and second language acquisition have developmental stages (Cook, 2010). In this sub-section, children's first language acquisition stages and children/adults' second language acquisition stages will be compared.

Similarities. Many researchers have observed that infants and children in various areas of the world go through similar first language acquisition stages (Liberman, 2011; Brown, 2000). (1) Between two and four months of age is the cooing stage; infants produce speech-like sound. (2) Between six and eight months of age is the babbling stage; babies start to have control over speech vocalization and are sensitive to phonetic distinctions. (3) Between nine and eighteen months of age is the holophrastic stage; babies communicate with singular words, relating a single word to many similar things. (4) Between 18 and 24 months of age is the two-word stage; babies produce mini-sentences with simple semantic relations. (5) Between 24 and 30 months of age is the telegraphic stage; toddlers can use key words similar to a telegram to communicate. (6) The final stage, after 30 months of age, is the multi-word stage; children's language ability blooms into fluent grammatical conversation. First-language acquisition stages are illustrated in Table 1.

Table 1

Stages of First Language Acquisition

Age	Developmental Stages	Lexical and Syntactic Knowledge
2-4 months	Cooing	Earliest speech-like sounds emergence. Laughter appears around 4 months
6-8 months	Babbling	Babies start to have control on speech vocalization, Sensitive to the phonetic distinction
9-18 months	Holophrastic stage	Children communicate with one word, relating it to many similar things.
18-24 months	Two-word stage	Mini-sentences with simple semantic relations. Example: More cereal, papa away, bye-bye car
24-30 months	Telegraphic stage	Telegraphic sentence structures of lexical rather than functional or grammatical morphemes.
30 months up	Multi-word stage	Children language blooms into fluent grammatical conversation.

Note. Adapted from Liberman (2011).

Krashen and Terrell (1983) proposed a series of second-language acquisition stages: (1) the first six months of encounter is the preproduction stage; (2) from six to 12 months is the early production stage; (3) from one to two years is the speech emergence stage; (4) from two to three years is the intermediate fluency stage; and (5) from five to seven years is the advanced fluency stage. Second-language acquisition stages are illustrated in Table 2.

Table 2

Stages of Second Language Acquisition

Time frame of L2 experience	Developmental Stages	Characteristics
0-6 months	Preproduction	Silent period. Focusing on comprehension
6-12 months	Early production	Focusing on comprehension. Using 1-3 word phrases. Maybe using routines/formulas (e.g., “gimme five”)
1-2 years	Speech emergence	Increased comprehension. Using simple sentences. Expanding vocabulary. Continued grammar errors.
2-3 years	Intermediate fluency	Improved comprehension. Adequate face-to-face conversational proficiency. More extensive vocabulary. Few grammar errors.
5-7 (10) years	Advanced fluency	

Note. Adapted from Krashen and Terrell (1983).

Comparing the stages between first and second language acquisition, a regular sequence of “milestones” becomes clear. Table 1 and Table 2 show that during the beginning six months, the main focus of language development is (listening) comprehension. Before reaching the 18th month, learners can use one-to-three word phrases to communicate. After two years of encountering, the learners may speak the language with errors, but they are able to say the sentences with correct syntactical order.

Differences. There are many differences between first and second language acquisition. In broad strokes, they can be broken down into four parts (Cook, 2010). (1) The first involves the strategies to acquire the language. Children observe the differences between concepts, simultaneously acquire vocabulary items and their categories, and use L1 to develop a cognitive/linguistic system; in L2, learners equate new phonetic/morphological forms for a known category/concept. (2) The second involves the ability to compare linguistic code features. Children construct their cognitive system while acquiring their L1, then they compare the differences of the same linguistic code feature between languages while acquiring the L2. (3) The third involves the patterns to produce error. L1 errors are often triggered by the limitation of cognitive capacity or over-generalizing a linguistic rule or the meanings of a concept, yet L2 errors are usually generated because of first language interference. (4) The fourth involves the ability to possess 'theory of mind' (Tomasello, 1999), namely, knowing how other people see the world and being able to respond to others' view. The differences between L1 and L2 acquisition is illustrated in Table 3.

The Implication of Information Processing

A special emphasis of this current study will be placed on the function of working memory. According to Mayer and Moreno (2003), the working memory is where "meaningful learning"

Table 3

Differences between L1 and L2 Acquisition

L1 learners	L2 learners
1. acquire vocabulary items and their categories at the same time.	1. acquire new phonetic form for a known category/concept.
2. have no or little meta-linguistic awareness	2. know linguistic categories from native language and have cognitive capacities such as analogical reasoning that develop parallel to the linguistic knowledge.
3. produce development errors (developmental sequence: acquisition of negation, etc.)	3. produce errors caused by L1 interference
4. not able to see how other people see the world	4. have theory of mind

Note. Adapted from Cook (2010).

takes place. Meaningful learning requires learners to engage in substantial cognitive processing, which involves the temporary storage and manipulation of information that is believed to be important for a wide range of complicated cognitive activities (Baddeley, 2003, p. 189). Baddeley and Hitch (1974) proposed that working memory could be divided into three sub-systems—verbal and acoustic information (the phonological loop), the visuo-spatial sketchpad, and the central executive (attentionally-limited) control systems. The three components of working memory are shown in Figure 5.

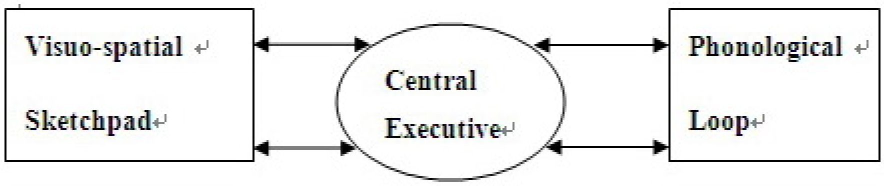

Figure 5. The three component model of working memory, adapted from Baddeley (2003, p. 191).

Baddeley and Hitch (1974) proposed that learner's capacity in the working memory for cognitive activity processing is severely limited. When the total processing demands exceed the learner's cognitive capacity, cognitive overload occurs. Baddeley and Hitch conducted several experiments and asked the participants to remember sequences of digits ranging in length from zero to eight items, while simultaneously performing a couple of tasks assumed to depend on working memory. Their results demonstrated that when the concurrent digit load was increased, their level of performance on the tasks declined. From the results of Baddeley and Hitch's experiments, inferences could be made; if the tasks in the central executive control system no more cognitive load than can be handled by the learners, it would be possible for them to comprehend the already existing concepts and extract new patterns into their cognitive structure more efficiently when rehearsal is constantly presented.

Based on Baddeley's and Hitch's (1974) theory of working memory, Mayer and Moreno (2003, p. 44) proposed a dual channel assumption to complement the theory of working memory. The two channels in the model include visual and auditory stimuli perceived by a person's ears and eyes and stored in the sensory memory. Figure 6 presents a cognitive model showing that pictures and words come in from the outside world as a multimedia presentation. The arrows between the five columns represent cognitive processing.

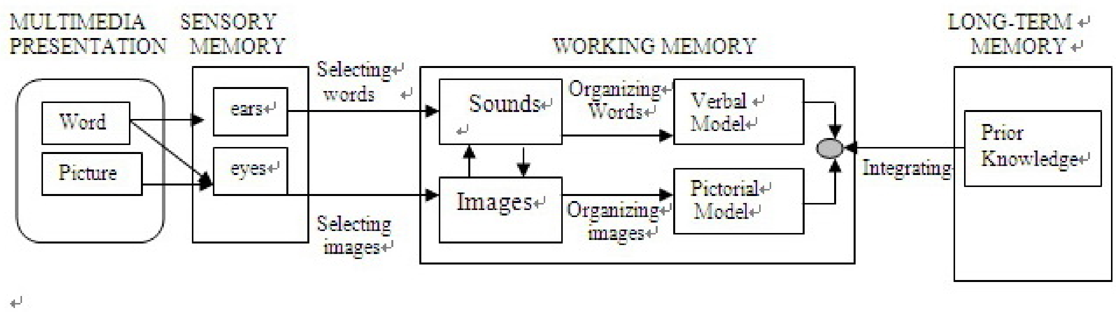

Figure 6. Cognitive theory of multimedia, adapted from Mayer and Moreno (2003, p. 44)

The arrow labeled selecting words or selecting images represents the learner's paying attention to some of the auditory sensations coming in from the ears or some of the visual sensations coming in through the eyes. The arrow labeled organizing words or organizing images represents the learner's constructing a coherent verbal representation from the incoming words or a coherent pictorial representation from the incoming images. The arrow labeled integrating represents the merging of the verbal model, the pictorial model, and relevant prior knowledge. Thus, meaningful learning requires the following cognitive processing (Mayer, 2002):

1. Selecting words and/or selecting images
2. Organizing words and/or organizing images
3. Integrating the presented material with existing knowledge

The central work of cognitive processing begins in the working memory, where learners can attend to distinctive features from the materials presented by auditory and visual inputs (i.e., selecting them) and build relation among them (i.e., organizing them) based on the existing knowledge (i.e., integrating them). The dual channel assumption suggests that only a limited amount of cognitive processing can take place in either the verbal channel or the visual channel at any one time. If the learning task exceeds the processing capacity (e.g., the pace of presentation is fast, the learning material is unfamiliar, the presentation layout is confusing, the information is overloading in either one or both channels, etc.), learners may not have enough time or skills to engage in the deeper processes of organizing the words into a verbal model, organizing the images into a visual model, and integrating the models in long-term memory (Mayer and Moreno, 2003).

On the other hand, this model implies that while receiving new information the first time, the learners need to spend a longer time selecting, organizing, and integrating the information. If the information is properly organized through both channels and if it is salient to learners' experience, they might have extra capacity in their central executive system to pay special attention to linguistic differences between languages or to generalize rules. While the linguistic information has integrated into long-term memory, the time needed for processing the information should be shorter.

The Brain Studies of Linguistic Strategy Emergence

At the beginning of Chapter 2, several rationalists' and empiricists' perspectives of second language acquisition were briefly introduced. It is worth noting that as early as 1957, the behaviorist Skinner conducted a series of research observations on the causal relation between utterances in extensive stimulus and response (S-R) conditions, trying to interpret the language mechanisms for his new book, *Verbal Behavior*. Skinner's attempts were acutely criticized by Chomsky (1959), who insisted that "speech is complex behavior whose understanding and explanation require a complex, mediational, neurological-genetic theory, and that . . . laboratory behavior may be different from real-life situation so that any law observed in the laboratory is *prima facie* suspect when applied to events outside" (MacCorquodale, 1970, p. 90 & p. 86). Skinner and his followers never systematically responded to Chomsky's review of *Verbal Behavior,* which left the argument unanswerable and thus Chomsky's criticism seemed valid. Therefore, a question arises as to whether or not the empirical findings on language behavior could advocate the existing theories and perfect second language acquisition paradigm.

With the advent of technology, linguistic-related disciplines in psychology have branched out to specific fields (e.g., psycho-linguistics, cognitive linguistics, neuro-linguistics, etc.) and have applied various analytical instruments to assess the verbal behaviors or physiological aspects of language to these fields. Contemporary neuroscientists use modern technology to try to account for mental phenomenon triggered by a series of "linguistic" stimuli.

Not satisfied with previous research findings, Lafontaine et al. (2012) modified[3] the on-line speech recognition tasks to find when and how phonological (P) and orthographic (O) systems interact. At the behavioral level, they investigated learners' reaction time and accuracy of responses by pressing "yes" and "no" buttons when hearing a female speaker pronounce pairs of sounds and encounter one of the four conditions: (a) *P+O+* words sharing both initial phonemes and graphemes (e.g., Gilet- Genou), (b) *P+O-* words sharing only their initial phonemes (e.g., Jambon-Genou), (c) *P-O-* words not sharing their initial graphemes (e.g., Comment-Genou), and (d) *P-O+* words sharing their initial graphemes (e.g., Gateau-Genou). At the brain-activity level,

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[3] They assumed that manipulating the initial phoneme (rather than rhyme) would maximize the possibility to reveal a difference in the activation time course of the phonological and orthographic information during Phonological Processing.

they monitored and recorded the activities in various sites of cerebrums using electroencephalogram (EEG) (p. 2899).

The results of behavioral data showed a significant effect on phonology with faster results depending on the phoneme condition. The same pattern was observed on the error rates: Participants made fewer errors in the same than in the different phoneme condition. The results of electrophysiological data in the 250–300 ms time-window showed that when the words did not share their initial phoneme, a significant main phonological effect was found, which also interacted with electrode site: the effect of phonology was restricted to the central and parietal electrodes. In the 300–500 ms time-window, the main effect of phonology was no longer significant while the main effect of orthography emerged. The interaction between phonology and orthography showed that the effect of orthography was significant only when the words did not start with the same phoneme (p. 2901).

The latest (500–700 ms) time window showed the opposite results of those observed in the earliest time window: Orthography no longer interacted with phonology or with electrode site, suggesting a widespread effect of orthographic information at all electrode sites regardless of the phonological relationship between stimuli (p. 2901). The research study concluded that the phonological effect emerged early at central and parietal electrode sites and faded away later on, whereas the orthographic effect increased progressively at central and parietal sites before generalizing at the frontal site (p. 2897). This study provided evidence to explain the emerging sequence of linguistic registers in the brain—starting with Phonological Processing and then Orthographical Processing.

Another similar neuro-cognitive study applied functional magnetic resonance imaging (fMRI) to explore developmental differences of Phonological and Semantic Processing mechanism in Chinese between adults and children. Cao et al. (2009) examined differences in Phonological and Semantic Processing between adult and child native speakers by asking them to determine whether a target word rhymed with or was semantically related to one of the two preceding words. Word pairs were categorized in one of the three conditions: (a) *P+O+* pairs (中枢 黑板：早饭) had similar phonology and orthography in that they shared the same phonetic radical and same vowel phoneme. (b) *P+O-* pairs (自然 兴奋：承认) had different orthography and similar phonology in that they had different phonetic radicals, but shared the same vowel phoneme. (c) *P-O-* pairs (连续 罪行：掌握) had different phonology and orthography in that they did not share the same vowel phoneme and had different radicals (p. 799-800).

The results showed that adults showed greater activation than children in right middle occipital gyrus on both the meaning and rhyming task. This suggests that adults engage more effectively using the right hemisphere brain regions involved in the visual-spatial analysis of Chinese characters. Another finding showed that adults showed greater activation than children in the left inferior parietal lobule[4] for the rhyming as compared with the meaning task, suggesting greater specialization of Phonological Processing in adults. The last findings showed that children who performed better in the rhyming task on characters with conflicting orthographic and phonological information relative to characters with non-conflicting information showed greater activation in the left middle frontal gyrus[5]. This suggests that children engage the brain regions involved in the integration of orthography and phonology (P. 797). This study provided evidence that while engaging adults and children to complete on-line speech recognition tasks—either Phonological or Semantic Processing—we can observe the differences between adults and children through their brain activities.

The above two studies demonstrated that technology could measure the physiological aspects of language processing in the brain; however, the researchers can only interpret what the brain activities are, when they happen, and how they proceed. As for why those activities happen and how learners incorporate various learning strategies to solve problems, there is still no answer.

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[4] Left inferior parietal lobule is thought to be involved in mapping between orthographic and phonological representations in both English and Chinese reading (Cao et al. 2009, p. 798).

[5] left middle frontal gyrus is thought to be associated with the integration of visual orthographic information with phonology (Cao et al. 2009, p. 798).

Chapter 3: Methods

Introduction

Many SLA researchers and practitioners have for years sought pedagogical theories that can help learners achieve desirable levels of proficiency in the least amount of time. They usually conduct effects-of-instruction studies to compare two or more instructional approaches to find out which one is better than the other(s). These researchers attempt to implement the techniques that had been proven better out of two or three different approaches; however, many students still felt frustrated when they were unable to communicate effectively after years of L2 learning. Researchers have exerted significant effort in conducting experimental and quasi-experimental studies, hoping to improve existing approaches to SLA instruction. Nevertheless, their attempts have had limitations: if researchers merely compare two or three out of various possibly hundreds of pedagogical approaches, it would be a difficult task to find the best solution. One reason may be that these SLA researchers have not adequately measured students' learning processes, identified their learning gaps, and assessed their required amount of time of exposure on material learning or skill practicing by strictly operationalizing the experimental conditions and predicting their success based on their learning behaviors. Without measurable understanding of the challenges, students' learning difficulties cannot be overcome.

With the advent of computer technology, SLA researchers are now able to implement instructional theories in online programs such as the *Chinese Learning Game (CLG)*[6], which provides carefully designed instruction, tracks and analyzes learners' behaviors, and assesses their learning outcomes. As used in this study, *CLG* utilized computer technology to combine various proven SLA techniques within parallel online programs and allowed the researchers to compare the learning effects of both instructional approaches and analyze learning behaviors. In short, the *CLG* was created as an instructional/assessment tool for the researcher to conduct the current study. During October of 2012, I solicited 74 volunteer participants from Brigham Young University and 65 children from Wasatch Elementary School in Provo, Utah, and administered the experiment.

Instructional Design Strategies

Based on the literature review discussed in Chapter 2, a language course should aim at engaging learners to decode meaning. Materials should be appropriate for learners. The

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[6] The *Chinese Learning Game* is not in its current form a "game" per se. In its final form, however, it would be experienced as such by learners who use it, due to its narrative feature. Nonetheless, in its current limited form it does allow simulation of experimental conditions for implicit learning and explicit instruction approaches that are presented through multimedia. It is based on *Chinese through Pictures*, a narrative-based approach for language learning created by the ARCLITE Lab of Brigham Young University.

presentation modalities (e.g., audio, visual, text) should be appropriate to avoid any chance of cognitive overload. A certain sequence of pedagogical strategies that enable the learners to optimize SLA skills should be implemented. These strategies include 1) modeling, which helps learners contextualize the task; 2) a narrative task, which allows learners to engage more; and 3) navigation rules that are logical, understandable, and easy enough for learners to observe the differences, formulate assumptions, verify hypotheses, and revise decisions.

Considering all the ideal conditions mentioned above, *CLG* was created to provide an alternative means for learners to learn and evaluate their Chinese proficiency. Based on Design Layering Theory (Gibbons & Rogers, 2009), *CLG* simulated both implicit learning and explicit instruction environments by applying SLA theories in the content layer and applying cognitive processing theories in the representation, control, and message layers, and utilizing both implicit and explicit instructional theories in the strategy and medial-logic layers. The *CLG* also allowed data to be recorded in the management layer and stratified variables for researchers to analyze the factors that affect second language acquisition.

Materials. The online application of this research study was based, to some extent, on the previous work for learning Arabic entitled *Yusuf's Illustrated Introduction to Egyptian Arabic* (Smith, 2012) and Richards', Ilsley's, & Gibson's (1950) language learning series, *French* *through Picture*. The *CLG* application is currently hosted on the university web servers and was available for participants during the data gathering phase of the study.

The content of the *CLG* consists of two hundred vocabulary items selected from the Most Common Chinese Characters (in order of frequency) list[7] cross-referenced with the reading materials of the *Utah Elementary School Chinese Immersion Program*. In this abridged version of *CLG*, 29 meaningful chunks (i.e., 29 words, including 37 characters) were chosen (See Appendix 1). The selected words were compiled and presented in conversational style within an adventure story. The MXML (Flash and Flex) system was chosen to present the materials, the page layout was created through a CSS style sheet, the program logic followed the Adobe Action Script (Flash) language, and the tracking system was stored in a Phonetic Tutor, created by ARCLITE Lab.

Design rationales. The abridged version of the *CLG* program contained two tasks. Every task had three phases—Learning, Practice, and Testing. In the Learning Phase, new vocabulary items were introduced in a sequence. In the Practice Phase, vocabulary items were reviewed along with the previously learned items and practiced through a formative self-assessment. Learners compared differences (e.g., meaning, sound, or sentence structure) between two target vocabulary

[7] The website of Most Common Chinese Characters http://www.zein.se/patrick/3000en.html

items in a slide, and encountered the same items several times in various comparative situations. In the Testing Phase, the target items were chosen from a pool of vocabulary items from the previous tasks. Learners went through the same meaning-mapping processes as they did in the Learning Phase, with the only difference being that learners' scores were recorded in the program and not shared with the test subjects. Figure 7 shows the movement between and within phases in each task.

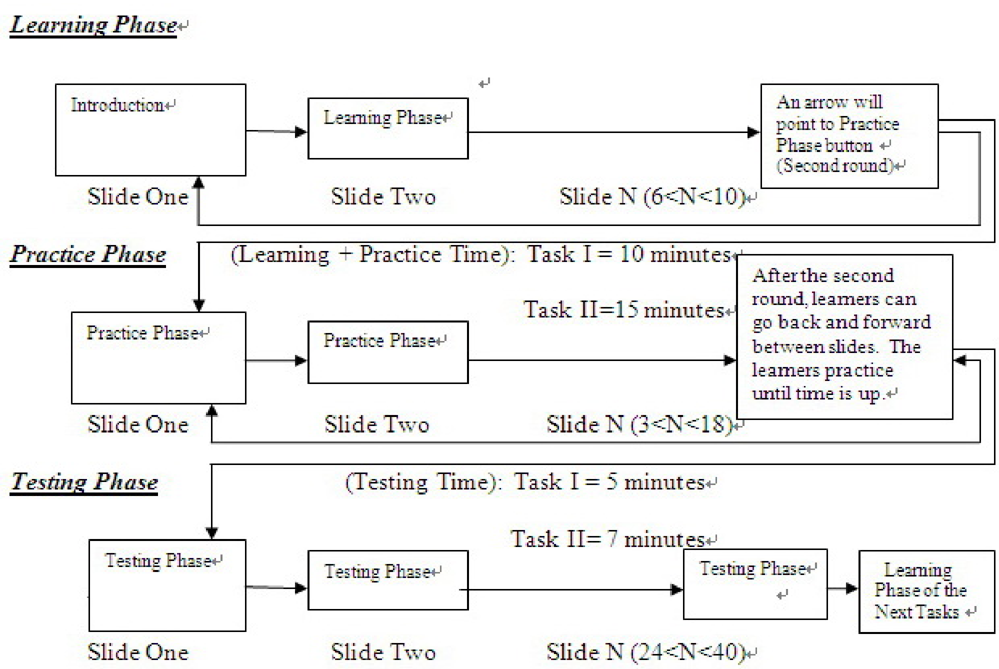

Figure 7. Movement between and within phases

In the *CLG* program, all the activities of the three different phases prepared learners to achieve the learning objectives of each task. The objective of each task was to engage learners to analyze the phonetic/phonologic, syntactic, and semantic features of a linguistic item in the

Learning and Practice Phases, and then demonstrated the ability to identify and organize the newly learned linguistic features in the Testing Phase.

To help learners achieve learning objectives, I applied several linguistic and instructional theories to adjust task difficulty. The purpose of this adjustment was to implement strategic augmentation rules to accommodate learners' cognitive load yet keep the learning process challenging. There were different kinds of instructional supports in the *CLG* program. The interface design guidelines were based upon the rules organized by Kenworthy (1993):

1. Keep cognitive load low.
2. Avoid dividing attention.
3. Use media to direct attention.
4. Keep important information visible.
5. Encourage rehearsal.
6. Use concrete words and multiple media.
7. Design effective exercises.
8. Create realistic simulations.

In order to reduce task difficulty, all the events in *CLG* were introduced in short and simple forms at first. In later phases, key phrases were integrated into longer and complex sentences and recycled several times in various and more complex situations. When a new word was introduced, it was practiced and tested many times in the same task, and then practiced and tested in more challenging situations in a later task. This repeated exposure feature encouraged learners to refresh a word's meaning, associate it with a new scenario, register the sound and meaning into their long-term memory, and increase the automaticity of the language production process.

Treatments

There were two treatments in this study: Implicit Learning Treatment and Explicit Instruction Treatment.

Implicit Learning Treatment. The representation channels of the Implicit Learning Treatment (ILT) included text (English, Chinese characters, and Chinese Pinyin in sentence level), audio, and animation. Learners observed two animated characters (stick figures) converse in Mandarin and decoded the meaning of individual L2 words. The activities in this treatment required learners to distinguish a series of concepts by comparing animated pictorial images with their corresponding Romanized sentences, Chinese sounds, and English translation at a manageable pace. The purpose of this pedagogical design was to draw the learner's attention to recognize each linguistic feature (i.e., phonological, morphological, syntactical, semantic) one feature at a time, decode the meaning of all individual words from a series of events, and immerse the learners in a contextualized language-use situation with multiple types of exposure. The following are the three phases of the ILT design.

The Learning Phase. This phase comprised a series of directed interactive events. Participants saw sentences in Pinyin (translated Roman characters) and Chinese characters next to each picture. When clicking "Watch," the participants heard the Chinese sound and saw the animation and English translation concurrently. Viewing from left to right, they subconsciously compared the meaning of the texts (Pinyin, Chinese sentence, and English translation), Chinese sound, and the differences between two animations (See Figure 8).

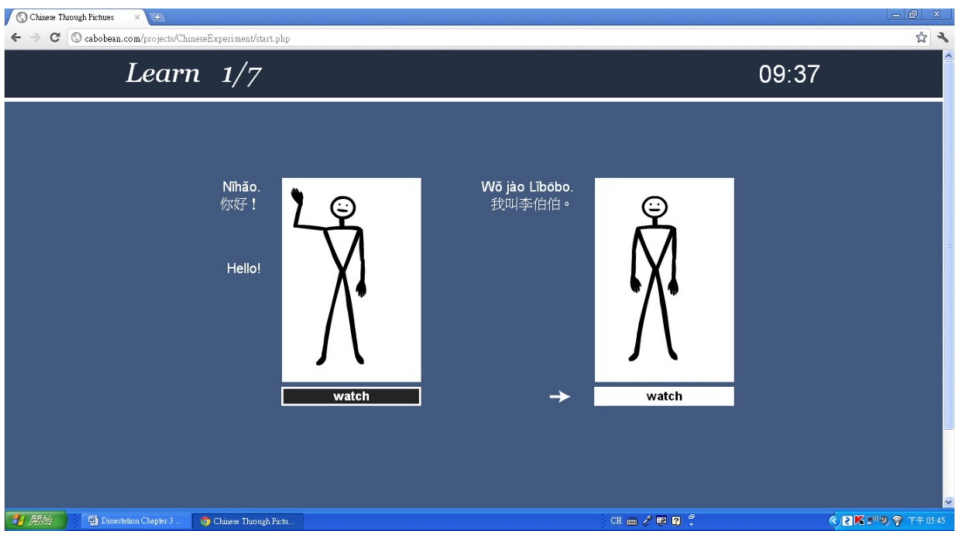

Figure 8. Experimental group learning phase.

Conversations in the Learning Phase were carefully sequenced. The participants learned each sentence as a meaningful unit. They listened to Chinese, observed the animations, and read English translation as subtitles. Then they analyzed the Chinese linguistic rules between two sentences within and between slides. Through this instructional design, the meaning of an individual word was expected to be generalized by the learners.

The Practice Phase. This phase helped the participants self-evaluate listening comprehension. When pressing "Listen," the participants heard a Chinese prompt and were instructed to click the correct animation. If the correct one was selected, they would see the English translation and a green frame as the positive feedback. The "Next" button would also show up (See Figure 9). If they selected the incorrect one, a red frame would appear, the arrow would point back to "Listen," and they would have to try again.

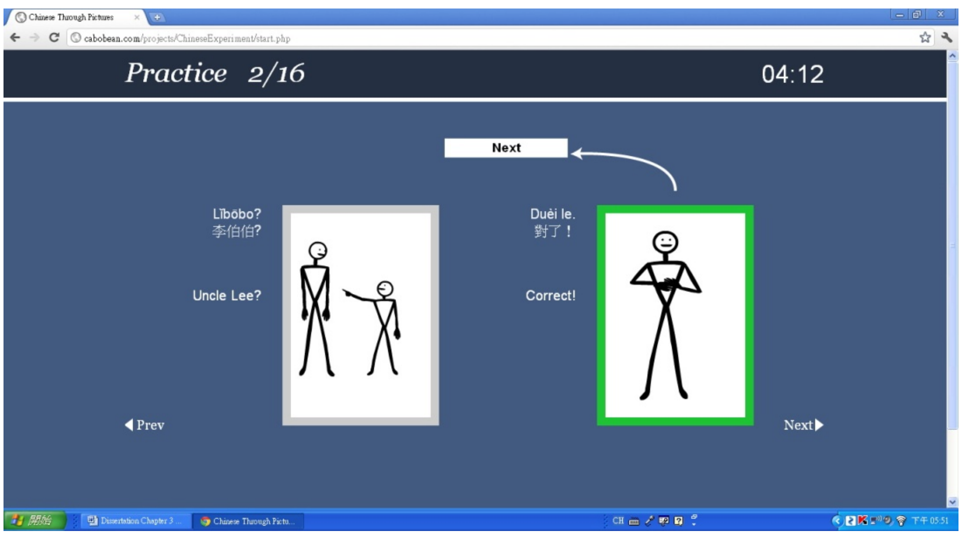

Figure 9. Experimental group practice phase.

The Testing Phase. Participants took a listening comprehension test when they entered this phase. There were two types of tests in the Testing Phase. In the first type (See Figure 10), the participants clicked the "Listen" button to listen to the prompt and select the correct animation. They then proceeded to the next question whether they had chosen the correct answer. There would be no feedback and no way to access previous questions.

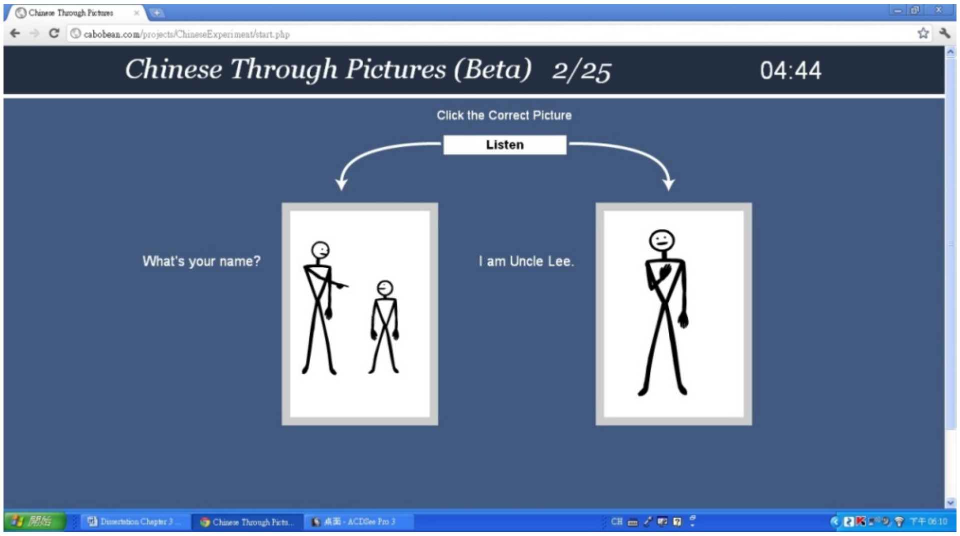

Figure 10. Experimental group testing phase type one.

The second type (See Figure 11) allowed participants to read an English prompt, click all the speaker icons to hear possible answers, and select the correct Chinese sound. These testing tasks examined whether the participants understood the meaning of the Chinese sounds.

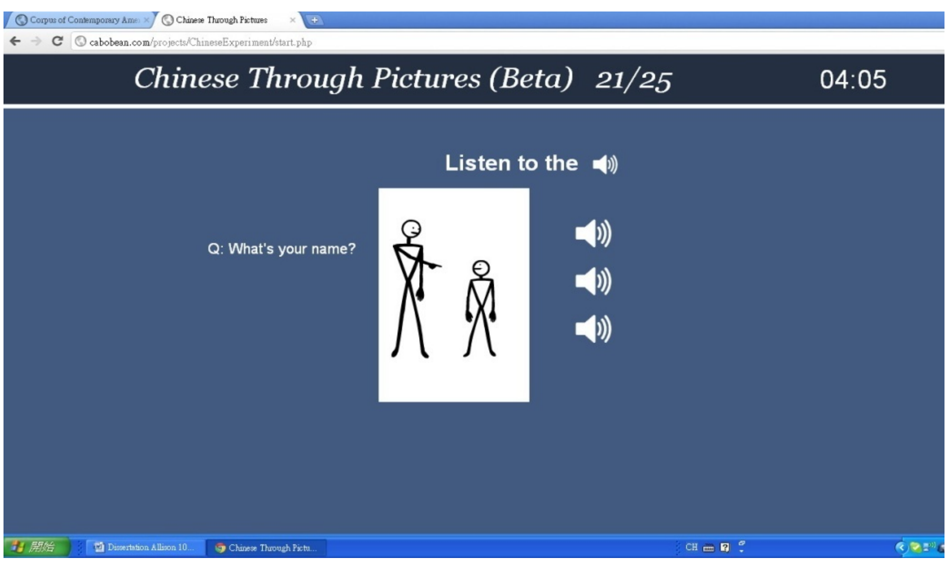

Figure 11. Experimental group testing phase type two.

Explicit Instruction Treatment. The representation channels of the Explicit Instruction Treatment (EIT) contained text (English, Chinese character, and Chinese Pinyin) and audio. Learners saw an English translation of color-marked individual Chinese words and Pinyin when they heard its corresponding sound. In each sentence, different parts of speech were represented by different colors so that the learners could define the word boundaries and understand the meaning and the grammatical function of each Chinese word (sound). The purpose of this design was to help learners visualize multiple linguistic (i.e., morphological or syntactical) forms between English and Chinese.

The Learning Phase. The participants first saw the texts in Pinyin and Chinese characters in the middle of the slide. When clicking "Listen," they heard the Chinese sounds, read the word-by-word translation, and saw the grammar explanation and English translation at the same time. Viewing from top to bottom, they could see the aligned texts with different color-coding. An example of the Learning Phase is illustrated in Figure 12.

The Practice Phase. In the Practice Phase, the participants saw an arrow pointing to the "Listen" button, which prompted them to click and listen to the Chinese sentence. Then, two arrows would direct them to choose the English text that matches the Chinese sound. If they selected the correct answer, they would see the Pinyin, Chinese characters, grammar explanation, and direct translation as positive feedback. If they selected the incorrect answer, the arrow would

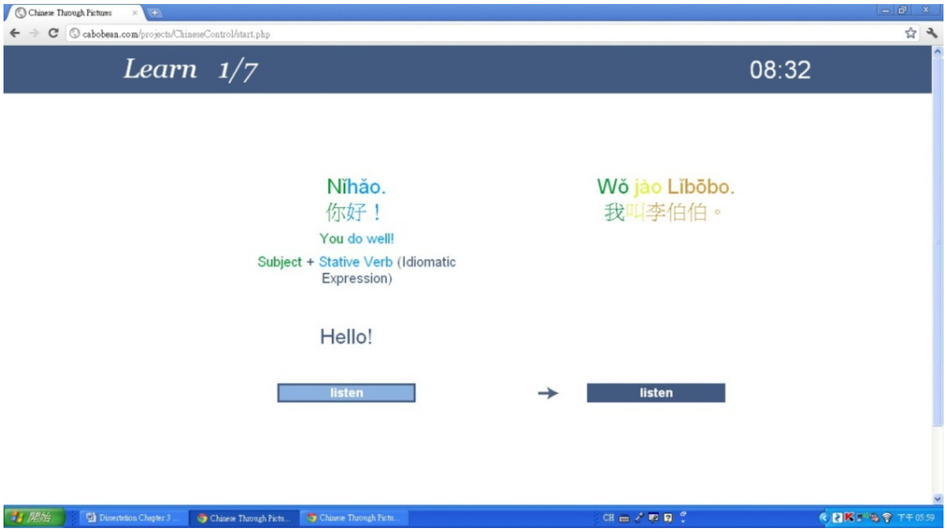

Figure 12. Control group learning phase.

point back to “Listen” and the participants needed to try again. Figure 13 shows the Practice Phase.

The Testing Phase. There were two matching tests in this phase—listening to a Chinese audio clip and choosing the correct English sentence translation or looking at an English sentence and selecting the correct Chinese audio translation. Participants clicked the “Listen” button to hear

Figure 13. Control group practice phase.

the prompt and make their choice. Whether they chose the correct answer or not, they proceeded to the next question. The first type of Testing Phase is illustrated in Figure 14.

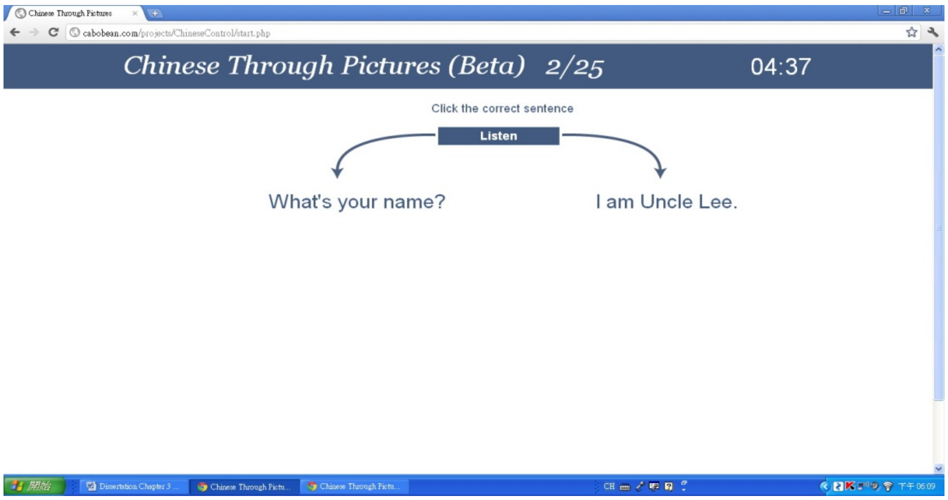

Figure 14. Control group testing phase type one.

The second testing type reversed the conditions. Participants read an English prompt, clicked each speaker icon to hear the possible answers, and selected the correct Chinese audio translation. The second type of Testing Phase is illustrated in Figure 15.

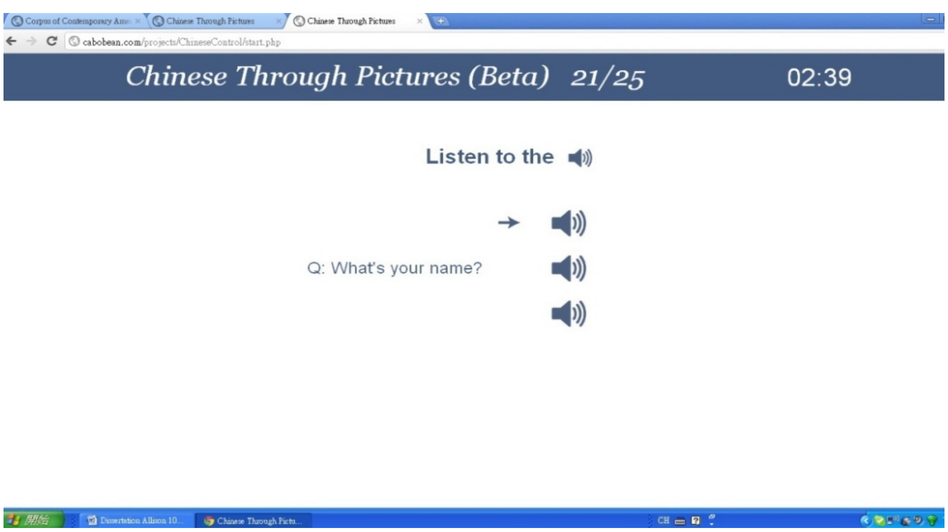

Figure 15. Control group testing phase type two.

Similarities and differences between treatments. The two treatments of this study were essentially parallel. The language content, instructional sequence, navigation rule, administration procedure, method of assessment, and total allowed testing time on each phase of both treatments were exactly the same. The listening comprehension test, the vocabulary test, questionnaire on learning attitudes, information processing time, and survey on participants' second language strategies were subjected to statistical analysis. The differences between the two treatments were in the assumption of randomly sampled and randomly selected participants' using implicit and explicit strategies in each simulated program.

Participants

The participants for this study consisted of 74 students from Brigham Young University (BYU) and 65 students from Wasatch Elementary School (Wasatch) none of who had been exposed to any Chinese learning. They were solicited from the BYU campus and from three sixth grade classes at Wasatch Elementary School in October, 2012.

Data Collection

Three types of data were collected in this study—survey, user behavior, and learning outcome. Demographic information was collected at the beginning with the participants' log-in before the treatment. The learners' implicit learning processes were analyzed using the online Qualtrics survey after the treatment. The Qualtrics survey elicited participants' preferences on SLA and cognitive strategies, and also investigated the willingness of the participants to continue using *CLG* for language learning.

Two types of tests measured participants' acquisition of the Chinese language from both treatments. The listening comprehension test measured learners' ability to correctly match Chinese sounds with their meanings. The vocabulary test measured learners' ability to generate new Chinese sentences based on the newly learned words and grammar. Learners were required to identify the correct translation of the unfamiliar Chinese sentences, or translate an English sentence into a grammatical Chinese sentence.

Instruments

The instruments of this study included login screen, user behavior analytics, listening comprehension test, Qualtrics survey, and vocabulary test.

Login screen. Data gathering in *CLG* started with the initial login screen, where participants entered personal information such as subject ID, gender, year in school, major, languages previously studied, language learning ability and age. The information was collected to identify specific groups of users (e.g., gender and age) and to analyze their fields of study and language experience.

User behavior analytics. *CLG* itself served as a data collection instrument. The behaviors of the users were recorded throughout each phase, which captured user action on each of the "Listen," "Previous," "Next," "Start Practicing," and "Begin Test" buttons, and on all "block of animation" or "block of text" options. The purpose of collecting the behavioral information was to analyze the time span between each click, which implicated learners' information processing time (in Learning and Practice) and decision-making time (in Testing).

Listening comprehension test. The listening test was implemented in the Testing Phase of the program, which was in multiple-choice format. The participants listened to a Chinese prompt and selected an answer to the question. The test was designed to assess whether learners could identify the meaning of 29 key phrases' sounds by choosing their corresponding visual representations. This test design correctly measured the construct—the recognition of the meanings and the acoustic features of 29 chunks of L2 sound.

Twenty-five and thirty listening comprehension questions were administrated in Task One and Task Two, respectively. The participants had five and seven minutes to complete each test (also respectively). Based on the data collected from each representative age/treatment group in the pilot tests (think-aloud protocol), on an average it took 10 to 12 seconds for a participant to answer a question. The participants were allowed to have multiple tries clicking the test prompts.

Qualtrics survey. An online questionnaire (Qualtrics) was designed to gather data related to the participants' preference on SLA or cognitive strategies and participants' enthusiasm for using the *CLG* online application. An online questionnaire was issued, instead of applying a *Think-Aloud Protocol*[8], because during the experiment, learners only had a limited amount of processing capacity in the working memory to analyze and organize linguistic information. In order to keep learners focused, the retrospective style of questionnaire was used after the treatment.

The Qualtrics survey included five sets of multiple-choice questions, which repeatedly appeared three times. These questions asked learners to recall what they were thinking or doing while going through the Practice Phase during the treatment. The participants were blind to the purpose of the questionnaire, which was—strategy elicitation. They were asked to choose the answers that best represented their thinking without paying attention to the correctness of each answering option. The answering options of the questionnaire were encoded into three types of

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[8] Based on Ericsson and Simon (1993), a *Think-Aloud Protocol* is a method of verbal report of subjects which is concurrent with a given mental task but the heeded information is not already linguistically encoded. Therefore linguistic encoding for verbalization is required.

SLA strategies and five types of cognitive strategies. The maximum frequency for each type of SLA strategy option is nine and for each type of cognitive strategy option is six.

To ensure that the contents of the learning and testing materials and questionnaire questions were consistent, all 15 questions in the Qualtrics survey were designed to be identical to the contents of the Practice and Testing Phases. The wordlist of the program is shown in Appendix 1 and Qualtrics survey questions are listed in Appendix 2.

The strategy rating rubrics were distributed to four trained[9] students in the department of linguistics at Brigham Young University. They were asked to match the answering options of the questionnaire into three SLA categories and five cognitive categories. The aim of this design was to determine whether the SLA and cognitive strategies correctly reflected their represented categories. The results of two-way mixed intra-class correlation coefficient test of inter-rater

[9] Each rater was individually trained on the definition of the terms (SLA and cognitive strategies) to ensure that they matched the linguistic knowledge of the rater, followed by a demonstration of coding sample questions and explanation of how to assign the value to each answer option of the questionnaire. The raters were asked several sample questions randomly until acceptable agreement on the terms had been reached.

reliability is acceptable (Cronbach α =0.72)[10]. The rating task sample for both treatments is listed in Appendix 4.

Vocabulary application test. This ten-question vocabulary test was implemented in the middle of the Qualtrics online survey. The test was also in multiple-choice format. The participants read and answered ten questions based on the vocabulary and knowledge of grammar that they learned or acquired in the program. The testing tasks included translating Chinese vocabulary into English, translating English into Chinese and Chinese into English sentences, answering a Chinese question, identifying plural forms of a Chinese pronoun, using logical reasoning skills to categorize Chinese nouns, and using just-learned Chinese vocabulary items to compose new Chinese sentences.

Scoring. The independent measure for the tests was computed as follows. A correct answer on each item received full credit—3.33 points on listening test one and 4 points on listening test two. For the vocabulary test, a correct answer on each item received 10 points. Discrepancy among the listening comprehension tests and the vocabulary application test was due to the following:

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[10] A commonly accepted rule of thumb for describing internal consistency using Cronbach's alpha is as follows: 1) $\alpha > 0.9$ means excellent (high stake testing); 2) $0.8 < \alpha < 0.9$ means good (low stake testing); 3) $0.7< \alpha <0.8$ means acceptable (survey); 4) $0.6 < \alpha <0.7$ means questionable; 5) $0.5 < \alpha <0.6$ means poor; and 6) $\alpha <0.5$ means unacceptable (Kline, 2000).

The listening comprehension tests were designed to measure the linguistic knowledge of 29 new words in L2 and measure how well the participants could hold the information in their working memory; whereas the vocabulary test was designed to measure how well the participants could organize the newly learned linguistic knowledge (e.g., meaning of 29 sounds, phonological rules, syntactic order, etc.) and apply the knowledge to a new situation. It is hypothesized that when learners could perform this problem-solving task, they have demonstrated the ability to integrate the organized information into their long-term memory. Therefore, the vocabulary application test was weighed about 2 times higher than the two listening comprehension tests. The research design structure is illustrated in Figure 16.

Procedure

All the experiments were conducted in October, 2012. Adult participants (BYU) in both EIT and ILT groups participated once sometime during five school days; while the elementary school children (Wasatch) in both treatments participated once sometime during two school days. Before conducting the actual experiments, I had run two test-runs for each school to check the stability of the BYU server and individual work stations in the language testing lab and classroom. All the tests were administrated by two proctors who used to serve as the presidents of Parent Teacher Association (PTA) of Wasatch Elementary School. At the beginning, one of the proctors briefly introduced the procedure of the experiment and had all the adult participants sign

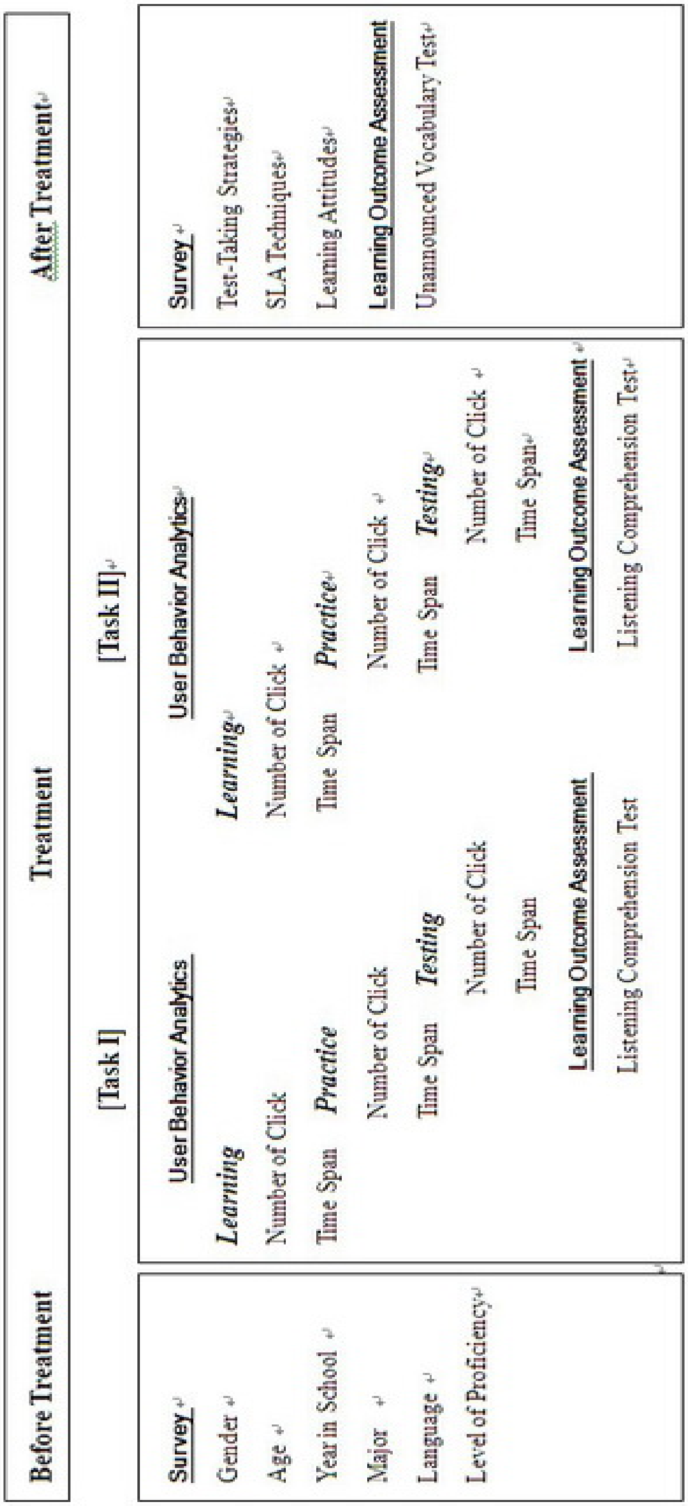

Figure 16. Research design structure.

the consent forms. For the children group, the parental consent forms were collected before children's assent forms were even distributed. The time for each section and testing rules were announced in advance. Then participants started to watch a five-minute tutorial video before the experiment. The program was also presented binaurally at a comfortable listening level through headphones. Once they entered the program, they could control their learning pace and practice the key points of each task as much as they wish, but they could not go back to the previous slide or section. Between each section, there was a block page appearing at the end of the timer that told the participants to wait for the instructor. The proctor could use the time to remind the participants of the testing procedure or rules if needed. After the *CLG* program, an online questionnaire (Qualtrics) appeared on the screen and a vocabulary test was administered in the middle of the Qualtrics online survey. The duration of the entire experiment was fifty-seven minutes.

Chapter 4: Results

Introduction

This study investigated the differences in learning outcomes between the Implicit Learning Treatment (ILT) and Explicit Instructional Treatment (EIT) and explored differences in information processing time and thinking processes of second language acquisition (SLA) and cognitive strategies between adult and child learners' using two treatments. All of the language practice was conducted using the *Chinese Learning Game* software created by the ARCLITE Lab in the Center for Language Studies at Brigham Young University. That software was used as a research platform to explore the following research questions:

1. What are the main effects and interaction effects of two instructional approaches (Implicit Learning Treatment and Explicit Instruction Treatment) on the language learning outcome of adults and children as implemented in a multimedia language learning environment?

2. Which learning strategies are used and which behaviors are exhibited by the most successful adult and child learners?

A 2 x 2 between-subjects factorial design was chosen to address the first research question because of its potential for examining not only the main effects of the two independent variables, maturity and treatment, but also the effects of any interaction that might occur. The dependent variable of this design was the total test score. The treatment variable consisted of two levels, "text" and "animation" and the maturity variable included "adults" and "children." The analysis of variance for two-way factorial designs was computed using SPSS. The alpha (α) level for all tests was set at .05.

A 3 x 2 factorial design MANOVA was chosen for the second research question with the dependent variable of information processing time. The between-subject factor consisted of "high," "mid," or "low" performance variables; the other between-subject variable included "text" or "animation" treatment; and the three types of dependent variables included "learning," "practice," or "testing" phase. Another 3 x 2 factorial design MANOVA were chosen for the second research question with the dependent variable of the ratio of selecting frequencies of the SLA and cognitive strategies. The between-subject factor consisted of "high," "mid," or "low" performance variables; the other between-subject variable included the group to which the learners belonged (ILT or EIT), and the dependent variables included "Phonological Processing Strategy," "Meaning-Based Strategy," or "Syntactical Strategy" for SLA strategies and "Elimination," "Noticing," "Guessing," "Repetition," or "Prediction" for cognitive strategies.

A stepwise regression procedure was chosen for the second research question to identify which learning behaviors and strategies predicted the students' high performance. All the data were computed using SPSS 20.0. An analysis of the results from this study is presented in this chapter.

This chapter will discuss the statistical results and answer the research questions following this sequence:

A. Research Question One:

1. Demographic information (descriptive statistics)
2. Total test scores among maturity and treatment groups (descriptive and inferential statistics)
3. Listening and vocabulary test sub-scores (descriptive and inferential statistics)

B. Research Question Two:

1. User-behavior analytics (descriptive and inferential statistics)
2. SLA and cognitive strategies (descriptive and inferential statistics)
3. Prediction of successful learners' learning model (inferential statistics)

Statistical Analysis

The statistical analyses of this study are as follows:

Demographic information. All the participants of this study came from BYU and Wasatch Elementary School from Provo School District. There were 74 adults and 64 children; among these 139 participants. Table 4 presents a summary of the participant data with regard to age and gender.

Table 4

Information about Participants

Demographic variable		*n*	%	Min	Max	*M*	*SD*
Maturity (yrs)							
	Adults	74	53.2	17	27	20.4	2.3
	Children	65	46.8	10	12	11.2	.4
Gender							
	Male	67	48.2				
	Female	72	51.8				

The adult students came from 40 different majors, with English being the most popular major (5% of adults). Among the adult students, two of the participants were graduate students from the department of Accounting and Computer Science. Table 5 shows the information about participants' majors in this study.

The foreign languages that the participants had learned before included—Arabic, French, German, Italian, Japanese, Korean, Portuguese, Russian, and Spanish. In addition, nine participants indicated exposure to other miscellaneous languages not specified[11], and 62

[11] In the original design, when learners selected the "other language" option, a pop-up box asked them to specify the language. In the pilot test, some children filled in the "other language" option in the text field with a nationality or country name, which made the data collection error-prone. Thus the fill-in-the-blank options were canceled.

Table 5

Study Majors of Participants

Majors	*n*	%	Majors	*n*	%
Accounting	2	1.4	International Relations	6	4.3
Acting	1	.7	Landscape Management	1	.7
Actuarial Science	1	.7	Linguistics	1	.7
Biological Science Education	1	.7	Mechanical Engineering	1	.7
Business	2	1.4	Mechanical Engineer	1	.7
Chemical Engineering	1	.7	Media Arts	1	.7
Chemistry	1	.7	Microbiology	2	1.4
Communication Disorders	2	1.4	Neuroscience	1	.7
Communications	2	1.4	Nursing	1	.7
Computer Science	7	5.0	Physics	1	.7
Dietetics	1	.7	Physiology and Developmental Biology	2	1.4
Economics	1	.7	Political Science	2	1.4
Electrical Engineering	1	.7	Pre-dietetics	1	.7
Elementary Education	2	1.4	Public Health	2	1.4
English	7	5.0	Recreation Management	5	3.6
English Education	1	.7	Statistics	1	.7
English/Portuguese	1	.7	Therapeutic Recreation	1	.7
Exercise Science	2	1.4	Undeclared	4	2.8
Finance	1	.7	International Relations	6	4.3
Food Science	1	.7	Landscape Management	1	.7
Genetic Engineering	1	.7	Linguistics	1	.7
Humanities	1	.7	Total	139	100

participants (mostly children) had never learned a foreign language before. The participants' foreign languages are presented in Table 6.

Table 6

Foreign Languages of Participants

Demographic variable	*n*	%
Languages other than first language		
Arabic	2	1.4
Italian	2	1.4
Russian	2	1.4
Japanese	2	1.4
Korean	3	2.2
German	4	2.9
Portuguese	5	3.7
Other [a]	9	6.5
French	10	7.2
Spanish	38	27.3
None	62	44.6
Total	139	100.0

[a] Variable had incomplete data.

Total test scores. The mean total test scores (i.e., Listening Test One, Listening Test Two, and Vocabulary Test) among four age and treatment groups are compared in this study. The maturity variable consisted of two levels, "adults" or "children" and the treatment variable consisted of two levels, "text" or "animation." Combination of these variable levels resulted in the following cells: C1 (adult/text), C2 (adult/animation), C3 (children/text), C4 (children/animation). The descriptive statistics are presented in Table 7, which shows that adults in the EIT has the highest mean score ($M = 289.34$, $SD = 10.68$) and children in the ILT group had the lowest mean score ($M = 226.25$, $SD = 36.40$).

Table 7

Summary of Mean Total Scores of Treatment and Maturity

Total test scores		*n*	*M*	*SD*	*Median*
Adult					
	EIT	38	289.34	10.68	290.00
	ILT	36	284.83	17.66	290.00
Children					
	EIT	33	239.91	30.36	239.00
	ILT	32	226.25	36.40	228.00

A factorial, two-way Analysis of Variance (ANOVA) was conducted. The results in Table 8 show that learners in the EIT group performed significantly better than those in the ILT group (F (1, 135) =4.495, p=.036). There were significant differences between adults and children (F (1, 135) =158.901, p<.001), but there was no statistically significant interaction between the two factors.

Table 8

Analysis of the Difference in Treatment and Maturity on All Tests

Variable	*SS*	*df*	*MS*	*F*	*Sig.*
Corrected Model	104178.684	3	34726.228	54.694	.000
Treatment	2854.137	1	2854.137	4.495	.036
Maturity	100889.534	1	100889.534	158.901	.000
Treatment * Maturity	724.002	1	724.002	1.140	.287

Listening and vocabulary test sub-scores. I measured the results of two listening comprehension tests (25-questions for Task 1 and 30-questions for Task 2) and a 10-question, vocabulary test (administered via Qualtrics) that was identical for both the experimental treatment and the control treatment. The only differences between the two treatments were their presentation modalities and their instructional design rationales. Table 9 shows the minimum and maximum scores received by 139 participants in the two listening and one vocabulary tests as well as the means and standard deviations observed.

Table 9

Descriptive Statistics on the Listening and Vocabulary Tests

Subtest scores (points)	Min.	Max.	*M*	*SD*
Listening comprehension test I	28.0	100	96.75	8.04
Listening comprehension test II	63.3	100	94.23	7.95
Vocabulary application test	0.0	100	70.94	26.56
Total	142.0	300	261.91	37.10

Table 10 presents the mean listening and vocabulary scores and standard deviation received by male and female adults and children under EIT and ILT groups.

The results of statistical analyses show that, overall, there was a significant effect for maturity on listening test 1, $t = 4.066$, $p<.001$, listening test 2, $t = 7.751$, $p<.001$, and the vocabulary test, $t = 12.484$, $p<.001$, with adults receiving higher scores than children. The

Table 10

Summary of Mean Scores of Treatment and Maturity Group

Test scores			*n*	*M*	*Median*	*SD*
Listening Test I	Adults	EIT	38	99.47	100.00	1.656
		ILT	36	99.22	100.00	1.606
	Children	EIT	33	94.55	100.00	12.916
		ILT	32	93.00	96.00	8.561
Listening Test II	Adults	EIT	38	98.55	100.00	3.607
		ILT	36	98.39	100.00	2.901
	Children	EIT	33	90.52	93.00	8.094
		ILT	32	88.25	91.50	9.709
Vocabulary Test	Adults	EIT	38	91.32	90.00	8.752
		ILT	36	87.22	90.00	15.234
	Children	EIT	33	54.85	50.00	21.083
		ILT	32	45.00	40.00	23.280

diagrams present the interaction between maturity and treatments. Figure 17 shows adults and children's performance on Listening Test One and Listening Test Two.

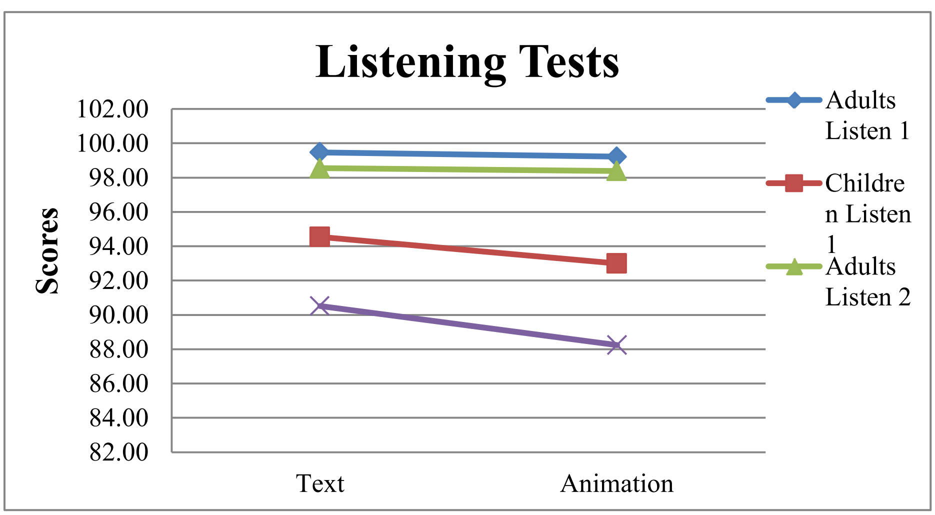

Figure 17. Estimated marginal means of listening test one and two.

The diagram in Figure 18 shows that the adults and children performed differently on their vocabulary test.

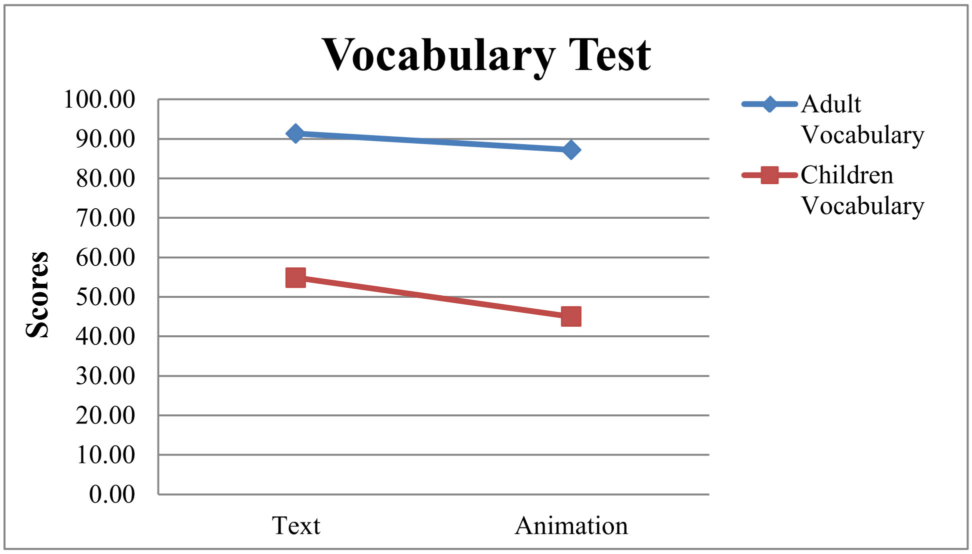

Figure 18. Estimated marginal means of vocabulary test.

From Figure 17 and Figure 18, we can conclude that there is no interaction between adults and children in two treatments on any of the listening tests or the vocabulary test. We can also conclude that the maturity is the main factor of performance.

User Behavior Analytics

One hypothesis the researcher of this study had was that participants under different treatments require a different amount of time to perceive, encode and store new information, and retrieve the organized information.

The aim of calculating information processing/decision making time is to find out whether three performance groups (high, mid, and low) in their respective treatments—EIT and

ILT—require different amount of time to process information. The results of this analysis, in conjunction with other findings of the study, perhaps could explain the correlation between task difficulty and information processing and further predict learners' performance based on their information processing time.

Adults' information processing time. To compare differences among performance groups and between subjects in the EIT and ILT groups, the adults' and children's performance on information processing time/decision making time were examined separately. This time, the high, mid, and low performance groups were evenly distributed based on their ranking in different treatments of adults and children groups.

The descriptive data in Table 11 shows that for all three adult performance groups in the Learning Phase, the mean information processing time for subjects in the EIT group is longer than for those in the ILT group; while in the Testing Phase, the information processing speed for subjects in the EIT group is slightly faster than those in the ILT group.

A two-way, mixed factorial (between-within) MANOVA was performed. The results in Table 12 show that there was a significant main effect on the information processing time among adults' performance groups (F (2, 67) = 4.893, p =.01) and between adults' treatment groups (F (1, 67) = 12.754, p <.01) in the Learning Phase. Post hoc comparisons using the Tukey HSD test

Table 11

Information Processing Time among Adults' Treatment and Performance Groups

Phases/Groups (Sec.)		*n*	*M*	*SD*
Learning Phase				
High Performance Group	EIT	13	5.90	1.20
	ILT	12	4.75	.81
Mid Performance Group	EIT	12	6.16	2.22
	ILT	12	4.97	1.14
Low Performance Group	EIT	13	4.90	.78
	ILT	12	4.05	.87
Practice Phase				
High Performance Group	EIT	13	2.81	.28
	ILT	12	2.91	.36
Mid Performance Group	EIT	12	2.89	.37
	ILT	12	2.85	.40
Low Performance Group	EIT	13	2.91	.68
	ILT	12	2.61	.55
Testing Phase				
High Performance Group	EIT	13	3.25	.43
	ILT	12	3.57	.43
Mid Performance Group	EIT	12	3.45	.49
	ILT	12	3.49	.42
Low Performance Group	EIT	13	3.24	.48
	ILT	12	3.38	.58

shows that the high performance group spent significantly longer time than the low performance group (p =.049) and mid performance group spent significantly longer time than the low performance group (p =.011) in the Learning Phase. In the Learning Phase, adult learners in the EIT group spent significantly longer time than in the ILT group.

Table 12

Information Processing Time among Adults Treatment and Performance Groups

Variable	Source	*SS*	*df*	*MS*	*F*	*Sig.*	Post hoc Tukey HSD
Performance							
	Learning	15.805	2	7.902	4.893	.010	High-Low* Mid-Low*
	Practice	.189	2	.095	.455	.637	
	Testing	.325	2	.162	.720	.490	
Treatment							
	Learning	20.599	1	20.599	12.754	.001	
	Practice	.123	1	.123	.589	.445	
	Testing	.514	1	.514	2.280	.136	
Performance * Treatment	Learning	.423	2	.212	.131	.877	
	Practice	.496	2	.248	1.192	.310	
	Testing	.253	2	.127	.562	.573	

The results presented in Table 12 indicate that both high and mid performance groups took significantly longer information processing time than low performance group in the Learning Phase. Figure 19 and Figure 20 show similar patterns for the information processing/decision-making times among the three performance groups of both treatments in all three phases.

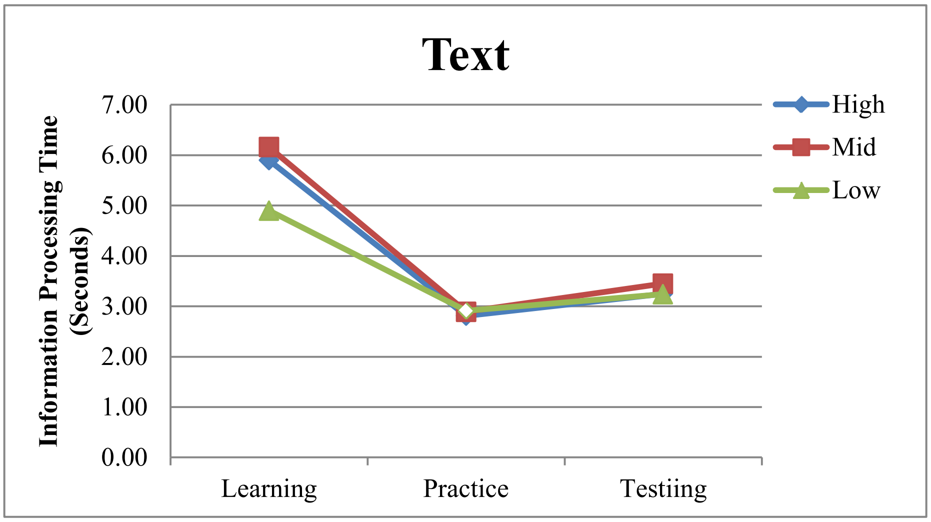

Figure 19. Information processing time of adults in the Explicit Instruction Treatment.

Figure 20 shows that adults in the low performance group in the Implicit Learning Treatment processed the information and made the decision quicker than those in the mid and high performance group in all three phases (statistics was shown in Table 12).

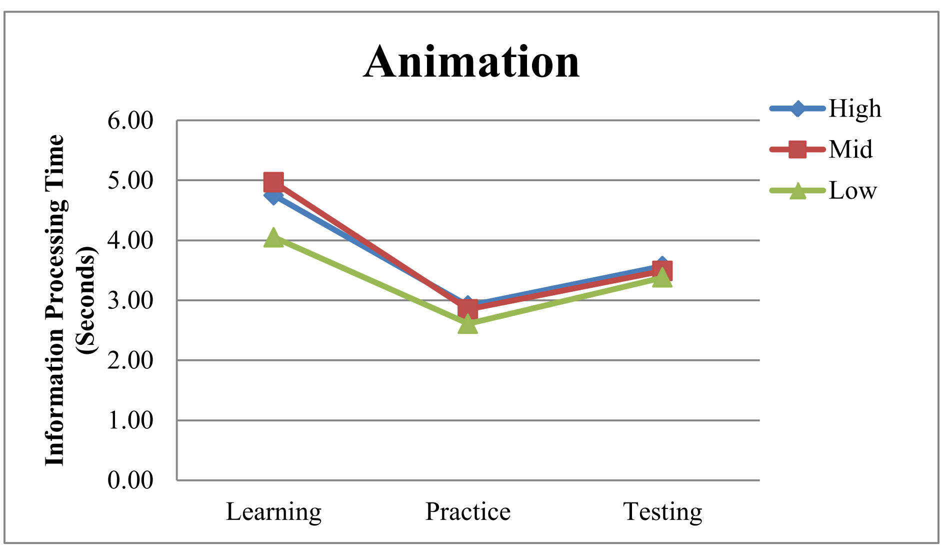

Figure 20. Information processing time of adults in the Implicit Learning Treatment.

Children's information processing time. A MANOVA was run for children again. The descriptive data are shown in Table 13.

Table 13

Information Processing Time among Children's Treatment and Performance Groups

Phases/Groups (Sec.)		*n*	*M*	*SD*
Learning Phase				
High Performance Group	EIT	11	3.96	.70
	ILT	11	4.32	.98
Mid Performance Group	EIT	11	4.16	1.13
	ILT	11	3.41	.98
Low Performance Group	EIT	11	4.60	1.23
	ILT	10	4.46	1.08
Practice Phase				
High Performance Group	EIT	11	2.70	.38
	ILT	11	2.69	.30
Mid Performance Group	EIT	11	2.94	.73
	ILT	11	2.34	.67
Low Performance Group	EIT	11	2.84	.52
	ILT	10	3.17	.70
Testing Phase				
High Performance Group	EIT	11	3.12	.34
	ILT	11	3.17	.44
Mid Performance Group	EIT	11	3.44	.68
	ILT	11	3.12	.58
Low Performance Group	EIT	11	3.65	.50
	ILT	10	3.59	.97

The results in Table 14 show that there is a significant main effect among performance groups for decision-making time in the Testing Phase ($F(2, 59) = 3.432$, $p < .05$) and a significant interaction effect for information processing time in the Practice Phase between performance and treatment groups (F (2, 59) = 3.640, p <.05). The results for the post hoc test show that high performance groups spent significantly less time on decision-making than the low performance group in the Testing Phase (p = .034).

Table 14

Information Processing Time among Children Treatment and Performance Groups

Variable	Source	*SS*	*df*	*MS*	*F*	*Sig.*	Post hoc Tukey HSD
Performance							
	Learning	5.984	2	2.992	2.827	.067	
	Practice	1.650	2	.825	2.530	.088	
	Testing	2.575	2	1.287	3.432	.039	High-Low*
Treatment							
	Learning	.509	1	.509	.481	.491	
	Practice	.150	1	.150	.461	.500	
	Testing	.176	1	.176	.468	.496	
Performance * Treatment	Learning	3.420	2	1.710	1.616	.207	
	Practice	2.374	2	1.187	3.640*	.032	
	Testing	.408	2	.204	.544	.584	

* p < .05.

The data in Figure 21 show that high performance group spent the least amount of time to process information in all three phases in the Explicit Instruction Treatment.

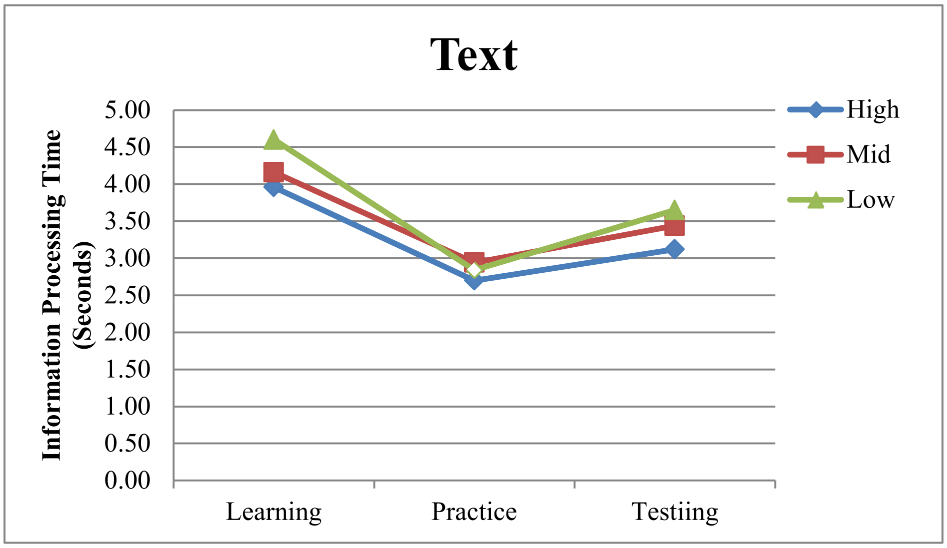

Figure 21. Information processing time of children in the Explicit Instruction Treatment.

The data in Figure 22 show that the low performance group spent the longest information processing time in all three phases in the Implicit Learning Treatment.

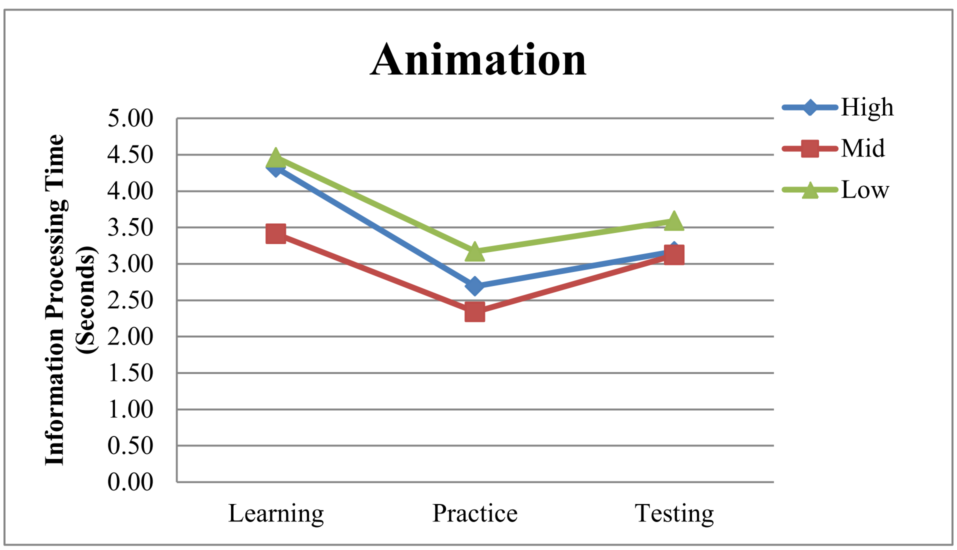

Figure 22. Information processing time of children in the Implicit Learning Treatment.

Learner Strategies

Learner strategies of this study included Second Language Acquisition strategies and cognitive strategies.

SLA and cognitive strategies. Learners apply Second Language Acquisition strategies to map linguistic form with meaning; while learners use cognitive (mental/logical) strategies to solve cognitive problems. The Qualtrics survey elicited learners' preferences on SLA and cognitive strategies. Again, a two-way mixed factorial MANOVA was used to examine whether three performance groups of either adult or child learners in different treatments applied second language acquisition (SLA) or cognitive strategies differently.

Adults' SLA strategies. The descriptive data in Table 15 show that the Phonological Processing Strategy was the most popular SLA strategy chosen by all three adults' performance groups; while the Syntactical Strategy was the least chosen strategy among all performance groups. The learners in the Implicit Learning Treatment selected Syntactical Strategy less frequently than did the learners in the Explicit Instruction Treatment.

Table 15

The SLA Strategies Employed among Adults' Groups

Strategies/Groups		*n*	*Frequency*	%	*SD*
Phonological Processing Strategy					
High Group	EIT	13	55	8.44	.161
	ILT	12	53	8.13	.133
Mid Group	EIT	12	47	7.21	.113
	ILT	12	55	8.44	.157
Low Group	EIT	13	47	7.21	.156
	ILT	12	48	7.36	.209
Meaning-Based Strategy					
High Group	EIT	13	55	8.44	.206
	ILT	12	39	5.98	.097
Mid Group	EIT	12	42	6.44	.132
	ILT	12	42	6.44	.132
Low Group	EIT	13	53	8.13	.127
	ILT	12	41	6.29	.122
Syntactical Strategy					
High Group	EIT	13	21	3.22	.139
	ILT	12	3	.46	.068
Mid Group	EIT	12	20	3.07	.098
	ILT	12	3	.46	.050
Low Group	EIT	13	17	2.61	.104
	ILT	12	11	1.84	.136

Figure 23 shows that the high performance group in the Explicit Instruction Treatment used SLA strategies, phonological processing and meaning-based strategies, equally frequently.

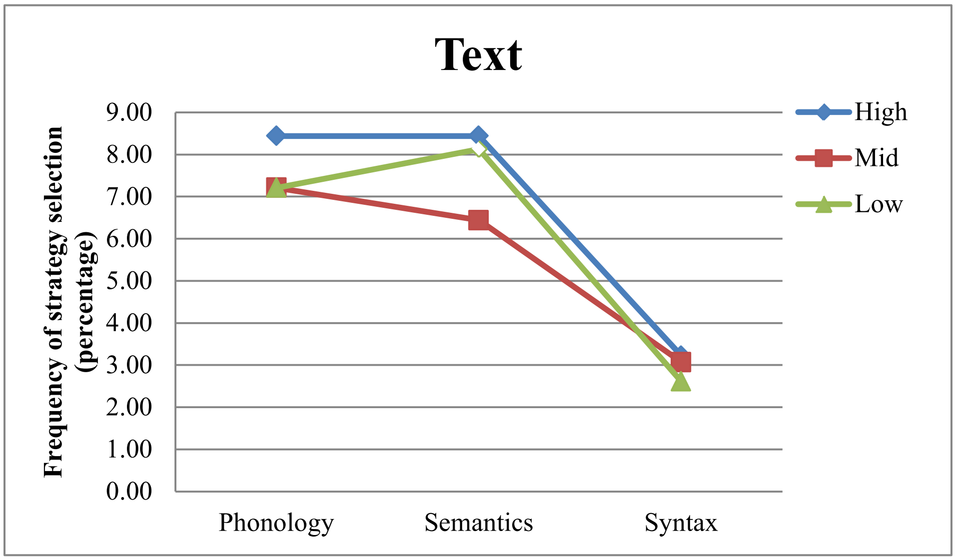

Figure 23. Adults' selection of SLA strategies in the Explicit Instruction Treatment.

Figure 24 shows that all three performance groups in the Implicit Learning Treatment demonstrated similar patterns of SLA strategy selection.

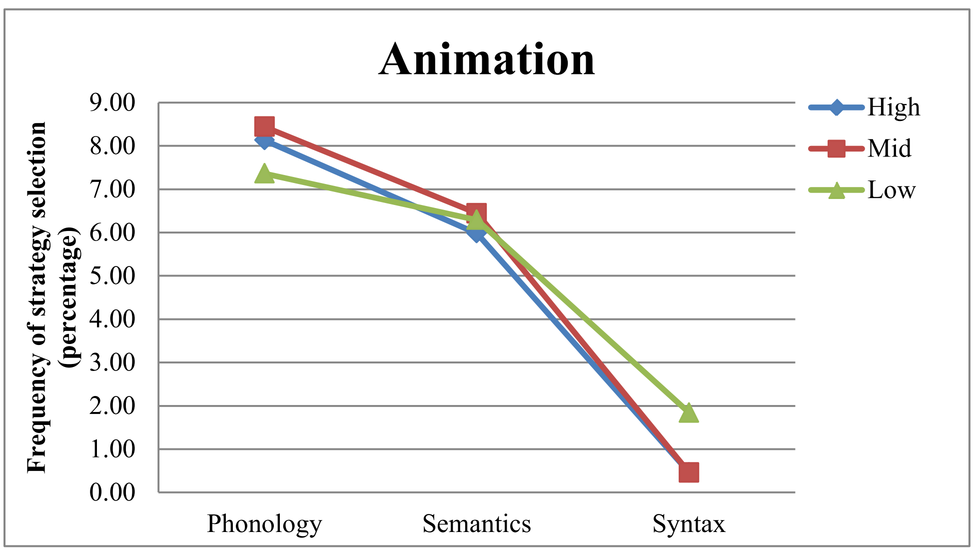

Figure 24. Adults' selection of SLA strategies in the Implicit Learning Treatment.

Table 16 shows that there was no significant difference among adult performance groups (p = .391) or treatments (p = .202) on selecting Phonological Processing as an SLA strategy, but there was a significant main effect between the subjects in the EIT and ILT groups (F (1, 68) = 22.693, p <.001) on selecting Syntactical Strategy as an SLA strategy.

Table 16

The SLA Strategies Employed among Adults' Groups

Variable	*SS*	*df*	*MS*	*F*	*Sig.*
Performance					
Phonological Processing	.047	2	.024	.952	.391
Meaning-Based	.043	2	.006	.316	.730
Syntactical	.006	2	.003	.257	.774
Treatment					
Phonological Processing	.041	1	.041	1.656	.202
Meaning-Based	.071	1	.071	3.589	.062
Syntactical	.250	1	.250	22.693	.000
Performance * Treatment					
Phonological Processing	.009	2	.005	.187	.830
Meaning-Based	.040	2	.020	1.001	.373
Syntactical	.050	2	.025	2.271	.111

* $p < .05$. ** $p < .01$.

Adults' cognitive strategies. A MANOVA was again used to examine whether three performance groups of adults select cognitive strategies differently. The descriptive data in Table 17 show that the most frequently selected cognitive strategies among the adults' high performance groups were Noticing and Guessing and the last strategy being chosen by the same groups was Repetition.

Table 17

The Cognitive Strategies Employed among Adults' Groups

Strategies/Groups			*n*	Frequency	%	*SD*
Elimination						
	High Group	EIT	13	4	.87	.105
		ILT	12	4	.87	.084
	Low Group	EIT	13	9	1.97	.185
		ILT	12	5	1.09	.112
Guessing						
	High Group	EIT	13	28	6.11	.202
		ILT	12	33	7.21	.144
	Low Group	EIT	13	25	5.46	.185
		ILT	12	28	6.11	.164
Noticing						
	High Group	EIT	13	20	4.37	.251
		ILT	12	41	8.95	.240
	Low Group	EIT	13	31	6.77	.226
		ILT	12	33	7.21	.190
Repetition						
	High Group	EIT	13	0	.00	.000
		ILT	12	0	.00	.000
	Low Group	EIT	13	0	.00	.000
		ILT	12	4	.87	.108
Prediction						
	High Group	EIT	13	12	2.62	.220
		ILT	12	7	1.53	.151
	Low Group	EIT	13	13	2.84	.152
		ILT	12	10	2.18	.171

The results in Table 18 show that there were no significant differences among adult performance groups selecting cognitive strategies, but there was a significant difference between treatment groups on selecting Noticing as their cognitive strategy (F (1, 68) = 12.361, p =.001).

There was also an interaction between performance and treatment groups on selecting Repetition as their cognitive strategy (F (2, 68) = 3.498, p =.036).

Table 18

The Cognitive Strategies Employed among Adults' Groups

Variable		*SS*	*df*	*MS*	*F*	*Sig.*
Performance						
	Elimination	.024	2	.012	.880	.419
	Guessing	.045	2	.022	.711	.495
	Noticing	.021	2	.010	.179	.837
	Repetition	.013	2	.006	1.181	.313
	Prediction	.013	2	.006	.199	.820
Treatment						
	Elimination	.003	1	.003	.258	.613
	Guessing	.078	1	.078	2.481	.120
	Noticing	.713	1	.713	12.361	.001
	Repetition	.000	1	.000	.000	1.000
	Prediction	.014	1	.014	.447	.506
Performance * Treatment						
	Elimination	.010	2	.005	.370	.692
	Guessing	.016	2	.008	.251	.779
	Noticing	.128	2	.064	1.107	.336
	Repetition	.038	2	.019	3.498	.036
	Prediction	.010	2	.005	.153	.859

Figure 25 shows that Repetition was the last chosen cognitive strategy among three performance groups in the Explicit Instruction Treatment.

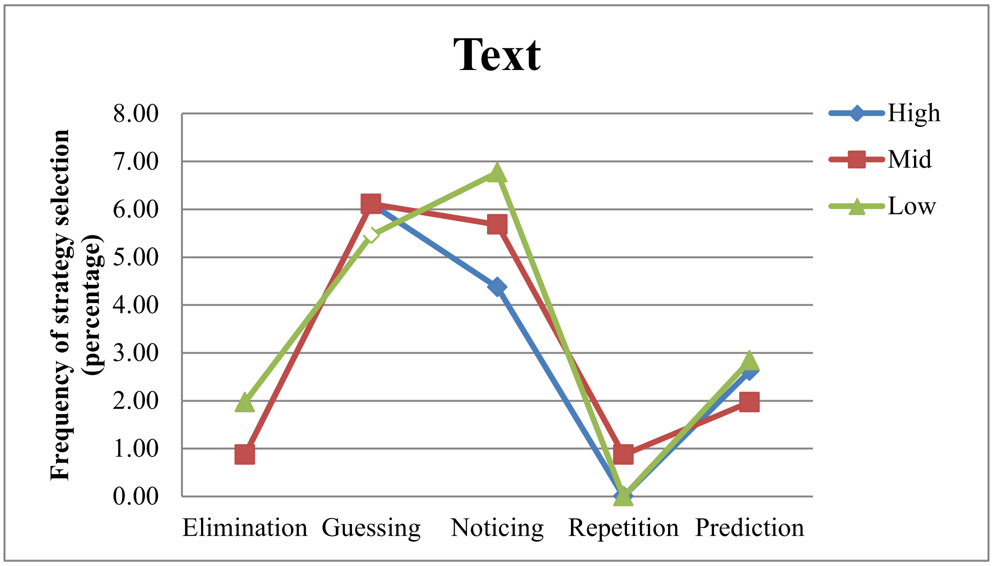

Figure 25. Adults' selection of cognitive strategies in the Explicit Instruction Treatment.

Figure 26 shows similarity in the patterns of cognitive strategy selection compared with the Explicit Instruction Treatment.

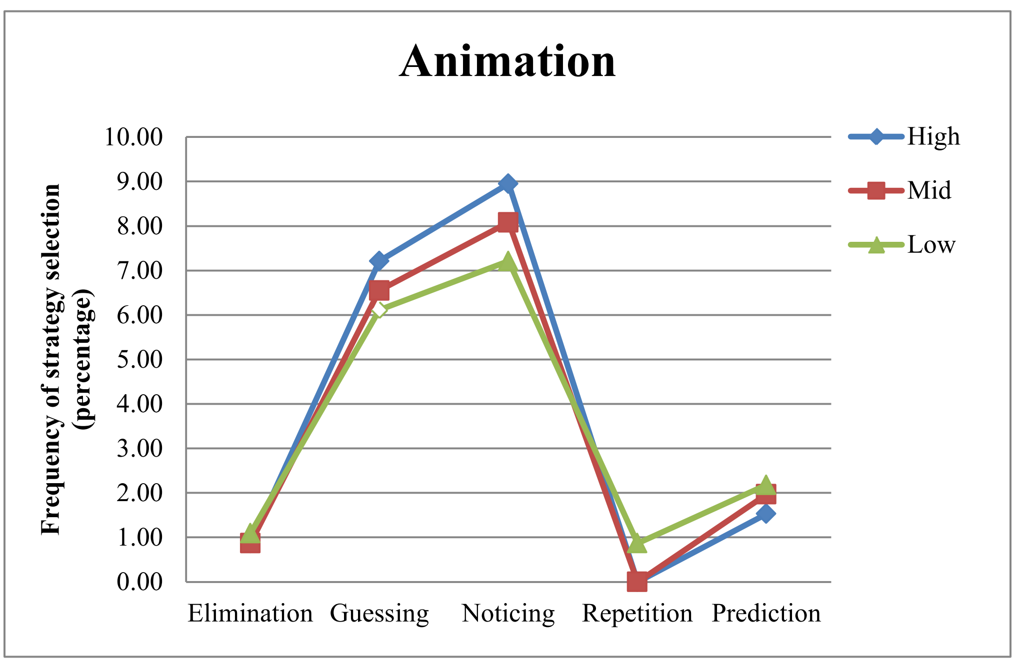

Figure 26. Adults' selection of cognitive strategies in the Implicit Learning Treatment.

Children's SLA strategies. Table 19 shows that in both treatments the SLA strategy that most successful children select was Phonological Processing Strategy.

Table 19

The SLA Strategies Employed among Children's Groups

Strategies/Groups		*n*	Frequency	%	*SD*
Phonological Processing Strategy					
High Group	EIT	11	37	6.56	.114
	ILT	11	42	7.45	.217
Mid Group	EIT	11	29	5.14	.143
	ILT	11	29	5.14	.161
Low Group	EIT	11	22	3.90	.121
	ILT	10	19	3.37	.175
Meaning-Based Strategy					
High Group	EIT	11	38	6.74	.177
	ILT	11	40	7.09	.189
Mid Group	EIT	11	39	6.91	.162
	ILT	11	42	7.45	.174
Low Group	EIT	11	43	7.62	.129
	ILT	10	38	6.74	.128
Syntactical Strategy					
High Group	EIT	11	20	3.55	.146
	ILT	11	22	3.90	.198
Mid Group	EIT	11	27	4.79	.142
	ILT	11	20	3.55	.128
Low Group	EIT	11	28	4.96	.133
	ILT	10	29	5.14	.062

The Levene test shows that the only two strategies that have strong homogeneity of variances were Phonological Processing Strategy (p = .243) and Meaning-Based Strategy (p = .478). The results in Table 20 show that there was no significant difference between treatment groups on SLA strategies that children chose, but there was a significant difference among performance groups when children chose Phonological Processing Strategy as their second language strategy (F (2, 59)= 7.174, p =.002). The post hoc test showed that children in the high performance group used Phonological Processing Strategy significantly more frequently than in the low performance group (p =.001).

Table 20

The SLA Strategies Employed among Children's Groups

Variable	*SS*	*df*	*MS*	*F*	*Sig.*	Post hoc Tukey HSD
Performance						
Phonological Processing	.363	2	.181	7.174	.002	High-Low**
Meaning-Based	.012	2	.006	.231	.794	
Syntactical	.090	2	.045	2.242	.115	
Treatment						
Phonological Processing	.003	1	.003	.130	.720	
Meaning-Based	.003	1	.003	.100	.753	
Syntactical	.000	1	.000	.009	.924	
Performance * Treatment						
Phonological Processing	.012	2	.006	.247	.782	
Meaning-Based	.006	2	.003	.105	.901	
Syntactical	.037	2	.019	.920	.404	

* $p < .05$, ** $p < .01$.

The data in Figure 27 and Figure 28 show the same pattern among three performance groups between EIT and ILT groups when children selected Phonological Processing Strategy as their SLA strategy.

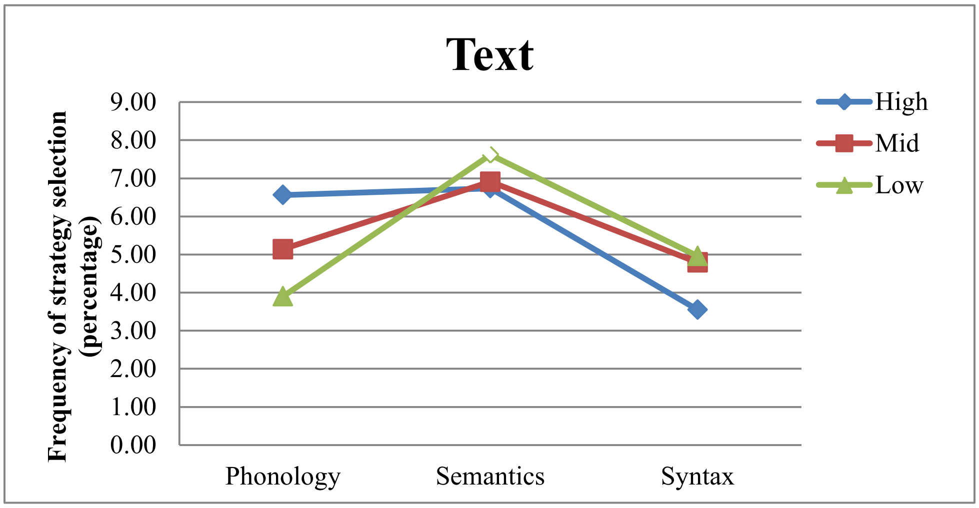

Figure 27. Children's selection of SLA strategies in the Explicit Instruction Treatment.

The data in Figure 28 show that the high performance group in the ILT group chose Phonological Processing more frequently than in the EIT group.

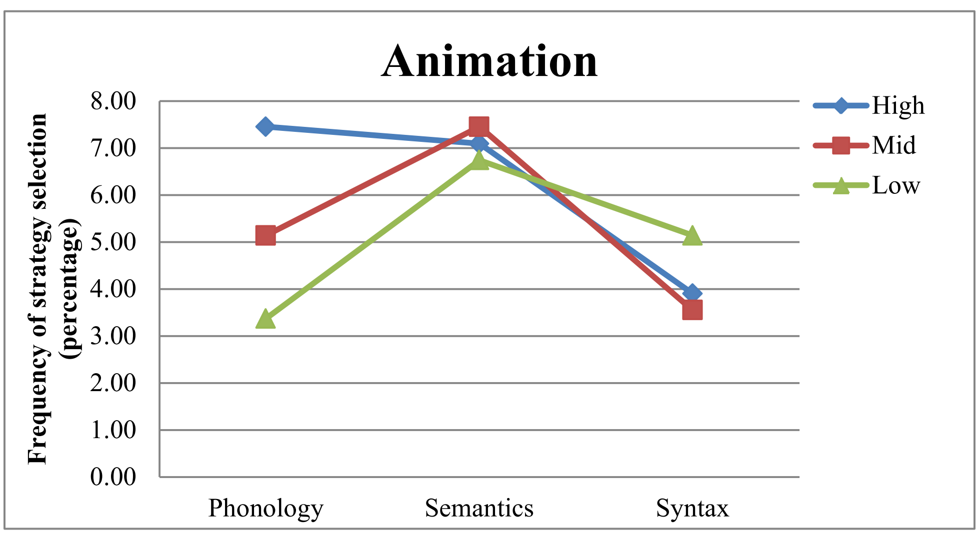

Figure 28. Children's selection of SLA strategies in the Implicit Learning Treatment.

Children's cognitive strategies. The descriptive data in Table 21 show that the cognitive strategy that successful children chose was Guessing; and the least chosen strategy between the treatment groups and among the performance groups was Repetition.

Table 21

The Cognitive Strategies Employed among Children Groups

Strategies/Groups			*n*	*Frequency*	*%*	*SD*
Elimination						
	High Group	EIT	11	10	2.43	.137
		ILT	11	0	.00	.000
	Low Group	EIT	11	2	.49	.069
		ILT	10	12	2.92	.130
Guessing						
	High Group	EIT	11	31	7.54	.125
		ILT	11	39	9.49	.172
	Low Group	EIT	11	29	7.06	.188
		ILT	10	20	4.87	.135
Noticing						
	High Group	EIT	11	21	5.11	.173
		ILT	11	17	4.14	.263
	Low Group	EIT	11	19	4.62	.183
		ILT	10	15	3.65	.161
Repetition						
	High Group	EIT	11	2	.49	.069
		ILT	11	1	.24	.051
	Low Group	EIT	11	11	2.68	.211
		ILT	10	9	2.19	.145
Prediction						
	High Group	EIT	11	6	1.46	.156
		ILT	11	4	.97	.112
	Low Group	EIT	11	11	2.68	.197
		ILT	10	8	1.95	.926

The Levene test showed that the only strategies that have strong homogeneity of variances are Guessing and Noticing. Due to the fact that the Levene test rejected the null hypothesis on equal population standard deviation on Repetition (*p*=.013), Guessing is the only strategy that is significantly different among performance groups (Table 22).

Table 22

The Cognitive Strategies Employed among Children Groups

Variable	*SS*	*df*	*MS*	*F*	*Sig.*
Performance					
Elimination	.028	2	.014	1.411	.252
Guessing	.226	2	.113	3.367*	.041
Noticing	.025	2	.013	.310	.735
Repetition	.230	2	.115	4.641*	.013
Prediction	.466	2	.233	1.477	.237
Treatment					
Elimination	.008	1	.008	.763	.386
Guessing	.002	1	.002	.047	.828
Noticing	.002	1	.002	.061	.806
Repetition	.005	1	.005	.001	.982
Prediction	.043	1	.043	.274	.603
Performance * Treatment					
Elimination	.285	2	.143	14.421*	.000
Guessing	.149	2	.075	2.222	.117
Noticing	.046	2	.012	.559	.575
Repetition	.008	2	.004	.158	.854
Prediction	.218	2	.109	.689	.506

The data in Figure 29 show that among all three performance groups in the Explicit Instruction Treatment, the frequency of selecting each cognitive strategy is similar.

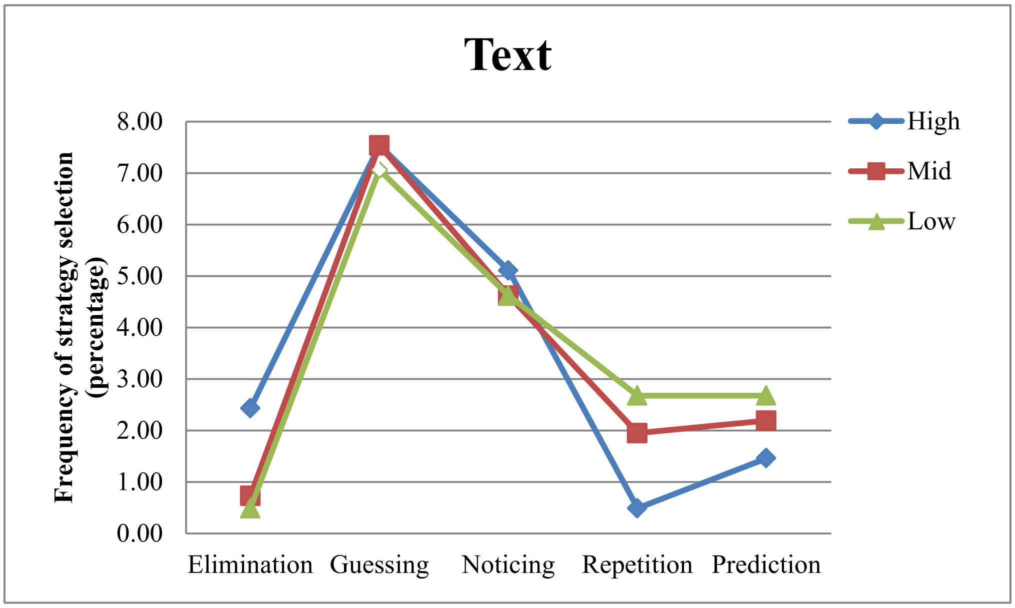

Figure 29. Children's selection of cognitive strategies in the Explicit Instruction Treatment.

The data in Figure 30 show that the high performance group tended to select one unique cognitive strategy while the low performance group selected each of the cognitive strategies with nearly equal frequency.

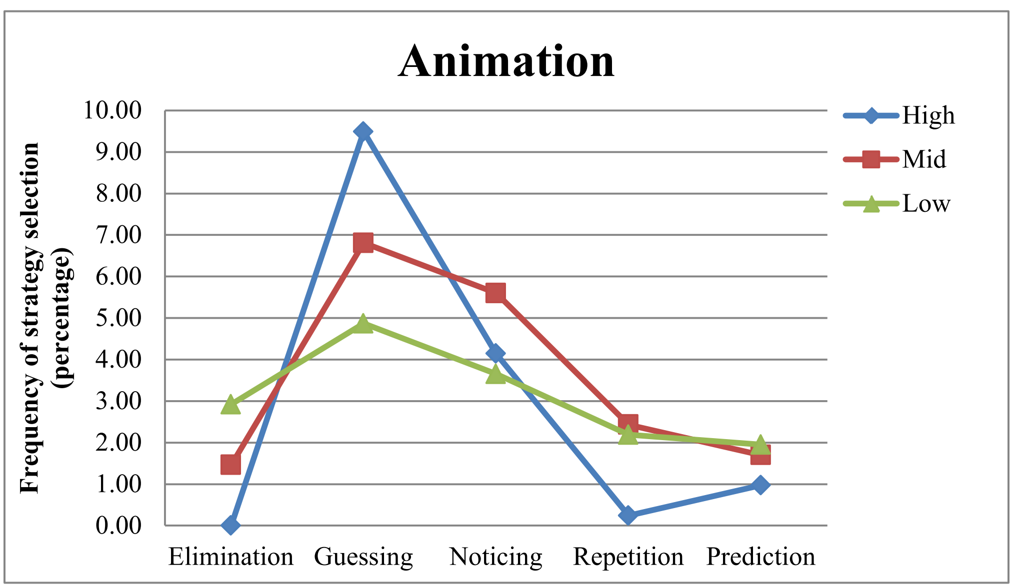

Figure 30. Children's selection of cognitive strategies in the Implicit Learning Treatment.

Prediction of successful learners' learning model. The main purpose of this study was to identify which learning behaviors and strategies[12] predicted the learner performance.

Adults' learning model. A stepwise multiple regression analysis was performed to partial out the effects of age, previously studied foreign languages, and language proficiency of the demographic characteristics to examine which areas were the best predictors of overall adults' test scores. Variables that explain adults' total scores, such as information processing time and learning strategies were entered.

Table 23 shows the Pearson's correlation matrices among factors that affected adult performance. The total scores were strongly correlated with the information processing time in

[12] The data collected from learning (SLA and cognitive) strategies were the number of times selected for each category. The learners were asked to choose the answers that most represent their thinking from four answer options (formulated from previously conducted *Think-Aloud Protocol*). The answer options were encoded into three types of SLA strategies and five types of cognitive strategies and were rated by four linguistic students at BYU. The maximum frequency appeared in the answer options for each type of SLA strategy was nine and the maximum frequency for each type of cognitive strategy was six. To ensure that the distributions of two types of strategies—SLA and cognitive—were homogeneous, the frequency of each SLA or cognitive strategies had been divided by the total possible number of that category and transformed into percentage.

Table 23

Pearson's Correlation among Adults' Performance

	Total	Lis1	Lis2	Vocab	Age	LT	PT	TT	Ph	Sm	Stx	E	G	N	R	P
Total	1.000															
Lis1	.427**	1.000														
Lis2	.567**	.255**	1.000													
Vocab	.969**	.304**	.370**	1.000												
Age	-.086	-.204	-.085	-.052	1.000											
LT	.310**	.114	.189*	.299**	-.259*	1.000										
PT	.151	.173	.131	.127	-.160	.347**	1.000									
TT	-.064	-.046	-.382**	.031	-.027	.212	.579**	1.000								
Ph	.183	-.037	.108	.191	.103	-.043	-.177	-.207	1.000							
Sm	.061	-.104	.075	.065	.208	.127	.080	-.118	-.070	1.000						
Stx	-.040	-.119	-.083	-.009	-.198	.271*	.215	.059	-.555**	.203	1.000					
E	-.154	.192	-.044	-.194	-.014	-.090	.186	.218	-.236*	-.322**	-.030	1.000				
G	.095	-.004	.079	.091	.053	-.066	-.063	.062	.093	-.176	-.145	-.1296	1.000			
N	-.025	.170	-.042	-.040	-.110	-.139	.052	.220	-.246*	-.692**	-.323**	.222	.073	1.000		
R	-.327**	.021	-.137	-.351**	.036	-.271*	-.179	-.038	-.130	-.153	-.029	.078	-.103	.082	1.000	
P	-.061	-.103	-.106	-.030	-.040	.114	-.026	.001	-.128	.181	.158	-.102	-.797**	-.166	-.101	1.000

Column group heading (spanning Vocab through N): Factors that Affect Adults' Performance

Note. LT = Learning Time per Click; PT = Practice Time per Click; TT = Testing Time per Click; Ph = Phonology; Sm = Semantics Stx = Syntax; E = Elimination; G = Guessing; N = Noticing; R= Repetition; P = Prediction

$^{*}p < .05$, $^{**}p < .01$, one-tailed.

the Learning Phase, *r* =.310, *p* =.007; and strongly negatively correlated with the Repetition Strategy selection, *r* = -.327, *p* =.004. In addition, among all the predictors, Guessing Strategy is strongly negatively correlated with the Prediction Strategy (*r* = -.797, p<.001), from which the issues of collinearity arose—students who selected Guessing were less likely to select Prediction as another cognitive strategy. Fortunately, with only the one exception mentioned above, the correlation among the rest of the independent variables was lower than .75. Since stepwise multiple regression statistics were used, there were no collinearity issues found in the tolerance, variance inflation factor (VIF), condition index (CI), or eigenvalue tests.

The results in Table 24 show that Repetition Strategy predicted learners' total scores (β = -.263, *p* <.05) as well as their information processing time in the Learning Phase (β = .239, *p* <.05). The Repetition Strategy and information processing time in the Learning Phase contributed 16.0% of the variation in the students' total scores (*F* (2, 70) = 6.763, *p* <.05).

Children's learning model. A stepwise regression analysis was performed for children. Table 25 shows the Pearson's correlation matrices among factors that affect children's performance. The mean total scores of Listening Test One and Two, and Vocabulary test were strongly positively correlated with the SLA strategy—Phonological Processing, *r* =.442, *p* <.001, and cognitive strategy—zGuessing, *r* = .293, *p* =.018. On the other hand, the total score was negatively correlated with the cognitive strategy—Repetition, *r* = -.314, *p* =.011, SLA strategy—Syntactical Strategy, *r* = -.293, *p* =.018, decision making time in the Testing Phase, *r* = -.278, *p* =.025, and cognitive strategy—Prediction, *r* = -.364, *p* =.003.

Table 24

Summary of Stepwise Multiple Regression for the Overall Adults' Performance, Strategies, and Behaviors

Variable entered	*R*	R^2	*R* square change	B	Standardized coefficient *Beta*	*F*	*t*
Constant				275.397			
Strategy							
Repetition	.327	.107	.107	-50.412	-.263	8.650	-2.325*
Processing Time	.400	.160	.053	2.466	.239	6.763	2.112*
Learning Time							

$^{*}p < .05$

The results showed that child learners used Phonological Processing Strategy to connect form with meaning, and they used Guessing strategy more frequently to solve problems. The results also showed that successful child learners spent less time on decision making in the Testing Phase than adults. Similarly to adults, however, if children selected Repetition as their strategy less frequently, they received better scores. Furthermore, when children avoided selecting Syntactical Strategy and selecting Prediction as their cognitive strategy, they received a better score. In line with other findings of adult learners, the SLA strategy, Phonological Processing, was strongly positively correlated with the vocabulary test, *r* = .370, *p* =.002. In

Table 25

Pearson's Correlation among Children's Performance

	Factors that Affect Children's Performance														
	Total	Lis1	Lis2	Vocab	LT	PT	TT	Ph	Sm	Stx	E	G	N	R	P
Total	1.000														
Lis1	.599**	1.000													
Lis2	.753**	.307*	1.000												
Vocab	.915**	.294*	.587**	1.000											
LT	-.072	-170	-.192	.050	1.000										
PT	-.155	-.088	-.276*	-.082	.462**	1.000									
TT	-.278*	-.232	-.334**	-.173	.519**	.636**	1.000								
Ph	.442**	.236	.454**	.370**	-.024	.010	.004	1.000							
Sm	-.070	.189	-.022	-.189	-.041	-.005	.101	.175	1.000						
Stx	-.293*	-.162	-.312*	-.239*	.308*	.226	.179	-.562**	-.325**	1.000					
E	-.164	-146	-.209	-.093	-.124	.016	-.073	-.149	-.299*	-.021	1.000				
G	.293*	-.054	.312*	.344**	.212	-.053	-.121	.248*	-.408**	.053	-.239	1.000			
N	.106	-.066	.060	.168	-.138	-.142	-.194	-.395**	-.445**	-.007	.059	.009	1.000		
R	-.314*	-.165	-.332**	-.261*	-.044	-.008	.117	-.348**	-.038	.000	.138	-.409**	-.052	1.000	
P	-.364**	-.201	-.306*	-.329**	-.171	-.040	-.051	-.347**	.023	.042	.081	-.343**	.044	.153	1.000

Note. LT = Learning Time per Click; PT = Practice Time per Click; TT = Testing Time per Click; Ph = Phonology; Sm = Semantics Stx = Syntax; E = Elimination; G = Guessing; N = Noticing; R= Repetition; P = Prediction

* $p < .05$, ** $p < .01$, one-tailed.

addition, the correlation among all the independent variables was lower than .75 and no collinearity issue was found. Since stepwise multiple regression statistics were used, there were no collinearity issues found in the tolerance, variance inflation factor (VIF), condition index (CI), or eigenvalue tests.

When the multiple regression analysis was performed for children, the variables were entered into the stepwise regression equation following the same sequence as adults. The results in Table 26 show that the Phonological Processing Strategy predicted learners' total scores (β =.354, p <.01) as well as decision-making time in the Testing Phase (β = -.293, p <.01) and Prediction strategy (β = -.256, p <.05). The SLA strategy—Phonological Processing, decision-making time in the Testing Phase, and cognitive strategy—Prediction contributed 33.1 % of the variations in the students' total scores (F (3, 61) = 10.076, p <.001).

Table 26

Summary of Stepwise Multiple Regression for the Overall Children's Performance, Strategies, and Behaviors

Variable entered	R	R^2	R square change	B	Standardized coefficient *Beta*	F	t
Constant				268.067			
Strategy							
Phonological Processing	.442	.195	.195	70.354	.354	15.303	3.175**
Processing Time							
Testing Time	.523.	.274	.078	-15.774	-.293	11.687	-2.790**
Strategy							
Prediction	.576	.331	.058	-21.963	-.256	10.076	-2.292*

$^{*}p < .05$, $^{**}p < .01$

Chapter 5: Conclusions

Overview of Study

The purpose of this study was to explore the main effects and interaction effects of two instructional approaches on the language proficiency of adults and children and to investigate whether there is a difference on language processing time and on preferred strategies between adults and children. The software used in this study had been designed to allow comparison between two parallel online programs using the same material and instructional sequence for learners who have never learned Chinese. I will begin this chapter by first summarizing the empirical findings of the research, and then turn to the general theoretical issues that are related to these findings.

Main Findings

The main findings of this study include the following areas: Test scores, behaviors, and strategies.

Test scores. The first question that this study aimed to answer was: What are the main effects and interaction effects of the two instructional treatments—Implicit Learning Treatment (ILT) and Explicit Instruction Treatment (EIT) on the language learning outcome of male and female adults and children as implemented in a multimedia language learning environment? The results showed that adults significantly outperformed children on all measures of learning outcomes. We also learned that students who participated in the EIT group outperformed those in the ILT group. However, there was no interaction between maturity and treatment factors.

These findings were not surprising, given the cognitive factors described in Chapter 2. First, we learned there that when children are accustomed to thinking in a language and thus ignore the primitive conceptual information, the ability to discriminate the attributes of objects (discriminative ability) is still available and can be invoked under certain situations (Clark, 2004). The first hypothesis of this study suggested that when children learn their first language, they use their discriminative ability to map the forms with meanings; likewise, since this discriminative ability does not disappear when children learn their second language, they may use the same ability to map the L2 forms with meanings. It is also possible that when children map the L2 forms with meanings, they may ignore the primitive discriminative ability, and directly map the L2 forms (text and sound) onto the L1 forms instead.

The assumption of the study design was that the activities in the ILT simulated the L1 acquisition environment that children typically apply and those in the EIT simulated the L2 acquisition environment that adults typically apply. The learners in each treatment naturally applied the default strategies fostered by study treatment. Therefore, if children in the EIT group were to outperform the children in the ILT group on all three tests, this would suggest that more children apply adults' L2 acquisition strategy to directly map the forms of L2 with L1. This study showed that children in the EIT group did perform significantly better than children in the ILT group. Thus, we can conclude that at the age of 11 and 12, children start to apply the adults' L2 acquisition strategy to connect the forms of L2 to L1 directly.

We also confirmed that adults have high potential to develop advanced strategies to simultaneously incorporate various rules into the acquisition process, allowing for integration of new information into their cognitive structure, whereas children's abilities are less developed in this area. Based on the connectionist model (Hulstijn, 2003) introduced in Chapter 2, adults are capable of completing several cognitive/L2 tasks at the same time and making inferences about the relationship among conceptual nodes fairly accurately. Children, however, pay close attention to the task at hand in order to familiarize themselves with the linguistic features of the L2, accumulate exemplars of the target language, and automatize their ability to improve their information processing speed. Therefore, although the Implicit Learning Treatment required learners to use more complex linguistic strategies to decode meanings of words and to analyze syntactic patterns, a more challenging task than the Explicit Instruction Treatment, the adult groups in the ILT group still outperformed the children in the EIT group. This suggests that learner performance was deeply affected not only by cognitive maturity but also by the efficacy of encoding and retrieving information, regardless of the complexity of the task.

Secondly, in Chapter 2 we learned that when children try to understand the world, they tend to seek the clues that can help them verify hypotheses about unfamiliar things (i.e., they perform a problem-solving task). Smith (1975) proposed that while receiving new information, children have to select among a limited set of alternatives (e.g., sound and meaning associations that are already known) to answer their cognitive questions. Stated in other terms they employ a Guessing Strategy, as defined in Chapter 1. In addition, Ausubel (1978) proposed that meaningful learning was defined as "relating the new material non-arbitrarily and substantively to a learner's cognitive structure and that the material learned be potentially meaningful to him or her—namely, relatable to his or her structure of knowledge on a non-arbitrary and non-verbatim basis" (p. 41). A key hypothesis for this study was that if the participants could incorporate meaningful learning on the problem-solving task during the treatment, they would be able to answer the questions in the vocabulary test. For the participants in the EIT group to outperform the participants in the ILT group suggests that the EIT is more effective because it allows learners to verify their hypotheses about the learning task. The finding of this study showed that the participants in the EIT group did perform significantly better than the participants in the ILT group. This suggests that the EIT promoted meaningful learning more effectively than did the ILT.

On the other hand, one of the possible explanations of why the participants in the implicit learning treatment were less successful is that the participants might have had too many possible alternatives in trying to elicit the distinctive features among sounds, animations, texts, and meanings between slides. Despite multiple repetitions, the participants in the ILT group still could not verify their cognitive hypotheses and register the form-meaning mapping nodes (exemplars) as accurately as the participants in the EIT group.

Behaviors. The second research question investigated which behaviors are exhibited by the most successful adult and child learners. The results showed that in the Learning Phase, the most successful adults spent significantly more information processing time than the low performance group. A partial explanation for this outcome may lie in the fact that successful adults spent more time than the low performance group to ensure that the new concept had been accurately formulated and that the route to retrieve the information had been identified. These results lend support to the dual channel assumption introduced in Chapter 2. The dual channel assumption suggests that only a limited amount of cognitive processing can take place in either the verbal channel or the visual channel at any one time. If the learning task exceeds the processing capacity, learners may not have enough time to engage in the deeper processes of organizing and integrating the models in long-term memory (Mayer and Moreno, 2003). This also implies that while receiving new information the first time, the learners need to spend a longer time selecting, organizing, and integrating the information. If learners spend enough time integrating new information into their long-term memory, they will perform well.

An additional finding of this research question showed that the most successful children spent significantly less decision-making time than less successful children in the Testing Phase. This is in complete agreement with Mayer's and Moreno's (2003) dual channel assumption, which implies that while the information is salient to learners' experience and is well-integrated into their long-term memory, they might have extra capacity to withdraw it quickly and accurately. This may explain why successful children spent shorter time making their decisions.

Strategies. The purpose of the second part to the second research question was to determine which specific learning strategies were used by the most successful adult and child learners. The results of the analyses showed that the second language acquisition strategy most frequently used by the successful adult learners was Phonological Processing. In addition, the most popular cognitive strategies were Guessing and Noticing. For the most successful child learners, Phonological Processing was also the most popular SLA strategy and the most popular cognitive strategy was also Guessing. Interestingly, there was no significant difference among adults' performance and treatment groups in selecting Phonological Processing as their SLA strategy. This may well explain why beginning adult learners in either EIT or ILT group, independent of their performance on the three tests, relied heavily on distinguishing acoustic features to associate the form with meaning for a new language. On the other hand, for beginning child learners, there was a significant difference among performance groups (i.e., high, mid, low), which may indicate that successful children, like cognitively well-developed adults, pay more attention to acoustic features when mapping the linguistic form with meaning; while less successful children may not know how to use the simplest and most effective strategies—phonological cues—to decode the meaning.

Test score prediction. To determine the relationship between learning behavior or strategy and learning outcome, two stepwise multiple regressions were performed. The results for both adults and children showed that the variables of information processing time and learning strategies were reliable predictors of the total scores. Adult learners who spent longer time analyzing new information in the Learning Phase and who chose the Repetition Strategy less frequently as their cognitive strategy scored higher on the listening and vocabulary tests. The finding for adults contradicts what is generally accepted as the value of "repetition." That is, most scholars believe that the more repetition one encounters, the stronger associations among exemplars can be built, thus resulting in better performance (Ellis, 2002, 2003; Bybee, 2006).

This study provided an alternative view of repetition. In other words, mere repetition without higher task-induced integration did not help strengthen the linkage between L2 forms and their meanings. The meaningful repetition introduced by connectionist theories refers to myriad incidental encounters in various learning contexts over time (Gatbonton & Segalowitz, 2005). "Indeed, some researchers suggest that repetition is meaningful when it is embodied in activities that involve multiple instances of a lexical item or a grammatical construction in various contexts, all of which include tools to help the learner comprehend the new language they encounter" (p. 2). Per the results of this study, if time does not permit a great quantity of various types of exposures, then the strategy of taking a little time to analyze the limited sets of distinctive features among variables may be a more effective way to master form to meaning connection tasks than simple repetition.

On the other hand, child learners who frequently selected Phonological Processing and less frequently selected Prediction[13] as their SLA and cognitive strategies and who spent less decision-making time on each test question in the Testing Phase received higher scores. This finding is in accord with previous findings of children's information processing time and strategy selection which could possibly explain why after children frequently applied phonetic cues to solve problems in the Practice Phase, they spent less time on decision making in the Testing

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[13] Among all the predictors, Guessing Strategy is strongly negatively correlated with the Prediction Strategy. In other words, students who selected the Prediction Strategy less frequently indicated high Guessing Strategy selection. This result is entirely consistent with the views of both Vygotsky and Smith's.

Phase and scored higher on all tests. This echoes Vygotsky's and Smith's observations. Vygotsky (1986) explained that children must determine what information to attend to and what information to ignore to make the "sounds" understandable to decode "meaning." Smith (1975) also explained that when children receive new information, they have to select among limited sets of alternatives (linguistic elements) from that utterance to pair the meaning with the sound, based on what they already know. If children fail to verify their hypotheses, they may be inundated with "noise" (p. 45). Therefore, based on Vygotsky's and Smith's theories, we may conclude that when children learn a new language, they go through a series of "sound" meaning-guessing processes. That is, if children apply the Phonological Processing Strategy more frequently, they have a higher tendency to derive the meaning correctly.

The findings of this study provide empirical evidence to support the views of both Vygotsky and Smith.

Additional Findings

The additional findings of this study include the following areas: Test scores and behaviors.

Three tests of learning outcomes. The scores of two listening comprehension tests measured the construct of acquisition of 29 chunks of L2 sounds. The vocabulary application test score reflected the ability to decode L2 syntactic patterns, to re-formulate grammatically correct sentences, and to translate the meanings of re-organized L2 sentences into L1, and vice versa. It was hypothesized that if learners could decode the meaning of the sounds of words in the listening comprehension tests, they would be able to use this phonological knowledge to tackle syntactical issues in the vocabulary application test later. The analysis of the data in Appendix 5 showed that in adult and child groups, the listening test scores were highly correlated with vocabulary test scores.

Behaviors. This section of the treatment measured the information processing time in the Learning and Practice Phases and decision-making time in the Testing Phase. The results showed that, in the Learning Phase, adult participants in the EIT group spent significantly longer time than those in the ILT group. However, there was no significant difference on information processing time between treatments in the children's group. One of the explanations may be that while directly comparing L1 and L2 forms, adult learners tended to pay attention to the details—comparing morphological, phonological, and syntactical features between two languages, memorizing the grammar explanation, attending to the word boundaries and the orthography of L2, and contrasting the meanings between correct translation and literal translation. The adults in the EIT group would take more time to integrate the information. On the contrary, while the adults in the ILT group compared the meanings of two sentences based on the semantic cues from the animations, they may have skipped verifying the meaning of individual words because there were not enough clues to crack the meaning of individual words. They might have made an inference, but needed to rush to the next slide to search new clues before they forgot the distinctive features they just figured out. Since the presentation modalities and the instructional rationales behind two treatments were so different, it would make the information processing time for learners in the Learning Phase of the Implicit Learning Treatment significantly shorter than subjects who experienced the Explicit Instruction Treatment.

On the other hand, children at the age of 11 or 12 may not fully grasp the concepts of the technical terms and grammar explanations in the Explicit Instruction Treatment. Thus this could explain why they spent similar amount of time decoding meaning as in the Implicit Learning Treatment.

Discussion

The interpretations of the findings are discussed as follows:

Cognitive development vs. learning context. The findings of this study are generally in line with the theories proposed by developmental psychologists, psycholinguists and educational psychologists as discussed in Chapter 2. That is, language acquisition is deeply shaped by early cognitive development, and mental lexicons. In addition, form-meaning mapping strategies expand and evolve through time. A specific example of current theory can be found in Clark's (2004) cognitive study: infants start to categorize concepts before they start to learn a language;

they develop categorical structure and use language to map the meaning of things. When infants are between 10 and 12 months old, they start to pay attention to phonological distinctions in the surrounding sounds, then they stop applying the earlier strategies they used between six to eight months. This phenomenon implies that once children acquire more advanced form-meaning mapping strategies, they ignore the less efficient strategies to manage their thoughts. Thus, a question arises as to whether or not form-meaning mapping strategies evolve while the association in the cognitive structure is strengthened by large amounts of exposure to the target language. Would it be possible that once an effective strategy is acquired, or the combination of several useful strategies is employed, the less efficient ones are then abandoned?

After comparing adults' and children's learning behaviors, strategies, and outcomes between two learning contexts, the findings suggest that age is the main factor to affect the cognitive-strategy use and performance. The results of the study showed that, even in a more challenging learning task, such as the Implicit Learning Treatment, most adults were able to attend to distinctive linguistic cues (i.e., use the Phonological Processing Strategy that was more frequently chosen by successful learners) to overcome the difficulties. The following data also lends support to the above findings. The adults in the ILT group selected syntax strategy significantly less often than those in the EIT group. Due to the nature of the design, it is easy to suggest that learners in the ILT group were unlikely to compare L1 and L2 sentences using syntactical cues. Since word-by-word translation and grammar explanation of L2 were not provided in the Implicit Learning Treatment, the only means to decode the meaning of text was to observe the limited sets of clues that enabled the connection between the animations and the sounds. If the learners merely compared the sound streams and morphological differences between L1 and L2 sentences, they may not be able to identify individual words in the L2 sentence. The data showed that those who carelessly selected syntactic cues to decode the meanings of words in the ILT group performed poorly on all three tests. This also could explain why children did not perform as well as adults. The three SLA strategies that children in both the ILT and EIT groups selected were evenly distributed, which suggested that they had not developed an effective strategy (or they had not abandoned a less effective strategy) to tackle the problems.

Fixed reaction time. From the regression analysis we found that there was a strong positive relationship between information processing time in the Learning Phase and the performance of the adults. Using the data collected, we could also find the time intervals the high performance group spent on each event and use them as the time guideline for a future study to see if it can yield better results than the current one. The assumption here is that if randomly selected participants have the same results as the high performance group of this study, we may conclude that there is an ideal information processing time that can help all the learners stay focused and avoid cognitive overload before new information is presented.

Effective strategies. The results of this study showed that for both adults and children, at the very beginning stage, the most effective SLA strategy was Phonological Processing and the most effective cognitive strategy was Guessing, which clearly supports the notions proposed by Smith (1975) and Ausubel (1978). Smith speculated that when children try to understand the world, they search the clue(s) that can help them verify hypotheses about the unfamiliar things (e.g., sounds, objects, or concepts) and that through understanding the meaning of the sounds, children at the very beginning stage could answer their cognitive questions.

For the children in this study, the SLA strategy, Phonological Processing, was strongly positively correlated with Listening Test 1, Listening Test 2, and the vocabulary test. It is hypothesized that frequently using Phonological Processing to map the L2 sound to its meaning could help child learners understand the meanings of new words more easily, and thus shorten the hypothesizing/confirmation process and achieve better learning outcomes. Although there is no significant difference between adults' groups on selecting Phonological Processing as their SLA strategy, Phonological Processing is no doubt the most frequently selected SLA strategy for adults.

Ausubel suggested that the first type of learning is representational learning, which consists of the learning of the meaning of a single word. As explained in Chapter 2, concept learning follows that phase and consists of the learning of objects, events, situations, or properties that possess common critical attributes. This type of learning requires children to use Guessing Strategies to extract the similarity between objects and categorize the abstract notions. The findings of this study seemed to support the theories posited by Smith and Ausubel. The agreement between the theories and the findings suggests that the instructional designers should implement the most effective strategies that facilitate learning in various developmental stages. That is, after learners master the strategies to connect L2 sound with meaning, it would be good to implement the tasks for learners to map the L2 sound to its meaning and the L2 text afterward, and finally reinforce the strategies they use to compare and contrast the syntactic patterns between L1 and L2. If the activities of learners are timed to complete various levels of tasks in every stage, they may be able to expedite the processing speed and increase the effectiveness of their learning.

Limitations

The main areas of limitations of this study include: The computer software and the research design.

Computer software. Data collection of this study relied heavily on computer software. All the data collection procedures via software were carefully designed, reviewed, and pilot-tested. Nevertheless, there were still some problems with the system as implemented that limited the data collected for all participants even, despite steps taken to double-check the stability of the server and the workstation of each site through several test-runs. Among the one hundred and forty-five participants, two adults and four children experienced program crashes and could not proceed with the narrative scenarios. Thus, they were asked to leave the program with full compensation and their data was excluded. Computer crashes happened at both adults' and children's sites on different days around the same time, two o'clock in the afternoon. We speculated that the program was designed to collect the time stamp data from every single event, which created a heavy workload on the server. To avoid future concurrent data overflow, using multiple servers could well be a good solution.

Research design. Several limitations regarding issues of validity and reliability of the data collected in this study are examined in this section.

External validity. First, although randomly selected, the demographic background of the adult participants might be homogeneous. One concern is that many of the students at Brigham

Young University (BYU) have achieved advanced proficiency in a second language through formal instruction and/or living in an L2 environment for extended periods of time[14]. Theoretically, this may help them to decode another language better when they are exposed to another new language. Because of this, the distribution of scores from convenience sampling groups (BYU) may be negatively skewed to the true population. Second, the data collection procedures in the artificial environments, such as the highly controlled computer lab, may not resemble "real-world" language learning situations. Third, the scores of this study could not be generalized to any existing standardized proficiency tests of Chinese, thus no criterion-referenced validity could be established.

Construct validity. To minimize the effect of measurement error, some controls had been made to rule out the competing explanations of the results. At the beginning of Chapter 1, the dependent variables of this study were categorized into two types of tests—listening and vocabulary. The construct for the listening test was defined as the recognition of the meanings of 29 L2 chunks of sounds. The construct for the vocabulary application test was defined as

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[14] Each year, approximately 46% students on the BYU campus have served as missionaries for the LDS Church (The Church of Jesus Christ of Latter Day Saints) in one of 405 missions in the world. Many of those missionaries learn a foreign language at a missionary training center for six to nine weeks and serve their missions in a foreign country for two years. Source: https://yfacts.byu.edu/article?id=264

understanding of the L2 syntactic patterns introduced in the program and the ability to re-formulate new L2 sentences. The instruments section of Chapter 3 explains how the task types and testing procedures for both listening and vocabulary tests could measure the construct for each test. However, statistical procedures such as "causal modeling" were not performed. Thus we could not infer that each test only measured the construct being defined and we could not exclude the possibility that the vocabulary application test also measured the construct of the listening comprehension test.

To determine learners' thoughts on strategy selection, a Qualtrics survey was created. Even though the survey questions and answering options were created based on the results of *Think-Aloud Protocol* that elicited responses from the participants in the pilot tests conducted with similar populations, the resulting survey may not completely represent a full range of the attitudes and thinking of the individuals who participated in this experiment.

Furthermore, since the Qualtrics survey questions were designed to elicit thoughts from adults and children, the instructions and questions were designed to be simple enough for both populations to understand. After the survey questions were generated from the adults' answers from *Think-Aloud Protocol*, the survey was revised by two BYU editing students to ensure the simplicity of the questions for children. The *Think-Aloud Protocol* was conducted again for the pilot-tested children. They were asked to interpret the meaning of each revised survey question.

The results of two child participants showed that the questions were easy to understand. However, even though the child participants from could interpret the survey questions easily and correctly, we still could not avoid the full range of interpretation errors that the full sample of sixth graders might have.

Inter-rater reliability. To ensure that the answer options of the Qualtrics survey reflected the correct SLA and cognitive strategies chosen by the learners, four raters (two in each treatment) from the Department of Linguistics at Brigham Young University were asked to define the strategies in the survey (Appendix 4). The raters' questionnaire followed the same sequence as the Qualtrics survey. The raters' versions included the definition of strategies in the instruction and all 15 questions and the 57 answer options were randomized. The distractors were added to one of the five multiple-choice options in 15 questions. The raters were also trained to define several strategies before starting their tasks. After analyzing the 57-item strategy identification tasks among four raters, the inter-rater reliability was not high but yet acceptable (Cronbach's $\alpha = 0.72$).

Parallel-forms reliability. The instruments section of Chapter 3 explains that the Qualtrics survey included five sets of multiple-choice questions which repeatedly appeared three times. These questions asked the learners to recall what they were thinking or doing while going through the Practice Phase during the treatment. Although the five types of questions appeared three times, the prompts (i.e., text or animation) were different throughout all 15 questions. The purpose of this design was to ensure that the selection of any unique strategy for each learner did not occur by chance. The parallel-forms (repeat each type of question three times) design was designed to measure the consistency of strategy selection within each participant. However, due to the scope of this particular study, this within-subject factor analysis was not performed.

Implications of this Research

Based on the Design Layering Theory (Gibbons & Rogers, 2009), this study operationalized two experimental conditions using parallel comparisons on each design layer to implement the narrative approach on the CALL programs. This research explored the combination effects of various instructional approaches and language acquisition theories and used analytical software to track learning behaviors, analyze learning strategies, and assess learning outcomes.

Subjects in both treatment groups achieved positive learning outcomes. That is, for all the participants, the mean score of two listening tests was 95.45 out of 100 points. In other words, they could memorize 95.45% of 29 meaningful chunks of Chinese sounds in 37 minutes. These outcomes lead us to believe that the designs and conditions of the treatments were strictly parallel. Both approaches could be extended to address the learning of two languages to compare the learning effects of the two treatments between cognate and non-cognate languages. It is possible that such an approach would contribute to the derivation of a theory of second language acquisition that would be useful in a wide variety of learning circumstances. The findings of this study indicate that both adults and children in the EIT group performed significantly better than those in the ILT group. This may be due to a large extent to the fact that the learners in the EIT group received instant feedback while concurrently comparing several linguistic features (e.g., phonological, orthographical, semantic features, etc.) between two languages to integrate the information. Therefore, it should be possible to use techniques embodied in the Explicit Instruction Treatment to compare the effects of L1 and L2 form-mapping strategies among various developmental-stage groups through longitudinal studies.

It would also be useful to assess the various levels of attention paid to the learning task at hand using advanced research techniques as discussed in Chapter 2. For example, future researchers could use various types of computer-based systems to track learner behavior in addition to cognitive activity during the learning process. Such systems would enable not only an analysis of time spent in each learning phase but would also employ cognitive functional magnetic resonance imaging during information processing. The outcome of those studies would enable an exploration of the causal relations of various mental behaviors upon second language acquisition among children and adults. Finally, an additional interesting avenue of investigation might be to consider whether combining elements of the ILT treatment with the EIT presentation modality might be more effective than either treatment alone.

Conclusions

The purpose of this study was to use an online tool to measure the construct of vocabulary acquisition—the processes and the results of L1 and L2 form-meaning mapping, then analyze whether the differences in learning outcomes could be attributed to two treatments, Implicit Learning Treatment (ILT) or Explicit Instruction Treatment (EIT), to the differences in cognitive development between adults and children, to information processing time, or to the linguistic or cognitive strategies that learners adopted.

The results of this study can be summarized in the following areas:

1. The age of learners and its interaction with the treatments
2. The differences in time spent in various phases by successful and less successful learners
3. The SLA and cognitive strategies preferred by adults and children

As we have seen, maturity is the main factor for determining performance, regardless of the complexity of the task. We have also learned that subjects who experienced the Explicit Instruction Treatment achieved greater learning outcomes than those in the Implicit Learning Treatment group for adults as well as children of the age investigated in this study. Children at this age begin to apply adults' L2 acquisition strategies to map form with meaning. During the Learning Phase, adults in the high performance group in both treatment groups spent significantly longer time than adults in the low performance group. Also, during the Learning Phase, the adults in the EIT group spent a significantly longer time than those in the ILT group. In contrast, children in the high performance group spent significantly shorter time during the Testing Phase than children in the low performance group. Finally, the most popular SLA strategy was Phonological Processing for both high performance children and all adults. Similarly again for both age groups, the most popular cognitive strategy was the Guessing Strategy.

Finally, the time spent in information processing and decision-making combined with the use of SLA and cognitive strategies together predict learning outcome better than other variables investigated in this study. These findings corroborate the developmental theories regarding language acquisition of a wide variety of scholars: Lev Vygotsky, a social constructivist, Frank Smith, a psycholinguist, and David Ausubel, an educational psychologist. This outcome suggests that this study can serve as a basis for future study of various developmental stages of learners' form-meaning mapping strategies and information processing foci and for exploring the causal relations of these strategies for a variety of second language learning tasks.

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APPENDIX 1

Language Contents

Phrases Appearing in Practice Phase, Testing Phase, and Qualtrics Survey Questions

Task 1

Chinese	Pinyin	English	Practice Slides	Testing Slides	Qualtrics Questions
你好!	Nǐ hǎo	Hello!	[1], [9]	[1], [8], [13], [23]	[6]
對了!	Duì le!	Correct!	[2], [4], [10], [12]	[14], [22]	[1], [10]
我叫李伯伯.	Wǒ jiào Lǐ Bō Bo.	I am Uncle Lee.	[1], [3], [6], [8], [9], [11], [14], [16]	[2], [7], [16]	[4], [5], [6], [15]
布洛斯	Bù Luò Sī	Boris	[4], [5], [12], [13]	[5], [9], [19]	[10]
我叫布洛斯.	Wǒ jiào Bù Luò Sī.	I am Boris.	[5], [7], [13], [15]	[3], [6], [18], [25]	
李伯伯	Lǐ Bō Bo.	Uncle Lee.	[2], [6], [10], [14]	[4], [10], [20]	[1], [5],
你叫什麼名字?	Nǐ jiào shén me míng zi?	What's your name?	[3], [7], [8], [11], [15], [16]	[11], [12], [15], [17], [21], [24]	[4], [15]

Note. Eight meaningful chunks and 15 Chinese characters were included: 你好, 你叫, 什麼, 名字, 我叫, 布洛斯, 李伯伯, 對了.

Task 2

Chinese	Pinyin	English	Practice Slides	Testing Slides	Qualtrics Questions
我	Wǒ	I	[1], [2], [7], [9], [13], [27], [28], [33], [35], [39]	[1], [16]	[2], [7]
你	Nǐ	You	[3], [4], [7], [8], [10], [14], [29], [30], [33], [34], [36], [40]	[2]	[2], [7]
他	Tā	He	[5], [6], [8], [9], [15], [31], [32], [34], [35], [41]	[3], [25]	[2], [7], [11]
我們	Wǒmen	We	[1], [2], [10], [12], [15], [27], [28], [36], [38], [41]	[7], [22]	[2], [11], [12]
你們	Nǐmen	You (all)	[3], [4], [11], [13], [29], [30], [37], [39]	[4], [17], [26]	[2], [12]
他們	Tāmen	They	[5], [6], [11], [12], [16], [31], [32], [37], [40], [42]	[5], [6], [8], [9]	[2], [12]
他是我的爸爸	Tā shì wǒde bà ba.	He is my father.	[17], [19], [43], [45]	[10], [28]	[14]
她是我的媽媽	Tā shì wǒde m ā ma.	She is my mother.	[18], [19], [20], [44], [45], [46]	[11]	[9], [14]
她是珍妮阿姨	Tā shì zhēn ní ā yí.	She is Aunt Jenny.	[20], [21], [46], [47]	[12], [23], [29]	[9]
她是瑪麗阿姨	Tā shì mǎ lì ā yí.	She is Aunt	[21], [47]	[21]	

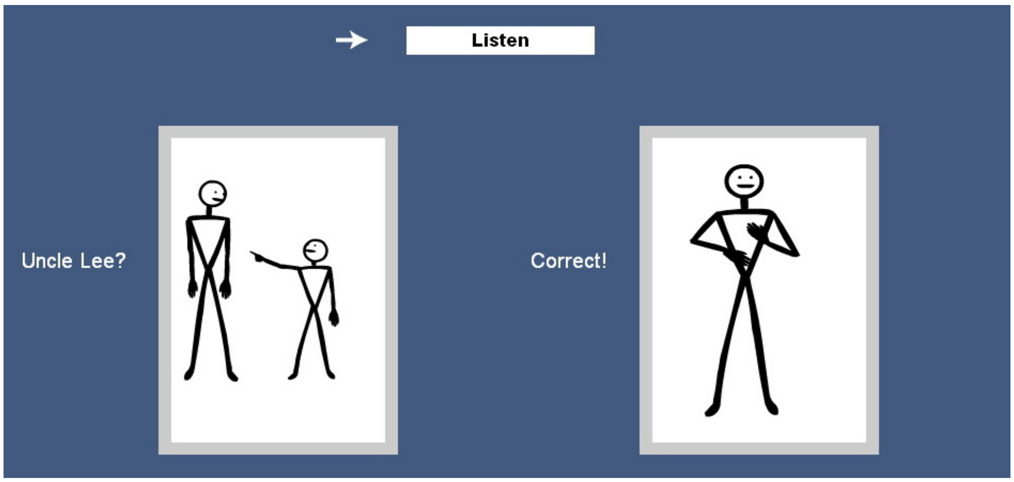
		Mary.			
他是湯姆叔叔	Tā shì tāng mǔ shū shu.	He is Uncle Tom.	[22], [48]	[13]	[13]
他是約翰叔叔	Tā shì yuē hàn shū shu.	He is Uncle John.	[22], [48]	[18]	[13]
她們是英國人	Tāmen shì yīn g guó rén.	They are English men.	[23], [25], [49], [51]	[14], [27]	[3]
他們是美國人	Tāmen shì měi guó rén.	They are Americ an.	[23], [25], [49], [51]	[24]	[3]
我是中國人	Wǒ shì zhōng guó rén.	I am Chinese	[24], [26], [50], [52]	[20]	[8]
我是法國人	Wǒ shì fã guó rén.	I am French.	[24], [26], [50], [52]	[15], [30]	[8]

Note. Twenty-one new meaningful chunks and 22 Chinese characters were included: 我, 我們, 你, 你們, 他, 他們, 我的, 他(她)是, 爸爸, 媽媽, 珍妮, 瑪麗, 湯姆, 約翰, 阿姨, 叔叔, 英國人, 美國人, 中國人, 我是.

APPENDIX 2

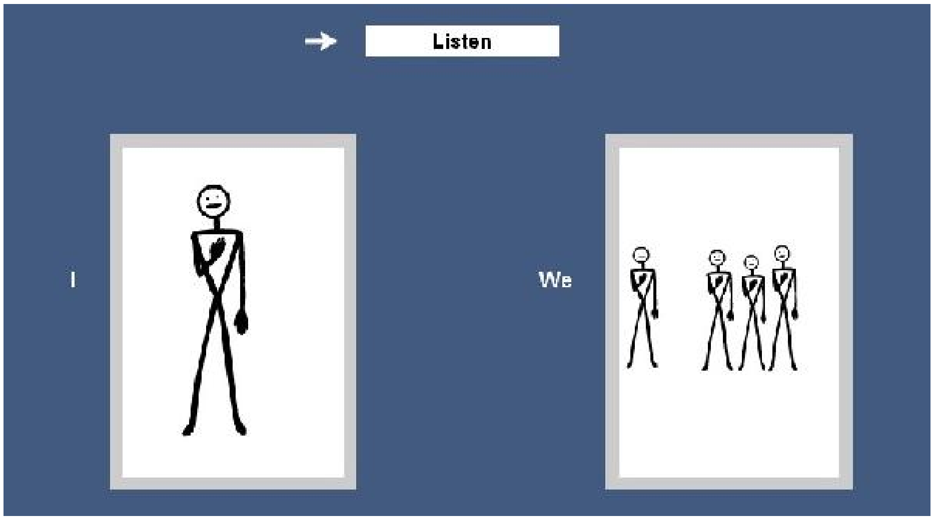
Qualtrics Survey Questions—Experimental Group

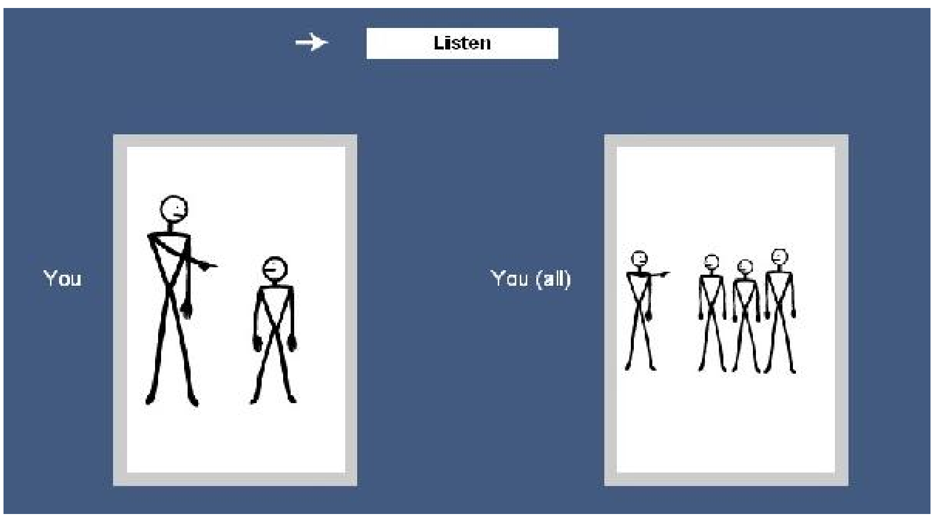
Q1. Below is a picture from the Testing Phase. When you listened to the sound "Duì le!" which clue helped you the most?

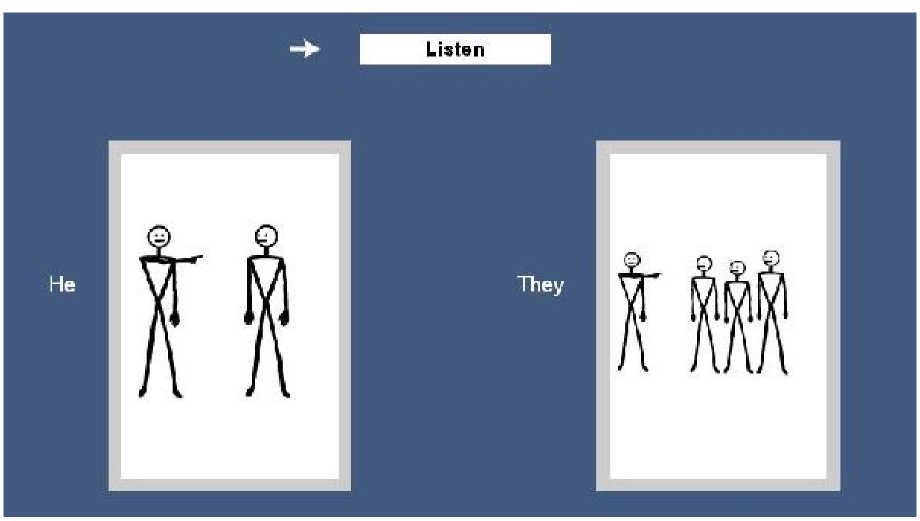


1. _______"Correct!" means "Duì le!"
2. _______"Uncle Lee" means "Lǐbōbo" so the other animation must be right.
3. _______"Duì le!" refers to the animation of the clapping man.
4. _______ I don't know why, but I just know the answer.

Q2. Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







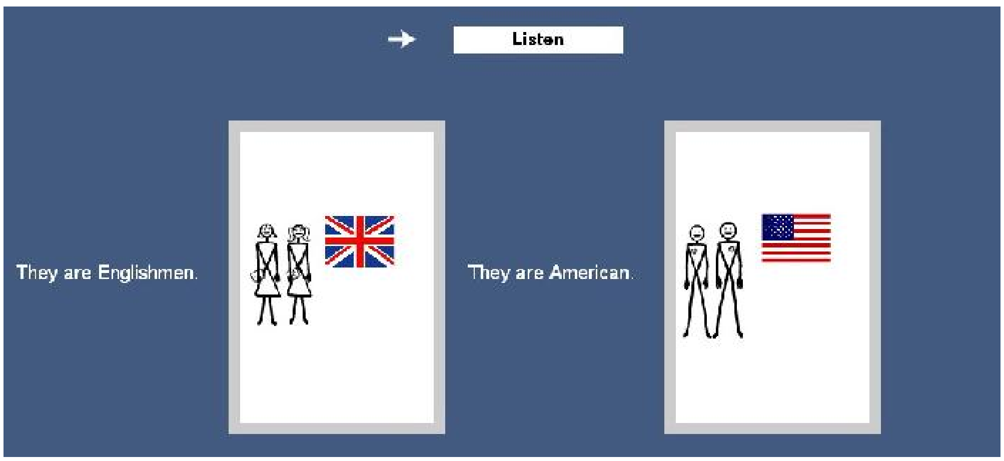
1. ________ The number of people was different between two animations of a slide.

2. ________ There was an extra sound "men" in the right animation.

3. ________ In both animations of the same slide, the people on the left had the same gesture.

4. ________ On each slide, the beginning sound of both animations was the same.

Q3. Below is a picture from the Testing Phase. When you compared these animations, which clue helped you the most?

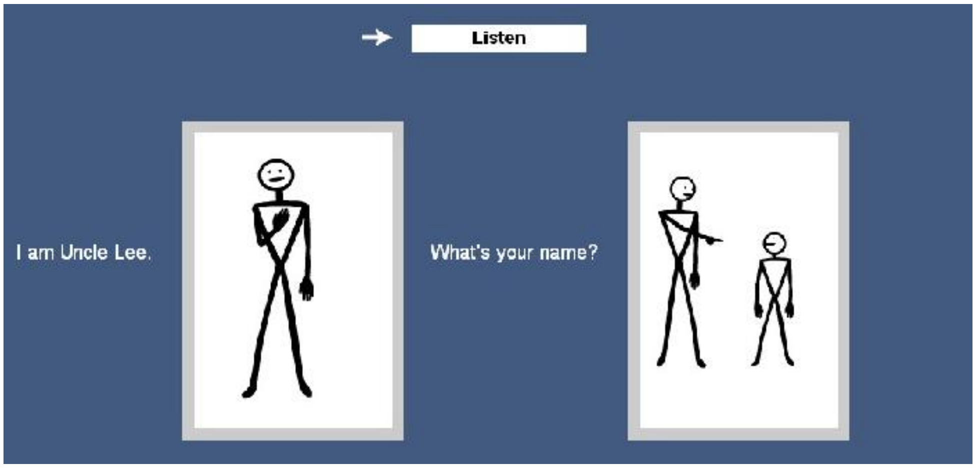


1. ________ The English sentence sounded similar to the Chinese sound.

2. ________ I knew the meaning of the animation and its Chinese sound.

3. __________ The structure of English sentence was similar to the Chinese one.

Q4. Below is a picture of Testing Phase. When you entered this page, what did you do?



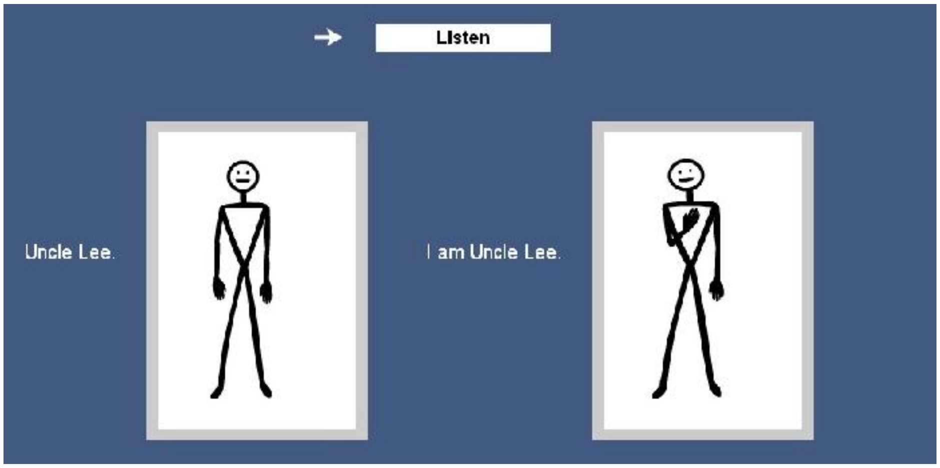
1. ________ Clicked the "Listen" button first.

2. ________ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.

3. ________ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.

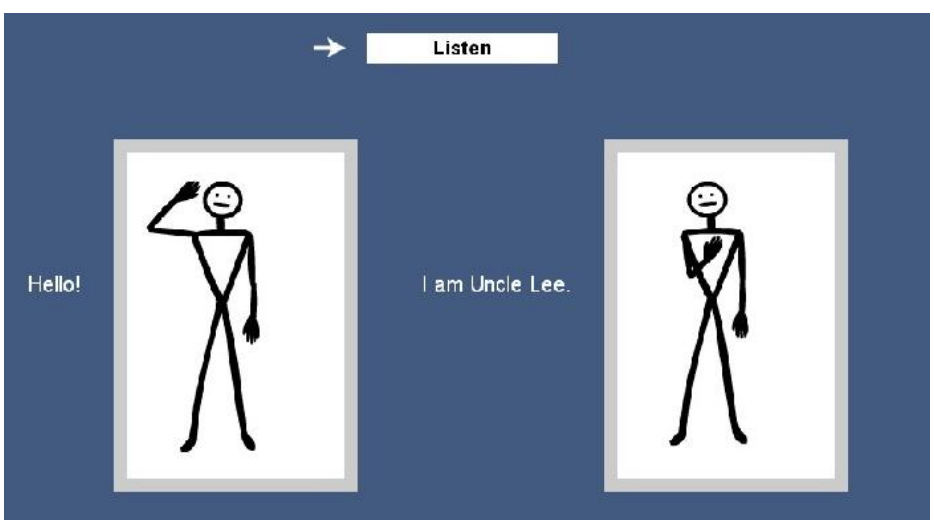
4. ________ Ruled out the sentence that doesn't match the Chinese sound.

Q5. Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



1. ________ Looked for the English sentence that was similar in length to the Chinese sound.
2. ________ Looked for the English sentence that sounded similar to the Chinese sound.
3. ________ Looked for the animation that matched the meaning of the Chinese sound.
4. ________ Clicked the “Listen” button again because the sound was not heard clearly before.

Q6. Below is a picture from the Testing Phase. When you listened to the sound “Nǐhǎo!” which clue helped you the most?



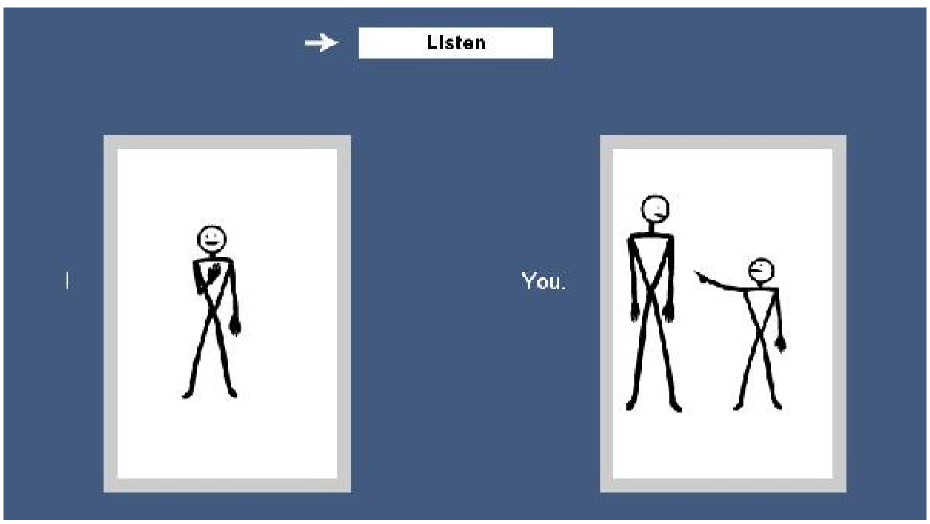
1. ________ "Nǐhǎo!" means "Hello!"

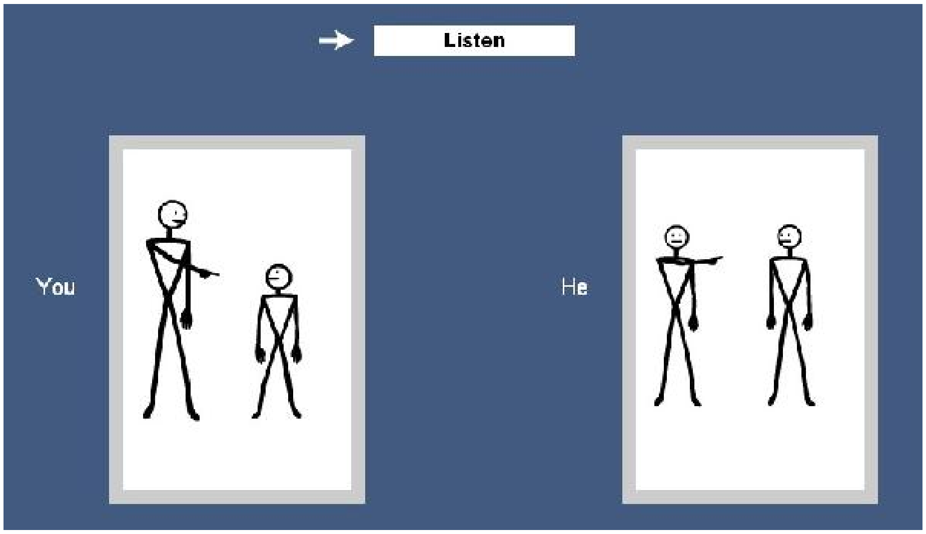
2. ________"Uncle Lee" means "Lǐbōbo" so it is unlikely to be correct.

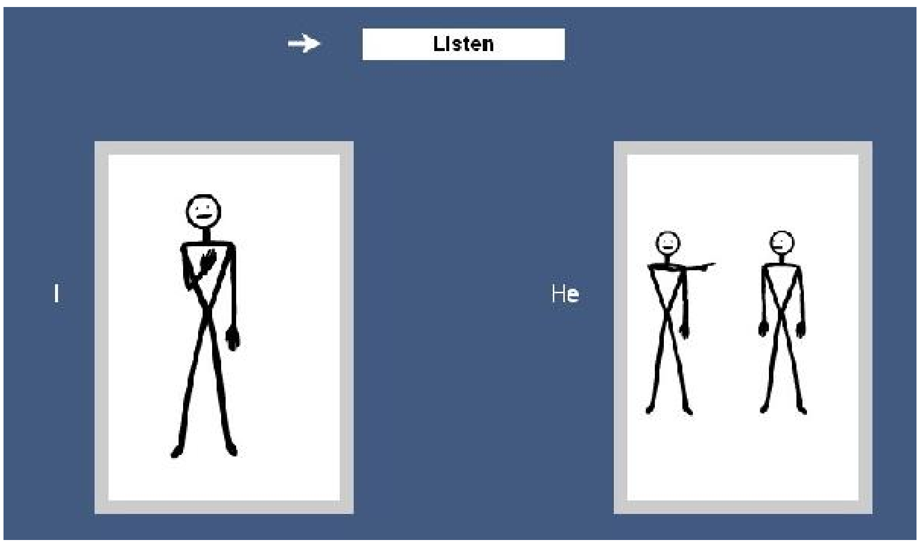
3. ________"Nǐhǎo!" refers to the animation of the waving man.

4. ________ I don't know why, but I just know the answer.

Q7. Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







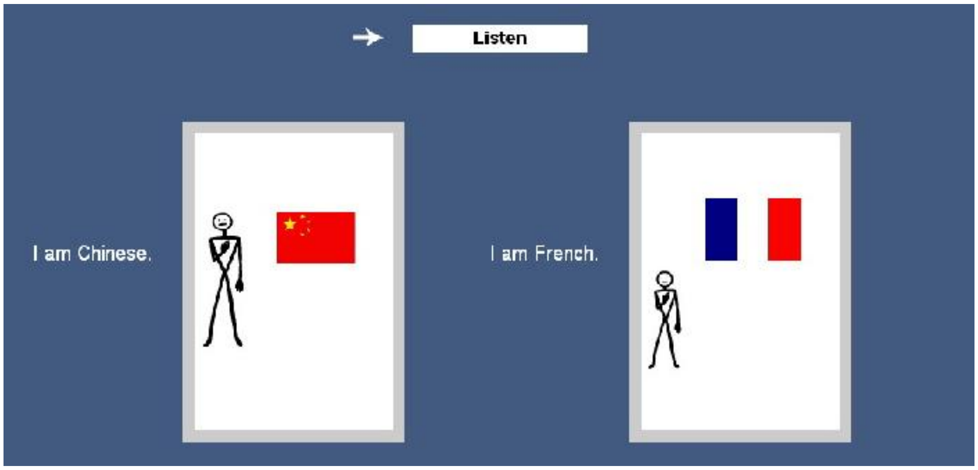
1. ________ The fingertip pointed to one person only.

2. ________ On all slides, the Chinese sounds between two animations were different.

3. ________ On each slide, the person who was pointing in each animation had different gesture.

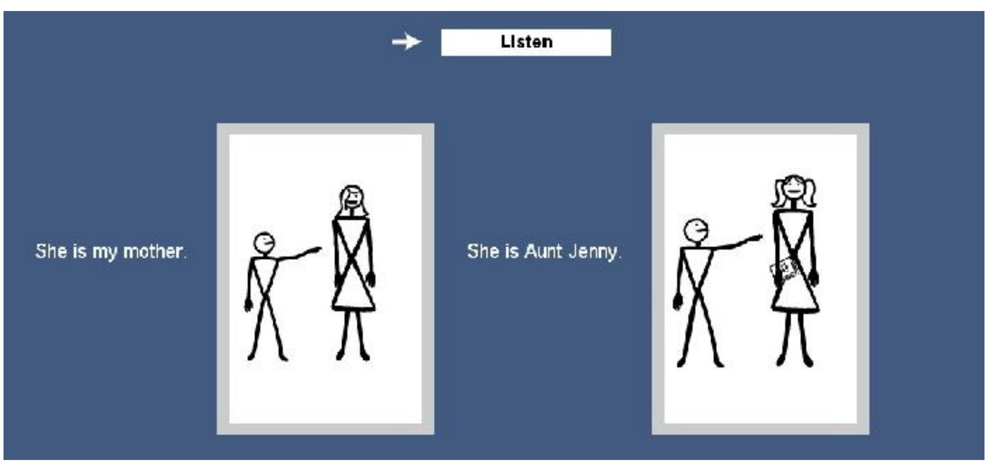
4. ________ On all slides, the Chinese sound of each animation had only one syllable.

Q8. Below is a picture from the Testing Phase. When you compared these animations, which clue helped you the most?



1. ________ The English sentence sounded similar to the Chinese sound.
2. ________ I knew the meaning of the animation and its Chinese sound.
3. _________ The structure of English sentence was similar to the Chinese one.

Q9. Below is a picture from the Testing Phase. When you entered this page, what did you do?

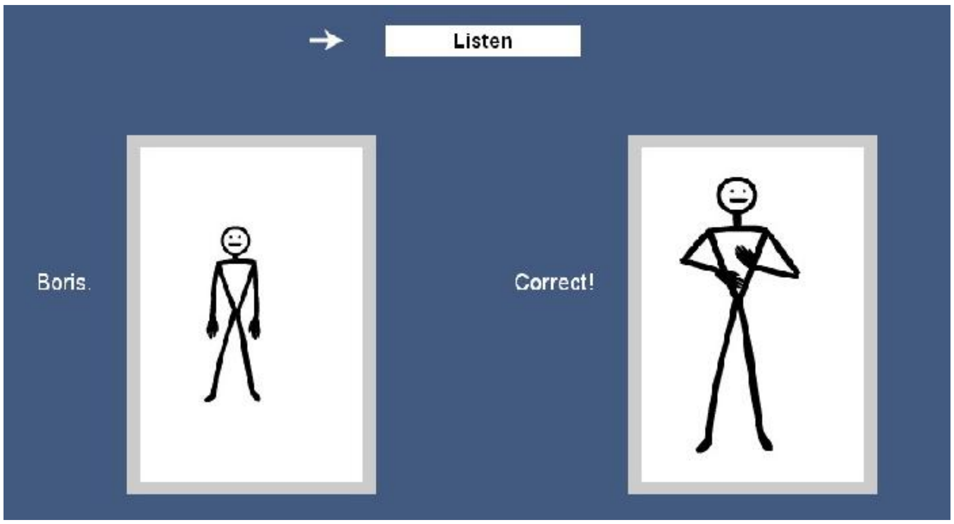


1. ________ Clicked the "Listen" button first.
2. ________ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.

3. _______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.

4. _______ Ruled out the sentence that doesn't match the Chinese sound.

Q10. Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



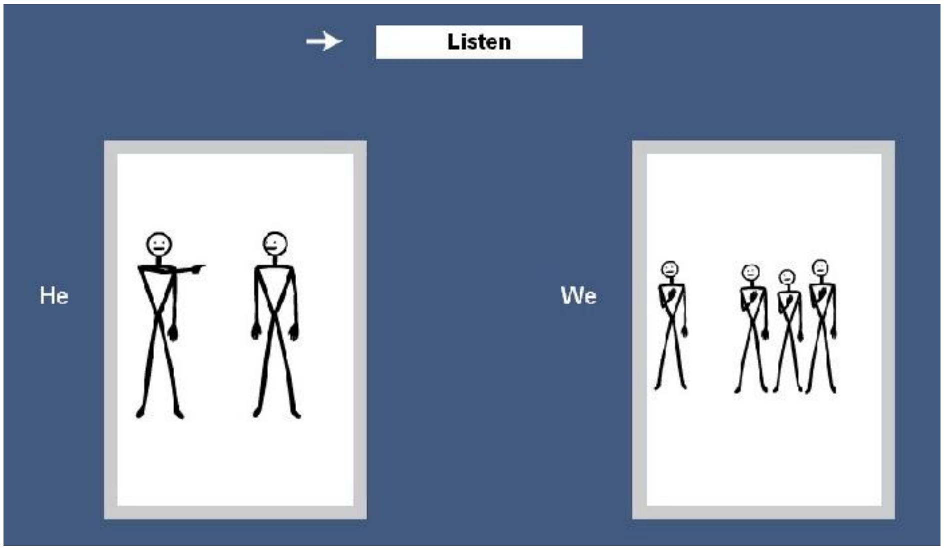
1. _______ Looked for the English sentence that was similar in length to the Chinese sound.

2. ______ Looked for the English sentence that sounded similar to the Chinese sound.

3. _______ Looked for the animation that matched the meaning of the Chinese sound.

4. _______ Clicked the "Listen" button again because the sound was not heard clearly before.

Q11. Below is a picture from Testing Phase. When you listened to the sound "Tā," which clue helped you the most?



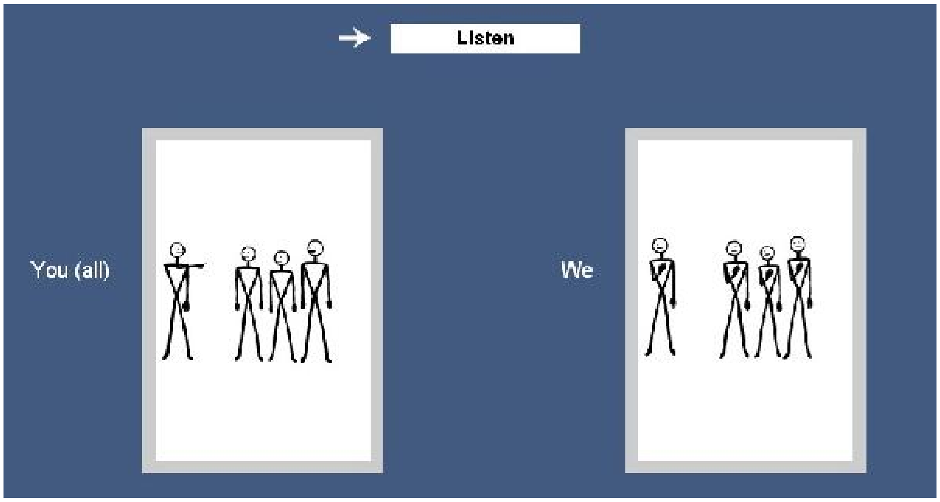
1. ________“He” means “Tā.”

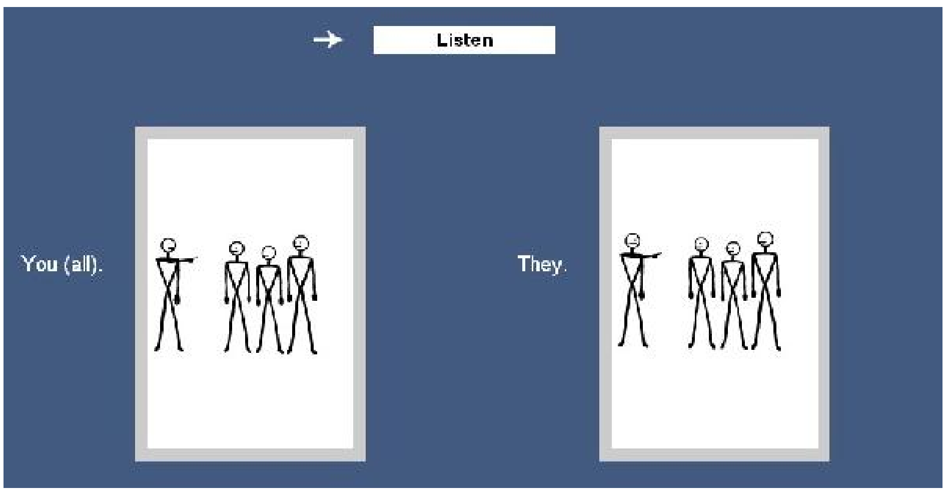
2. ________ The animation that refers to many people must have a “men” sound so the other animation must be right.

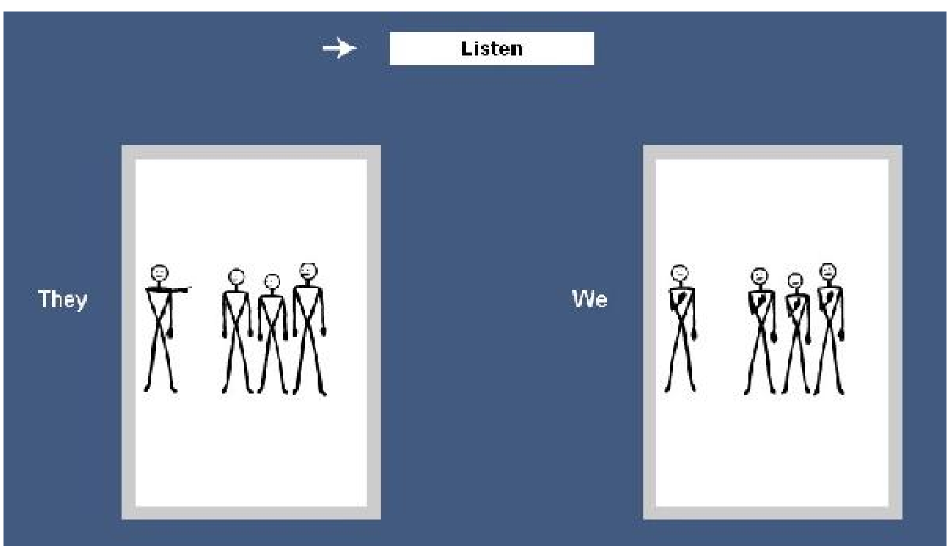
3. ________ “Tā” refers to a person neither I nor you.

4. ________ I don’t know why, but I just know the answer.

Q12. Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?


Listen
You (all)
We


Listen
You (all).
They.


Listen
They
We

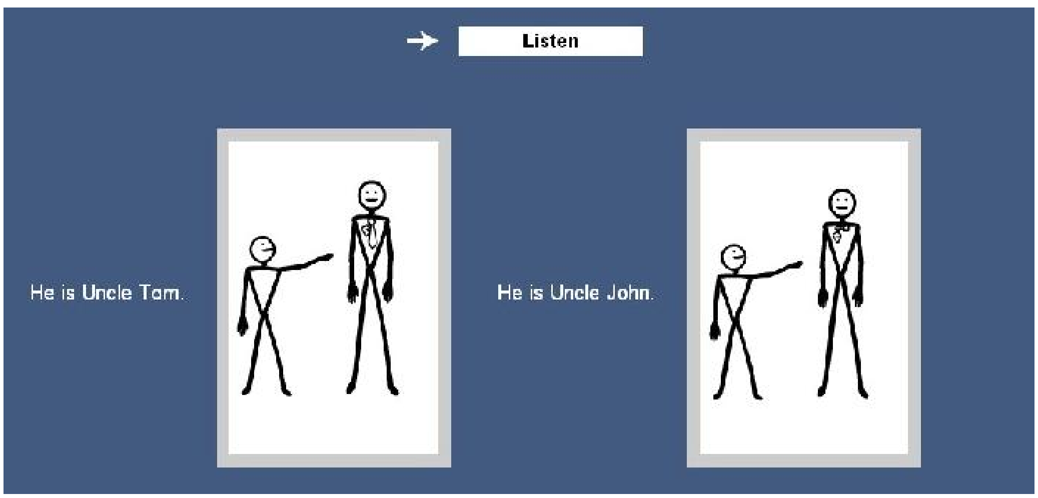
1. ________ The number of people in all animations was the same.

2. ________ There was a sound "men" in every animation.

3. ________ On each slide, the people on the left in the two animations had different gestures.

4. ________ On each slide, the beginning sound of the two animations was different.

Q13. Below is a picture from the Testing Phase. When you compared these animations, which clue helped you the most?

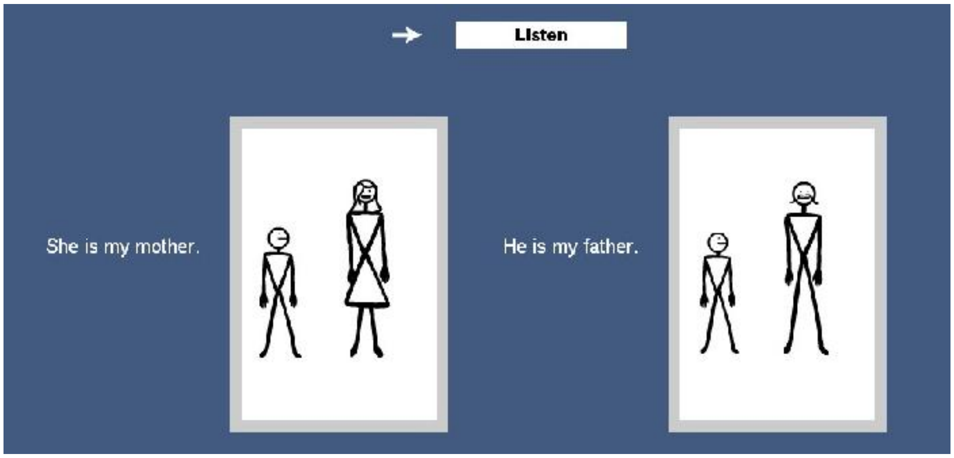


1. ________ The English sentence sounded similar to the Chinese sound.

2. ________ I knew the meaning of the animation and its Chinese sound.

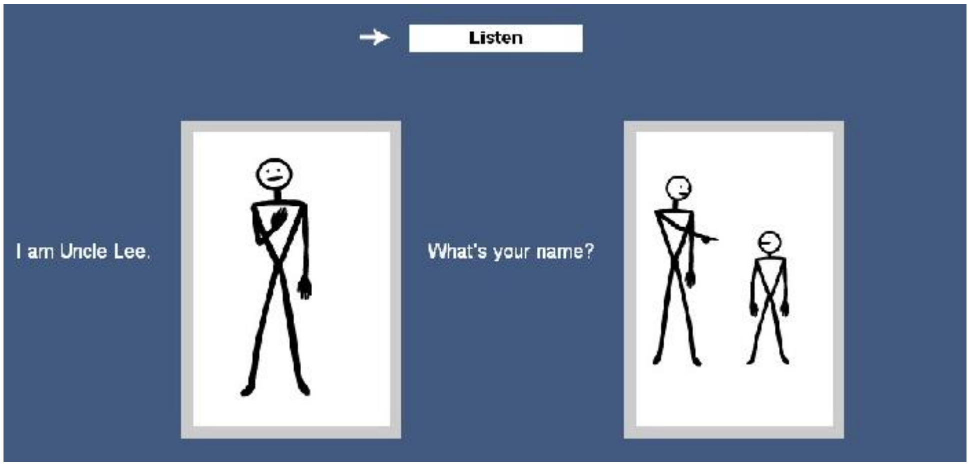
3. _________ The structure of English sentence was similar to the Chinese one.

Q14. Below is a picture from the Testing Phase. When you entered this page, what did you do?



1. _______ Clicked the “Listen” button first.
2. _______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.
3. _______ Guess what each sentence sounds like in Chinese before clicking the “Listen” button.
4. _______ Ruled out the sentence that doesn’t match the Chinese sound.

Q15. Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



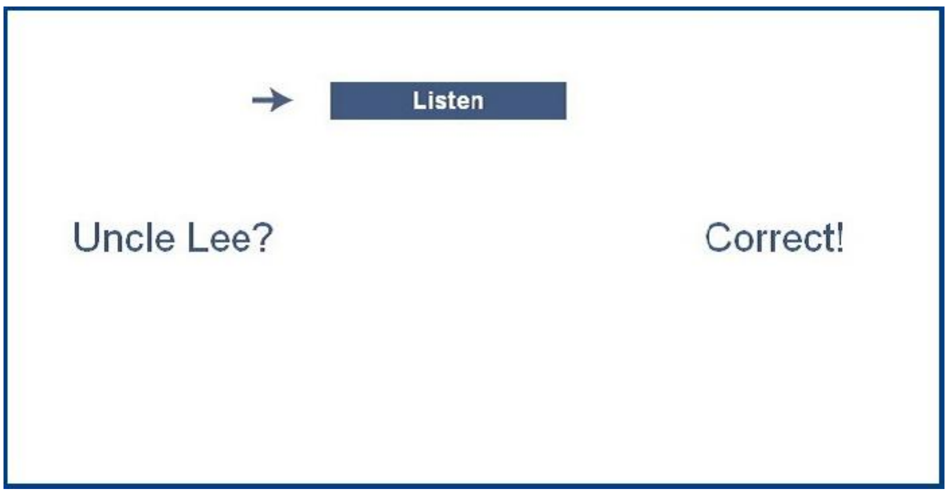
1. _________ Looked for the English sentence that was similar in length to the Chinese sound.
2. _________ Looked for the English sentence that sounded similar to the Chinese sound.
3. _________ Looked for the animation that matched the meaning of the Chinese sound.
4. ________ Clicked the "Listen" button again because the sound was not heard clearly before.

Qualtrics Survey Questions—Control Group

Instruction: There will be 27 questions total. Please take your time to finish these questions.

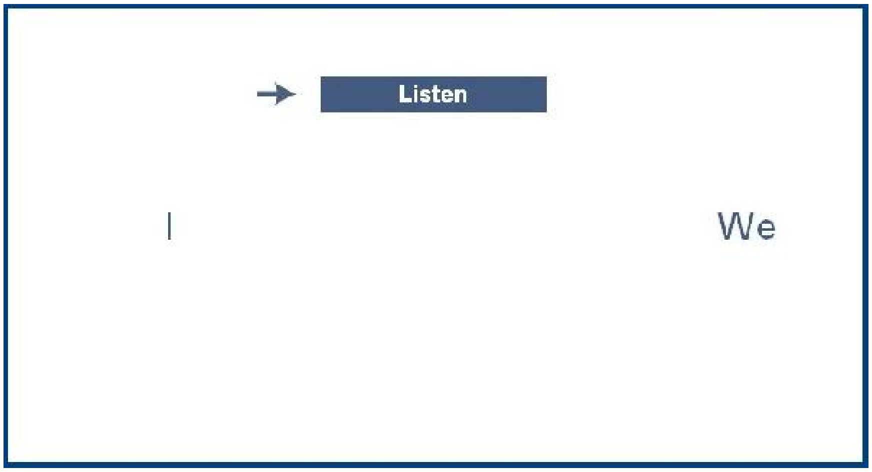
For question 1 through 15, please decide which clue helped you the most. There is no wrong answer, so simply answer each question based on what you think.

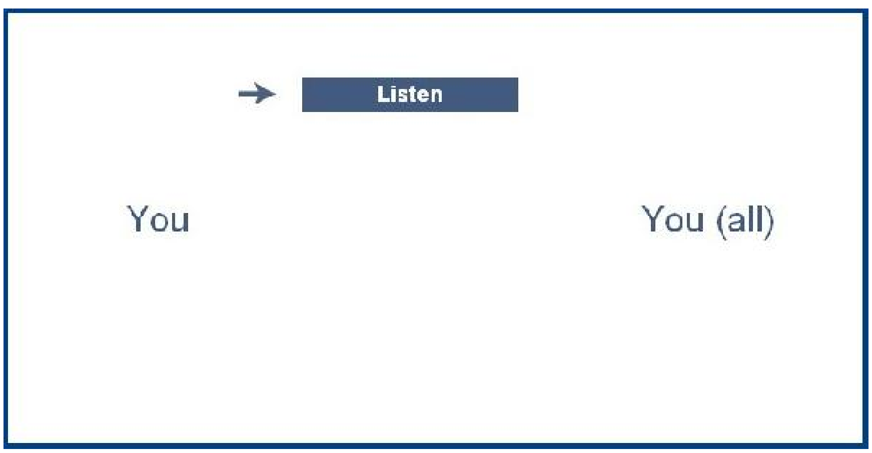
Q1. Below is a picture from the Testing Phase. When you listened to the sound “Duì le!” which clue helped you the most?

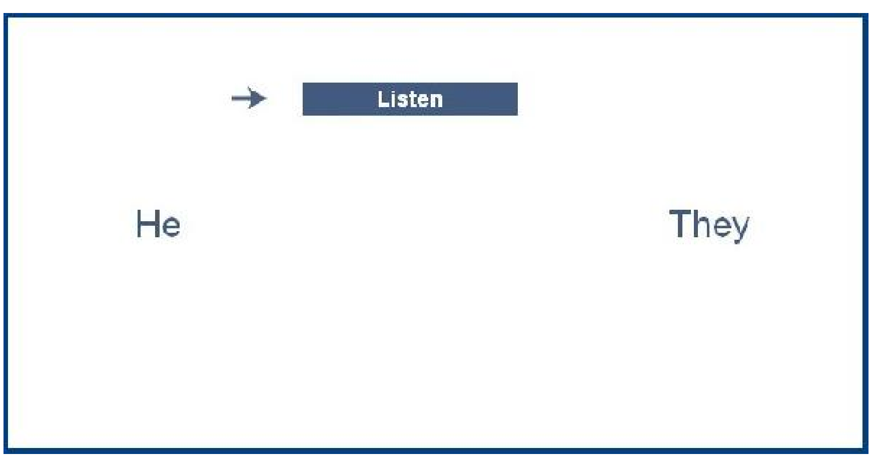


1. _______“Correct!” means “Duì le!”
2. _______“Uncle Lee” means “Lǐbōbo” so the other sentence must be right.
3. _______ “Duì le!” means “Matched already!”
4. _______ I don’t know why, but I just know the answer.

Q2. Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







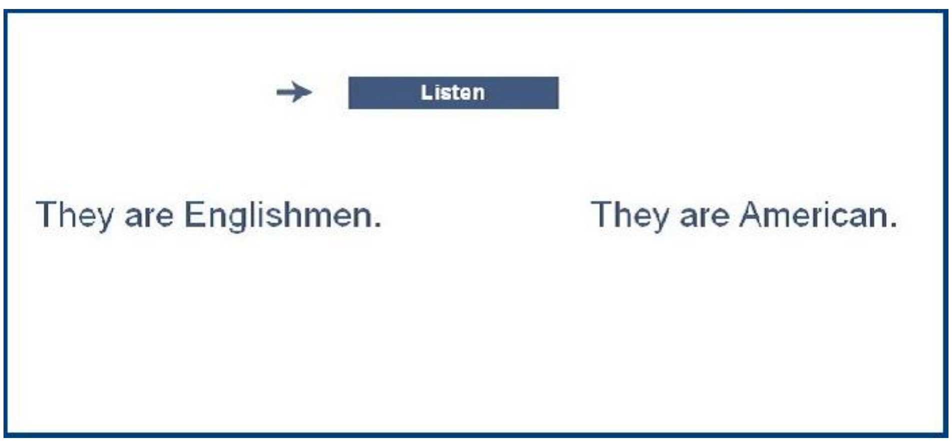
1. ________ The word on the left means one person and the word on the right means more than one person.

2. ________ There was an extra sound “men” in the word on the right.

3. ________ The word on the left represented the singular person form while the word on the right represented the plural person form.

4. ________ On each slide, the beginning sounds of both words were the same.

Q3. Below is a picture from the Testing Phase. When you compared these sentences, which clue helped you the most?



1. _________ The English sentence sounded similar to the Chinese sound.

2. _________ I knew what each word meant in Chinese.

3.__________ The structure of English sentence was similar to the Chinese one.

Q4. Below is a picture from the Testing Phase. When you entered this page, what did you do?

1. _________ Clicked the “Listen” button first.
2. _________ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.
3. _________ Guessed what each sentence sounds like in Chinese before clicking the “Listen” button.
4. _________ Ruled out the sentence that doesn’t match the Chinese sound.

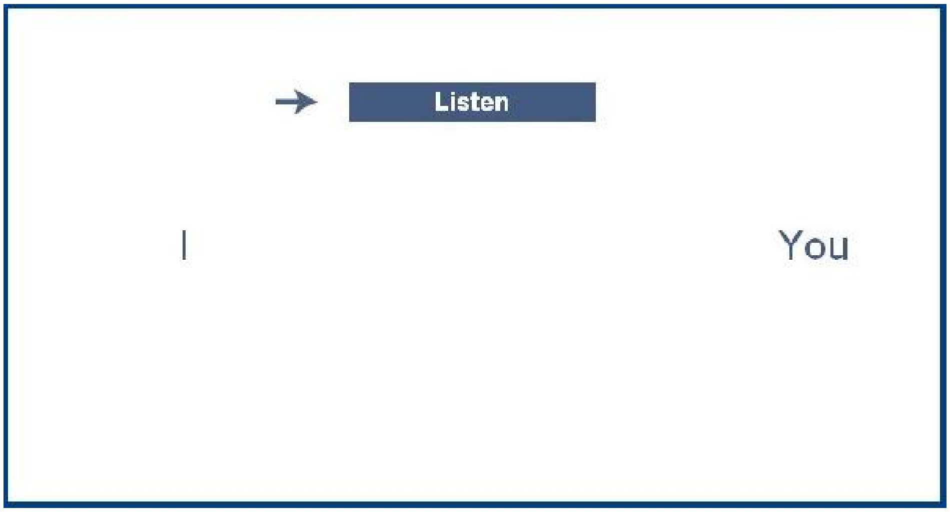
Q5. Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?

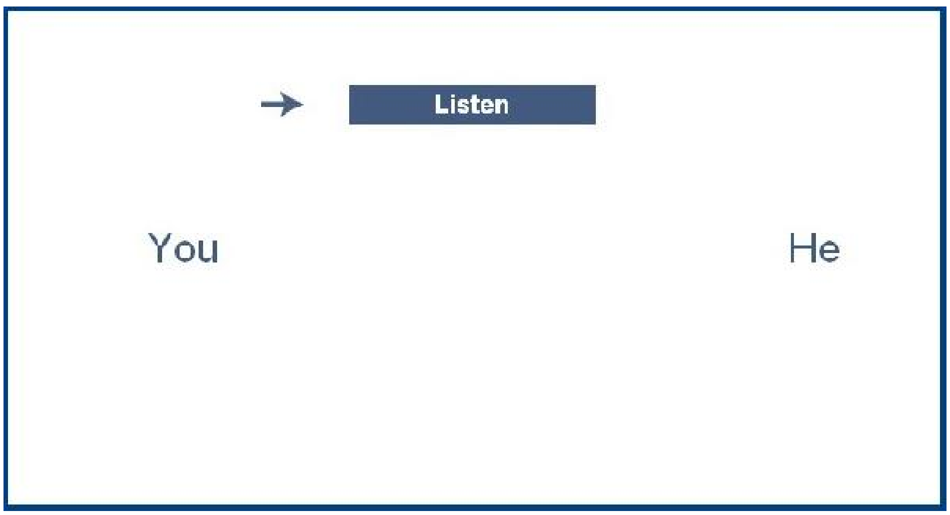
1. ________ Looked for the English sentence that was similar in length to the Chinese sound.
2. ________ Looked for the English sentence that sounded similar to the Chinese sound.
3. ________ Looked for the English sentence that matched the meaning of the Chinese sound.
4. ________ Clicked the "Listen" button again because the sound was not heard clearly before.

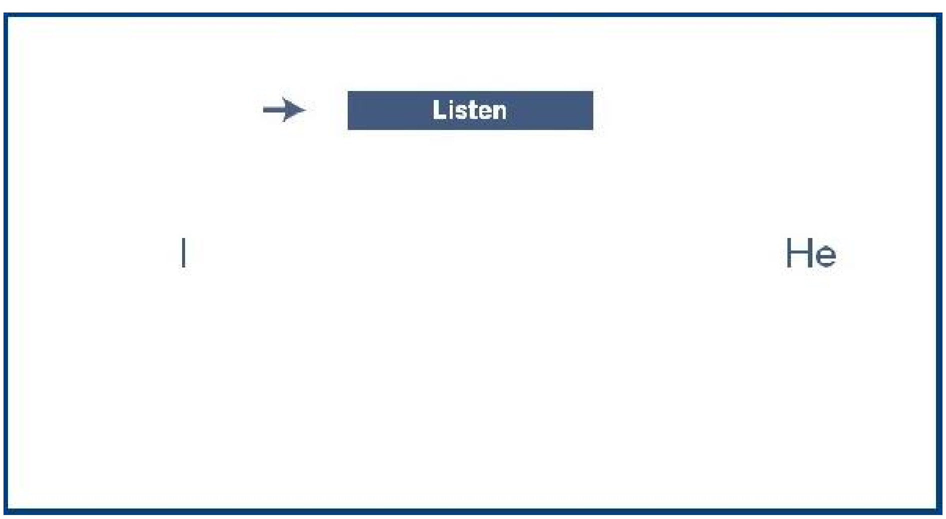
Q6. Below is a picture from the Testing Phase. When you listened to the sound “Nǐhǎo!” which clue helped you the most?

1. ________ “Hello!” means “Nǐhǎo!”
2. ________ “Uncle Lee” means “Lǐbōbo” so it is unlikely to be correct.
3. ________“Nǐ” means “You” and “hǎo!” means “do well!”
4. ________ I don’t know why, but I just know the answer.

Q7. Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?


Listen
I
You


Listen
You
He

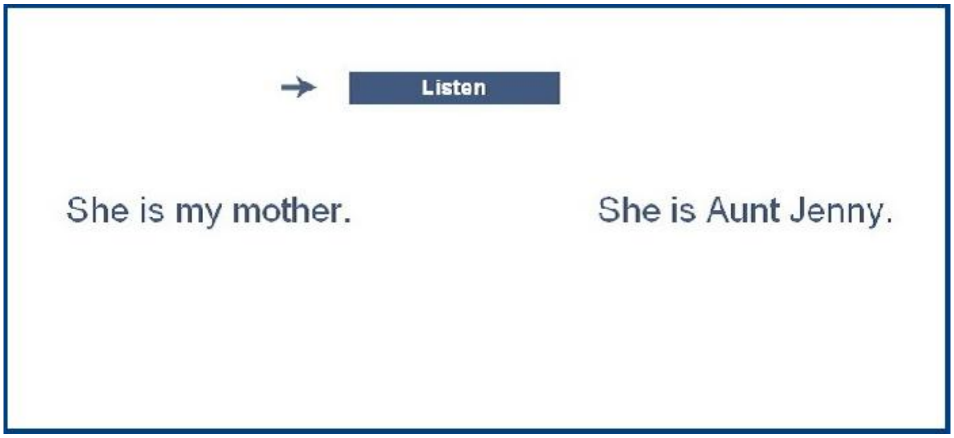

Listen
I
He

1. _________ Each word referred to different person.
2. _________ On all slides, the Chinese sounds between two words were different.
3. _________ Each word referred to one person only.
4. _________ On all slides, the Chinese sound of each word had only one syllable.

Q8. Below is a picture from the Testing Phase. When you compared these sentences, which clue helped you the most?

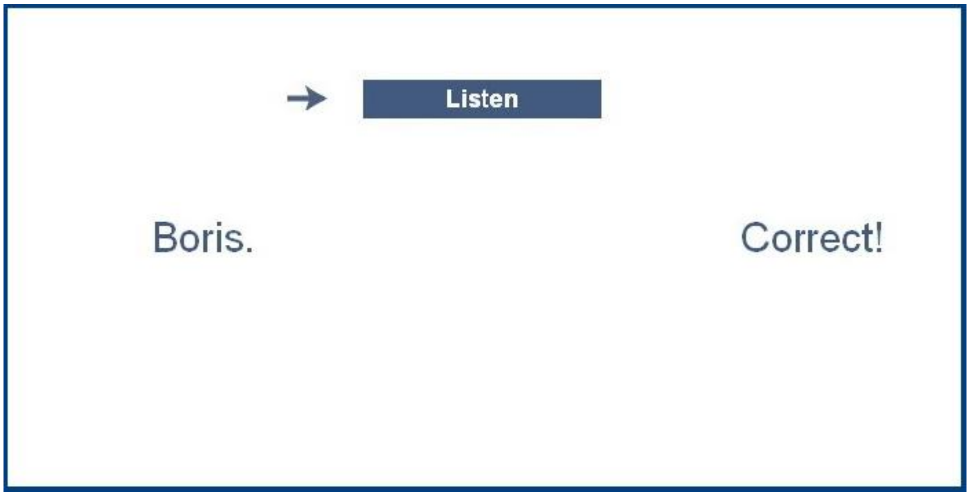
1. ________ The English sentence sounded similar to the Chinese sound.
2. ________ I knew what each word meant in Chinese.
3. _________ The structure of English sentence was similar to the Chinese one.

Q9. Below is a picture from the Testing Phase. When you entered this page, what did you do?



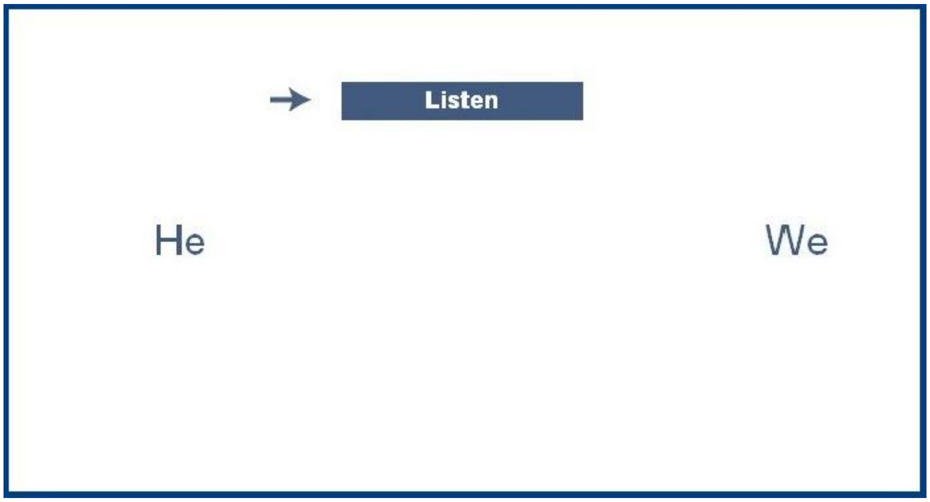
1. _______ Clicked the “Listen” button first.
2. _______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.
3. _______ Guess what each sentence sounds like in Chinese before clicking the “Listen” button.
4. _______ Ruled out the sentence that doesn’t match the Chinese sound.

Q10. Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



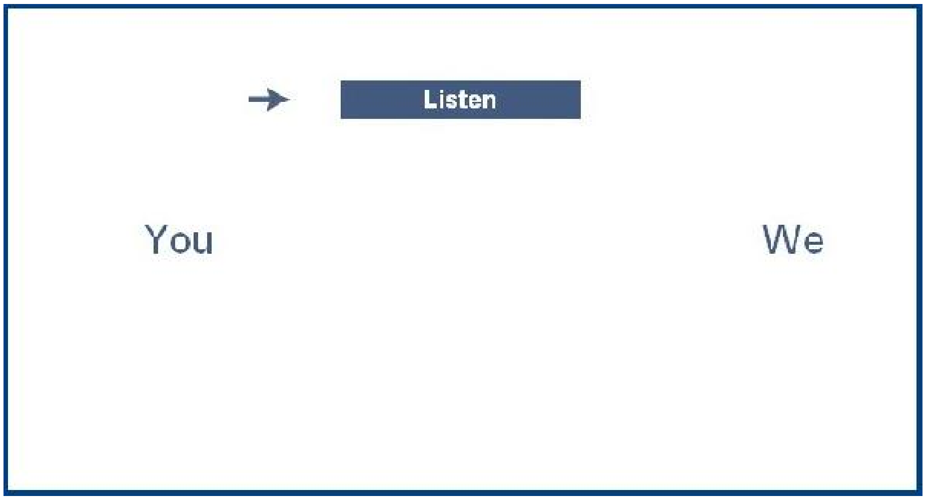
1. ________ Looked for the English sentence that was similar in length to the Chinese sound.
2. ________ Looked for the English sentence that sounded similar to the Chinese sound.
3. ________ Looked for the sentence that matched the meaning of the Chinese sound.
4. ________ Clicked the “Listen” button again because the sound was not heard clearly before.

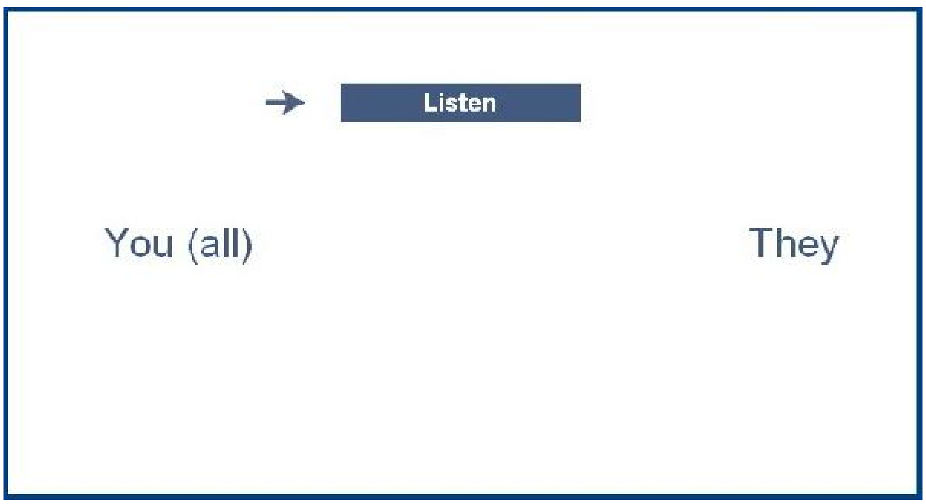
Q11. Below is a picture from the Testing Phase. When you listened to the sound “Tā,” which clue helped you the most?



1. ________“He” means “Tā.”
2. ________ The word that refers more than one person must have a “men” sound so the other word must be right.
3. ________ “Tā” refers to a person neither I nor you.
4. ________ I don’t know why, but I just know the answer.

Q12. Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?


Listen
You
We


Listen
You (all)
They


Listen
They
We

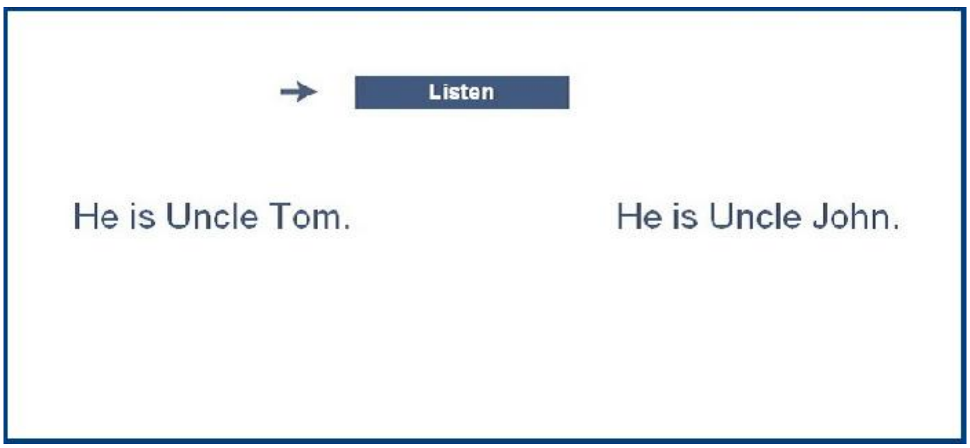
1. ________ On each slide, both words meant more than one person.

2. ________ There was a sound “men” in every word.

3. ________ On each slide, the words referred to different person.

4. ________ On each slide, the beginning sounds of both words were different.

Q13. Below is a picture from the Testing Phase. When you compared these sentences, which clue helped you the most?

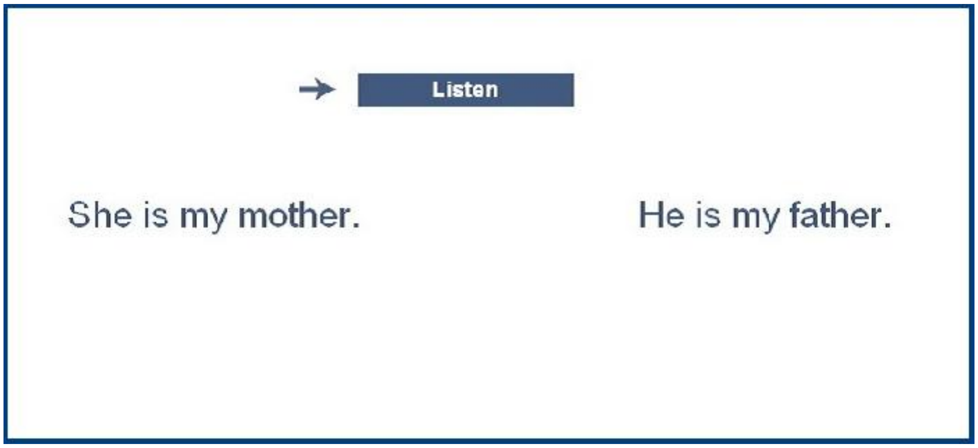


1. ________ The English sentence sounded similar to the Chinese sound.

2. ________ I knew what each word meant in Chinese.

3. ________ The structure of English sentence was similar to the Chinese one.

Q14. Below is a picture from the Testing Phase. When you entered this page, what did you do?



1. _______ Clicked the "Listen" button first.
2. _______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.
3. _______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.
4. _______ Ruled out the sentence that doesn't match the Chinese sound.

Q15. Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?

1. ________ Looked for the English sentence that was similar in length to the Chinese sound.
2. ________ Looked for the English sentence that sounded similar to the Chinese sound.
3. ________ Looked for the sentence that matched the meaning of the Chinese sound.
4. ________ Clicked the “Listen” button again because the sound was not heard clearly before.

Qualtrics—Vocabulary Application Test Questions
for both Experimental and Control Groups

Q16. What is the plural form of "you" in Chinese?
1. Nǐ
2. Wǒmen
3. Nǐmen
4. Nǐhǎo

Q17. What is the possible response (answer) to “Nǐ jiào shénme míngzi”?
1. Nǐhǎo!
2. Duì le!
3. Wǒ shì zhōng guó rén.
4. Wǒ jiào Bù Luò sī.

Q18. What does “shì” mean?
1. am
2. are
3. is
4. all of the above

Q19. Which of the following tells you about the nationality (country)?
1. ā yí
2. guó rén
3. bà ba
4. shū shu

Q20. Choose the word that does NOT belong.
1. bōbo
2. ā yí
3. shū shu
4. Duì le

Q21. Please select the answer that matches the meaning of this sentence.

“Tā shì tāng mǔ shū shu.”

1. She is my mother.
2. He is my father.
3. He is Uncle Tom.
4. He is Uncle John.

Q22. Please select the answer that matches the meaning of this sentence.

“What's your name?”

1. Wǒ jiào Lǐbōbo.
2. Nǐ jiào shénme míngzi?
3. Wǒ jiào Bù Luò sī.
4. Tā shì mǎ lì ā yí.

Q 23. Please guess the meaning of this sentence.

“Wǒmen shì měi guó rén.”

1. Women are Mary and Jenny.
2. They are Englishmen.
3. You are French.
4. We are American.

Q24. Please guess the Chinese of this sentence.

“My mother is Mary.”

1. Wǒde mā ma shì mǎ lì.
2. Wǒde bà ba shì yuē hàn.
3. Wǒde mā ma shì měi guó rén.
4. Wǒde bà ba shì fǎ guó rén.

Q25. Please guess the Chinese sound of this sentence.

“Boris is French.”

1. Wǒ jiào Bù Luò sī.
2. Wǒ shì fǎ guó rén.
3. Bù Luò sī shì měi guó rén.
4. Bù Luò sī shì fǎ guó rén.

Qualtrics—Learning Attitude Survey Questions

for both Experimental and Control Groups

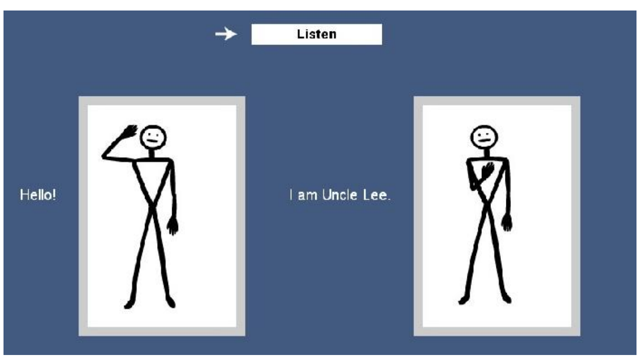
Q26. Please answer the following questions according to how you feel about the learning activities.

Rating values: 1 (disagree); 2 (slightly disagree); 3 (slightly agree); 4 (agree).

I like using this program to learn Chinese.	1	2	3	4
This program was easy to use.	1	2	3	4
This program was interesting to me.	1	2	3	4
I think Chinese is easy to learn.	1	2	3	4
I think I can speak a few Chinese sentences now.	1	2	3	4

Q27. The program has two different looks (one with animation and the other with text). Click the one you like better.

1. ___________



2. _________

APPENDIX 3

Qualtrics Survey Question Rubrics

Q1, Q6, Q11 Choice

1. SLA: Semantics

2. Cognitive: Elimination

3. SLA: Semantics

4. Cognitive: Guessing

Q2, Q7, Q12 Choice

1. SLA: Syntax

2. SLA: Phonology

3. SLA: Syntax

4. SLA: Phonology

Q3, Q8, Q13 Choice

1. Cognitive: Noticing

2. SLA: Semantics

3. SLA: Syntax

Q4, Q9, Q14 Choice

1. Cognitive: Guessing

2. Cognitive: Repetition

3. Cognitive: Prediction

4. Cognitive: Elimination

Q5, Q10, Q15 Choice

1. Cognitive: Prediction

2. Cognitive: Noticing

3. SLA: Phonology

4. Cognitive: Repetition

SLA Techniques

1.1. SLA: Semantics
1.3. SLA: Semantics
2.1. SLA: Syntax
2.2. SLA: Phonology
2.3. SLA: Syntax
2.4. SLA: Phonology
3.2. SLA: Semantics
3.3. SLA: Syntax
5.3. SLA: Phonology

Semantics	Phonology/Phonetics	Syntax
1.1	2.2	2.1
1.3	2.4	2.3
3.2	5.3	3.3
6.1	7.2	7.1
6.3	7.4	7.3
9.2	10.3	8.3
11.1	12.2	12.1
11.3	12.4	12.3
13.2	15.3	13.3

Cognitive Strategies

1.2. Cognitive: Elimination
1.4. Cognitive: Guessing
3.1. Cognitive: Noticing
4.1. Cognitive: Guessing
4.2. Cognitive: Repetition
4.3. Cognitive: Prediction
4.4. Cognitive: Elimination
5.1. Cognitive: Prediction
5.2. Cognitive: Noticing

5.4. Cognitive: Repetition

Eliminate	Act First/ Guess	Observe/Notice	Predict	Repeat
1.2	1.4	3.1	4.3	4.2
4.4	4.1	5.2	5.1	5.4
6.2	6.4	8.1	9.3	9.2
9.4	9.1	10.2	10.1	10.4
11.2	11.4	13.1	14.3	14.2
14.4	14.1	15.2	15.1	15.4

SLA Technique Categories

	Semantics	Phonology/Phonetics	Syntax
Value	**1**	**2**	**3**

Cognitive Strategy Categories

	Eliminate	Act First/ Wild Guess	Observe/Notice	Predict	Repeat
Value	**4**	**5**	**6**	**7**	**8**

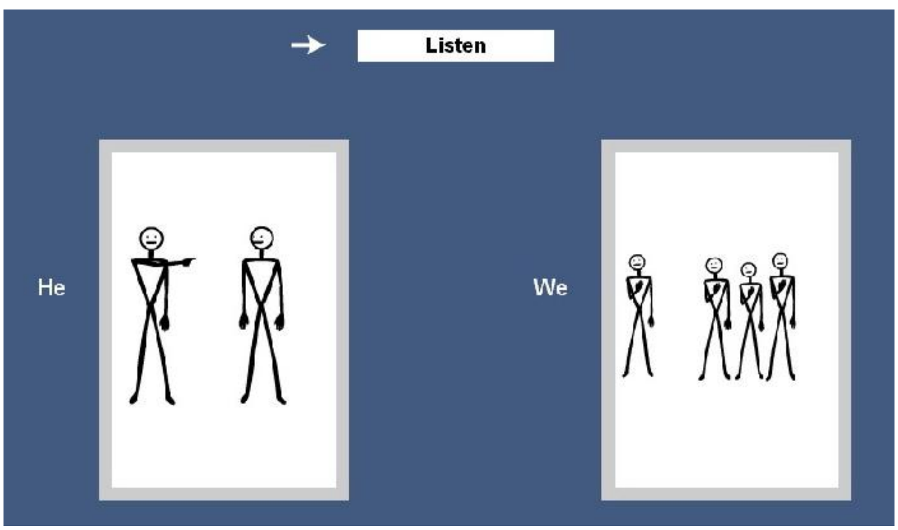
APPENDIX 4

(Rater) Strategy Identification Task—Experimental Group

The example below is part of a survey that was distributed to second language learners at the end of the online language game. The purpose of the survey is to collect the data that reflected which strategies learners apply during the game. In the survey, the learners are told to select the clue that most helps them solve the problems. This survey has no right or wrong answers; answers are only used for insights into the participant's learning style. The example is contained in this box immediately below.

Example:

Below is a picture from Testing Phase. When you listened to the sound "Tā," which clue helped you the most?



1.________"He" means "Tā."

2.________ The animation that refers to many people must have a "men" sound so the other animation must be right.

3. ________ "Tā" refers to a person neither I nor you.

4. ________ I don't know why, but I just know the answer.

YOUR TASK, over the next few pages, is to help the researcher analyze the strategies the learners used during their clue-identification tasks in the survey.

In the example below, if you believe that when the learners select ***"He" means "Ta"*** is an example of selecting **<semantics: meaning>** strategy, you would place the letter "c" on the line next to the number "1", like this:

1. ___c___ "He" means "Tā."

Which strategy do you believe learners used if they selected this response to this question?

a. phonology: sound
b. elimination: deletion
c. semantics: meaning
d. prediction: tell in advance
e. noticing: pay attention to distinctive features

Begin the task below, now.

Instruction: Following are the definitions of three second language acquisition (SLA) strategies—phonology, semantics, and syntax and five cognitive strategies—Elimination, Guessing, Noticing, Repetition, and Prediction.

Please read these definitions carefully:

SLA Strategies

Phonology. Phonological strategy is measured when learners focus on distinguishing the features of **sounds**.

Semantics. Semantic strategy is measured when learners understand the **meanings** of symbols or image.

Syntax. Syntactic strategy is measured when learners focus on **sentence structures** or grammar rules.

Cognitive Strategies

Elimination. Elimination strategy is measured when learners **delete** an unwanted element.

Guessing. Guessing strategy is measured when learners believe that they made a decision based on **intuition** or took an action without thinking.

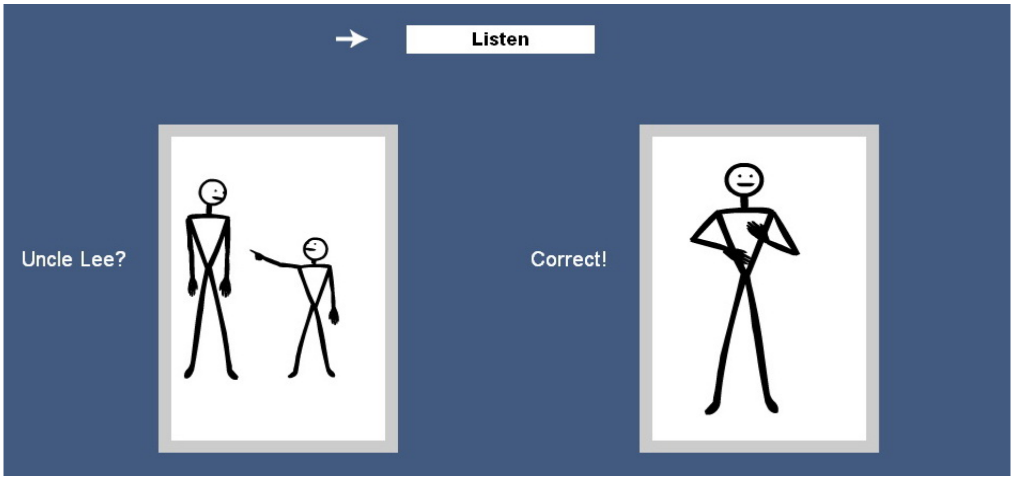
Noticing. Noticing strategy is measured when learners pay attention to **distinctive features** of things.

Repetition. Repetition strategy is measured when learners **try** the same action **multiple times** to confirm their hypotheses.

Prediction. Prediction strategy is measured when learners **tell** about something **in advance** of its occurrence by means of special knowledge or inference.

Q1. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you listened to the sound "Duì le!" which clue helped you the most?



1. ________ ***"Correct!" means "Duì le!"***
2. ________ ***"Uncle Lee" means "Lǐbōbo" so the other animation must be right.***
3. ________ ***"Duì le!" refers to the animation of the clapping man.***
4. ________ ***I don't know why, but I just know the answer.***

1. ________"Correct!" means "Duì le!"

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. phonology: sound
b. elimination: deletion
c. semantics: meaning
d. noticing: pay attention to distinctive features
e. syntax: sentence structure

2. _______“Uncle Lee” means “Lǐbōbo” so the other animation must be right.

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning
b. guessing: intuition
c. elimination: deletion
d. syntax: sentence structure
e. repetition: try multiple times

3. _______“Duì le!” refers to the animation of the clapping man.

The learner picked this response, which strategy do you think they used?

a. guessing: intuition
b. semantics: meaning
c. elimination: deletion
d. syntax: sentence structure
e. phonology: sound

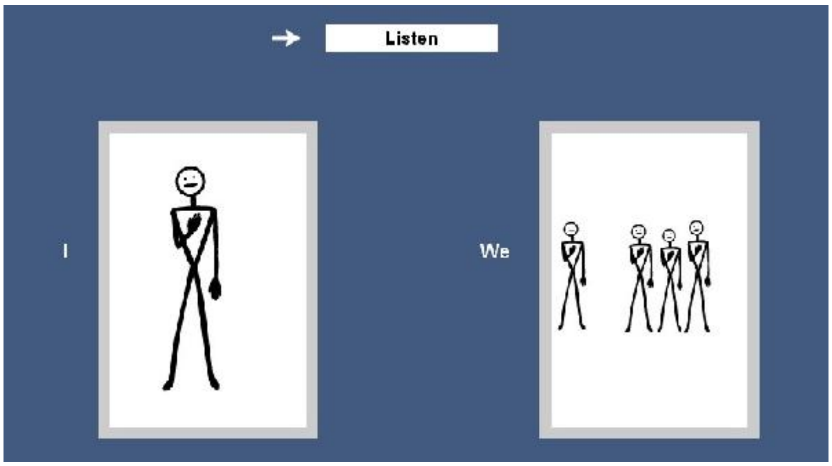
4. _______ I don’t know why, but I just know the answer.

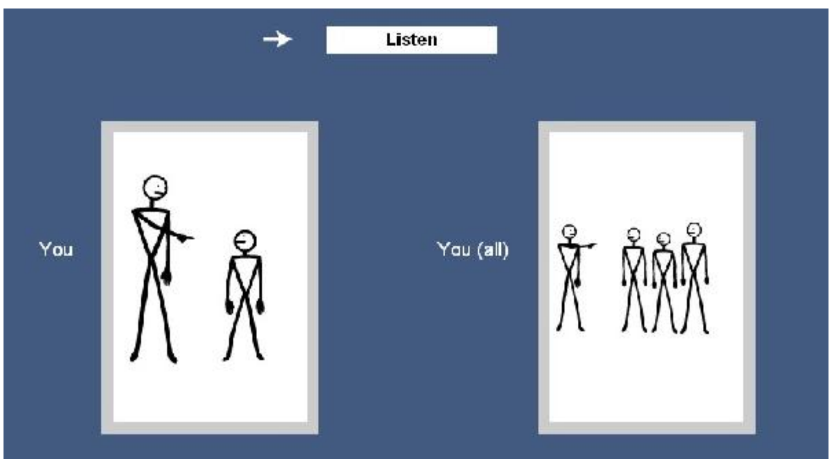
Which strategy was used if the learner picked this response?

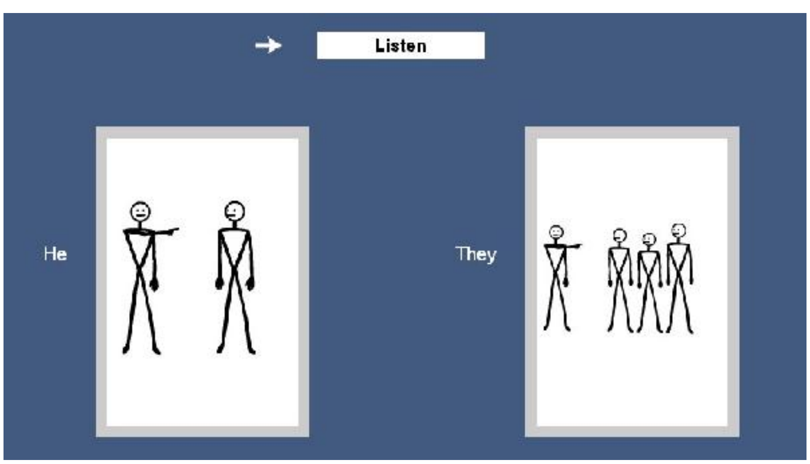
a. semantics: meaning
b. elimination: deletion
c. guessing: intuition
d. phonology: sound
e. syntax: sentence structure

Q2. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







1. **_______ *The number of people was different between two animations of a slide.***
2. **_______ *There was an extra sound "men" in the right animation.***
3. **_______ *In both animations of the same slide, the people on the left had the same gesture.***
4. **_______ *On each slide, the beginning sound of both animations was the same.***

1. **_______ *The number of people was different between two animations of a slide.***

The learner picked this response, which strategy do you think they used?

a. syntax: sentence structure
b. phonology: sound
c. repetition: try multiple times
d. elimination: deletion
e. guessing: intuition

2. **_______ *There was an extra sound "men" in the right animation.***

Which strategy do you believe learners used if they selected this response to this question?

a. syntax: sentence structure
b. repetition: try multiple times
c. phonology: sound
d. prediction: tell in advance
e. semantics: meaning

3. **_______ *In both animations of the same slide, the people on the left had the same gesture.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. repetition: try multiple times
b. syntax: sentence structure
c. guessing: intuition
d. phonology: sound
e. elimination: deletion

4. _______ On each slide, the beginning sound of both animations was the same.

Which strategy was used if the learner picked this response?

a. elimination: deletion

b. syntax: sentence structure

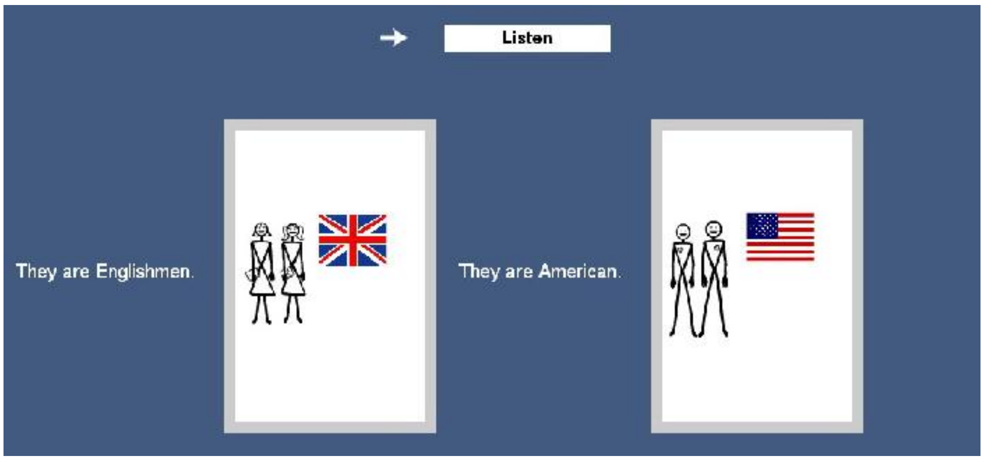
c. repetition: try multiple times

d. phonology: sound

e. semantics: meaning

Q3. When you see these three answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you compared these animations, which clue helped you the most?



1. ________ The English sentence sounded similar to the Chinese sound.
2. ________ I knew the meaning of the animation and its Chinese sound.
3._________ The structure of English sentence was similar to the Chinese one.

1. ________ The English sentence sounded similar to the Chinese sound.

Which strategy do you believe learners used if they selected this response to this question?

a. elimination: deletion
b. syntax: sentence structure
c. semantics: meaning
d. noticing: pay attention to distinctive features
e. repetition: try multiple times

2. ________ I knew the meaning of the animation and its Chinese sound.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. semantics: meaning

b. syntax: sentence structure

c. noticing: pay attention to distinctive features

d. repetition: try multiple times

e. elimination: deletion

3._________ The structure of English sentence was similar to the Chinese one.

Which strategy was used if the learner picked this response?

a. noticing: pay attention to distinctive features

b. semantics: meaning

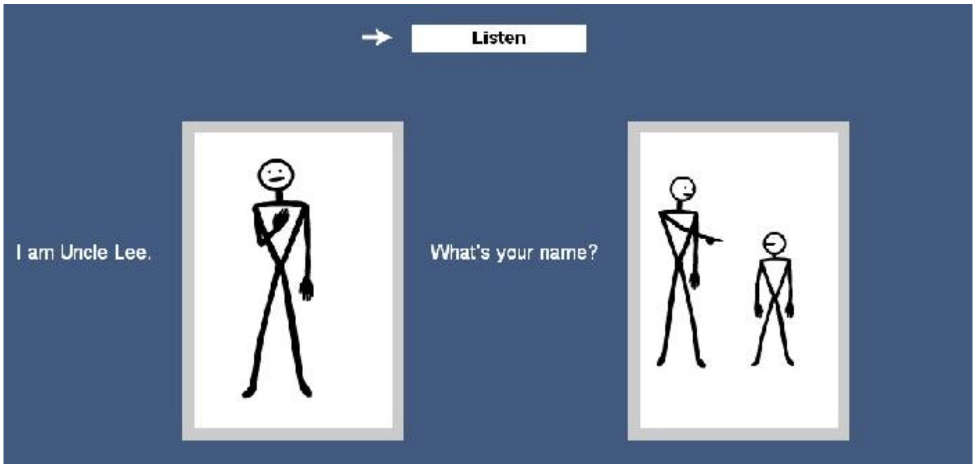
c. syntax: sentence structure

d. guessing: intuition

e. phonology: sound

Q4. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture of Testing Phase. When you entered this page, what did you do?



1. ***________ Clicked the "Listen" button first.***
2. ***________ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***
3. ***________ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***
4. ***________ Ruled out the sentence that doesn't match the Chinese sound.***

1. ***________ Clicked the "Listen" button first.***

   If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

   a. semantics: meaning
   b. elimination: deletion
   c. guessing: intuition
   d. syntax: sentence structure
   e. repetition: try multiple times

2. ________ ***Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***

Which strategy was used if the learner picked this response?

a. syntax: sentence structure
b. repetition: try multiple times
c. elimination: deletion
d. semantics: meaning
e. prediction: tell in advance

3. ________ ***Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***

The learner picked this response, which strategy do you think they used?

a. prediction: tell in advance
b. semantics: meaning
c. repetition: try multiple times
d. syntax: sentence structure
e. elimination: deletion

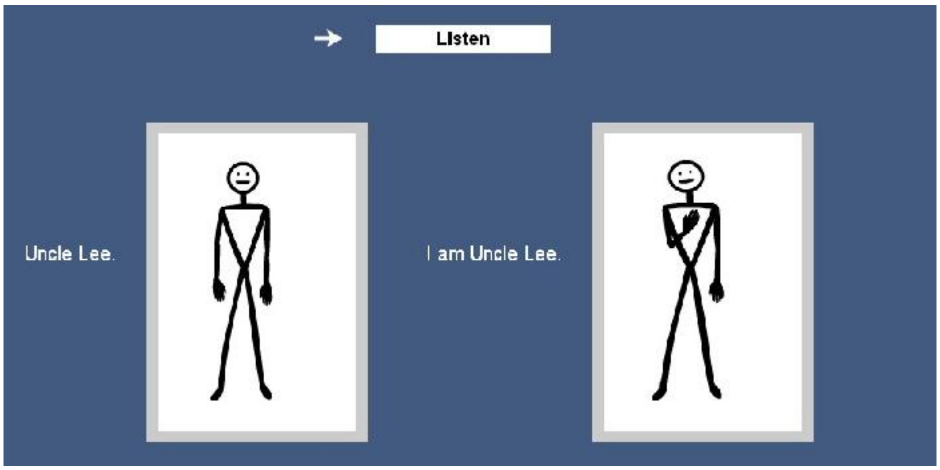
4. ________ ***Ruled out the sentence that doesn't match the Chinese sound.***

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning
b. elimination: deletion
c. guessing: intuition
d. syntax: sentence structure
e. repetition: try multiple times

Q5. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



1. ***________ Looked for the English sentence that was similar in length to the Chinese sound.***
2. ***________ Looked for the English sentence that sounded similar to the Chinese sound.***
3. ***________ Looked for the animation that matched the meaning of the Chinese sound.***
4. ***________ Clicked the "Listen" button again because the sound was not heard clearly before.***

1. ***________ Looked for the English sentence that was similar in length to the Chinese sound.***

Which strategy was used if the learner picked this response?

a. repetition: try multiple times
b. phonology: sound
c. prediction: tell in advance
d. semantics: meaning
e. guessing: intuition

2. ***________ Looked for the English sentence that sounded similar to the Chinese sound.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. semantics: meaning

b. elimination: deletion

c. syntax: sentence structure

d. noticing: pay attention to distinctive features

e. guessing: intuition

3. ________ Looked for the animation that matched the meaning of the Chinese sound.

The learner picked this response, which strategy do you think they used?

a. phonology: sound

b. repetition: try multiple times

c. elimination: deletion

d. syntax: sentence structure

e. prediction: tell in advance

4. ________ Clicked the "Listen" button again because the sound was not heard clearly before.

Which strategy do you believe learners used if they selected this response to this question?

a. repetition: try multiple times

b. syntax: sentence structure

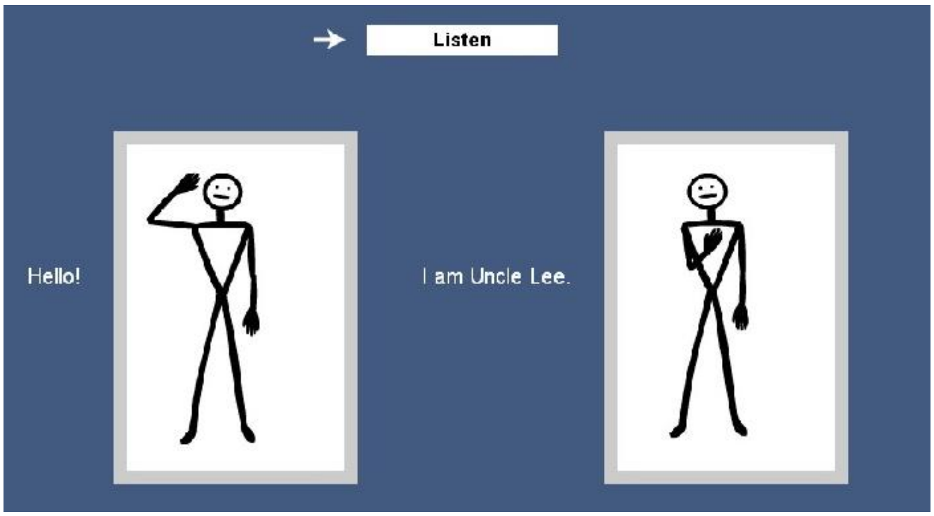
c. prediction: tell in advance

d. semantics: meaning

e. phonology: sound

Q6. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you listened to the sound "Nǐhǎo!" which clue helped you the most?



1. ***________"Nǐhǎo!" refers to the animation of the waving man.***
2. ***________"Uncle Lee" means "Lǐbōbo" so it is unlikely to be correct.***
3. ***________ I don't know why, but I just know the answer.***
4. ***________ "Nǐhǎo!" means "Hello!"***

1. ***________"Nǐhǎo!" refers to the animation of the waving man.***

Which strategy was used if the learner picked this response?

a. guessing: intuition
b. phonology: sound
c. semantics: meaning
d. repetition: try multiple times
e. prediction: tell in advance

2. ________"Uncle Lee" means "Lǐbōbo" so it is unlikely to be correct.

The learner picked this response, which strategy do you think they used?

a. elimination: deletion
b. phonology: sound
c. guessing: intuition
d. syntax: sentence structure
e. repetition: try multiple times

3. ________ I don't know why, but I just know the answer.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. guessing: intuition
c. elimination: deletion
d. phonology: sound
e. prediction: tell in advance

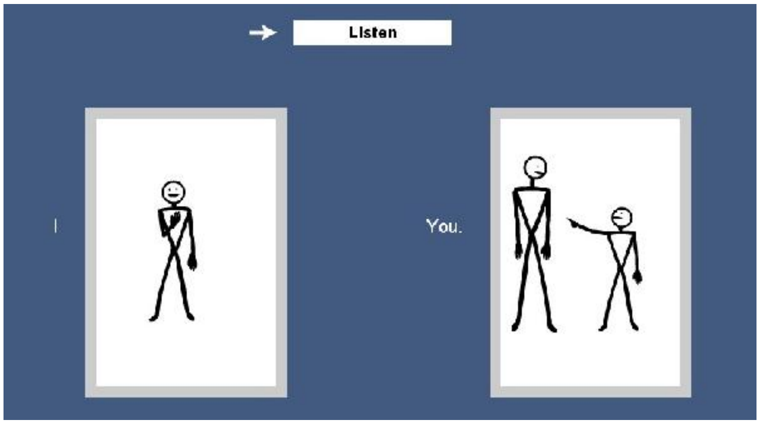
4. ________ "Nǐhǎo!" means "Hello!"

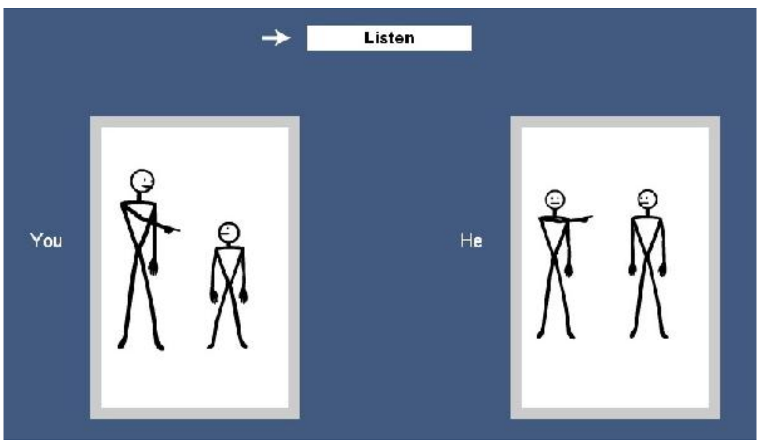
Which strategy do you believe learners used if they selected this response to this question?

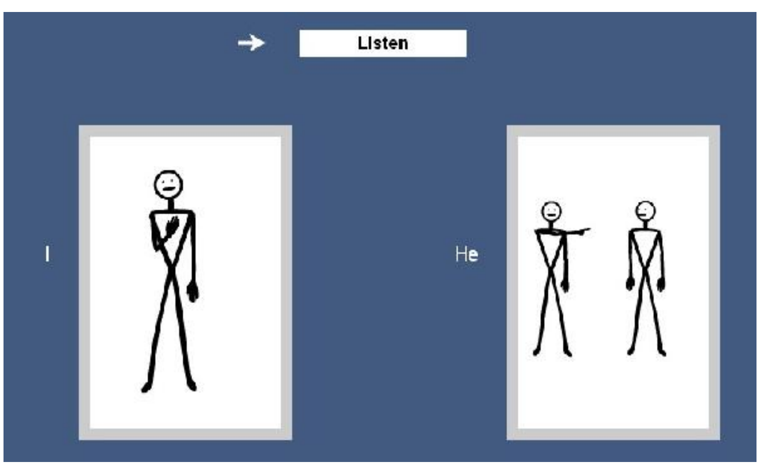
a. semantics: meaning
b. elimination: deletion
c. syntax: sentence structure
d. repetition: try multiple times
e. phonology: sound

Q7. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







1. ________ ***On each slide, the person who was pointing in each animation had different gesture.***
2. ________ ***On all slides, the Chinese sound of each animation had only one syllable.***
3. ________ ***The fingertip pointed to one person only.***
4. ________ ***On all slides, the Chinese sounds between two animations were different.***

1. ________ ***On each slide, the person who was pointing in each animation had different gesture.***

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. phonology: sound
c. syntax: sentence structure
d. guessing: intuition
e. elimination: deletion

2. ________ ***On all slides, the Chinese sound of each animation had only one syllable.***

Which strategy was used if the learner picked this response?

a. elimination: deletion
b. phonology: sound
c. syntax: sentence structure
d. prediction: tell in advance
e. semantics: meaning

3. ________ ***The fingertip pointed to one person only.***

Which strategy do you believe learners used if they selected this response to this question?

a. repetition: try multiple times
b. elimination: deletion
c. syntax: sentence structure
d. phonology: sound
e. semantics: meaning

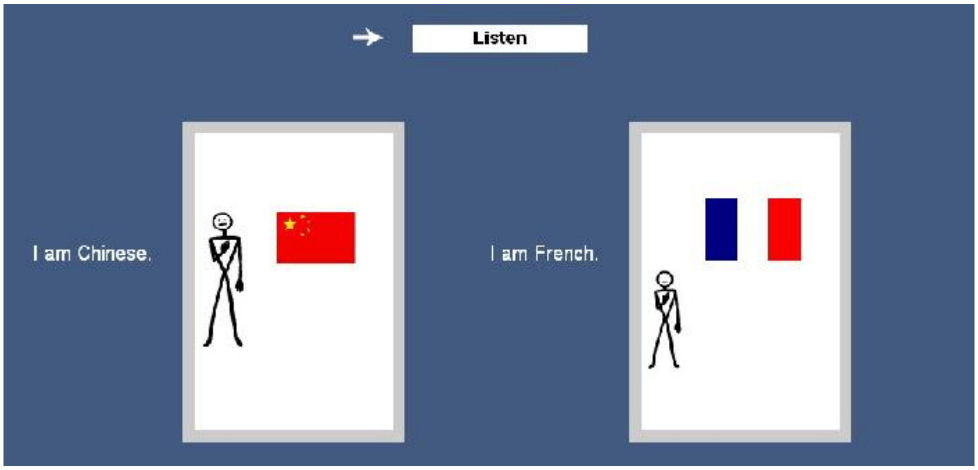
4. ________ On all slides, the Chinese sounds between two animations were different.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. phonology: sound
b. semantics: meaning
c. elimination: deletion
d. prediction: tell in advance
e. guessing: intuition

Q8. When you see these three answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you compared these animations, which clue helped you the most?



1. ***________ The structure of English sentence was similar to the Chinese one.***
2. ***_______ The English sentence sounded similar to the Chinese sound.***
3. ***_______ I knew the meaning of the animation and its Chinese sound.***

1. ***________ The structure of English sentence was similar to the Chinese one.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. phonology: sound
c. noticing: pay attention to distinctive features
d. repetition: try multiple times
e. elimination: deletion

2. ***_______ The English sentence sounded similar to the Chinese sound.***

Which strategy was used if the learner picked this response?

a. syntax: meaning
b. elimination: deletion

c. noticing: pay attention to distinctive features

d. semantics: meaning

e. prediction: tell in advance

3. _______ I knew the meaning of the animation and its Chinese sound.

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times

b. semantics: meaning

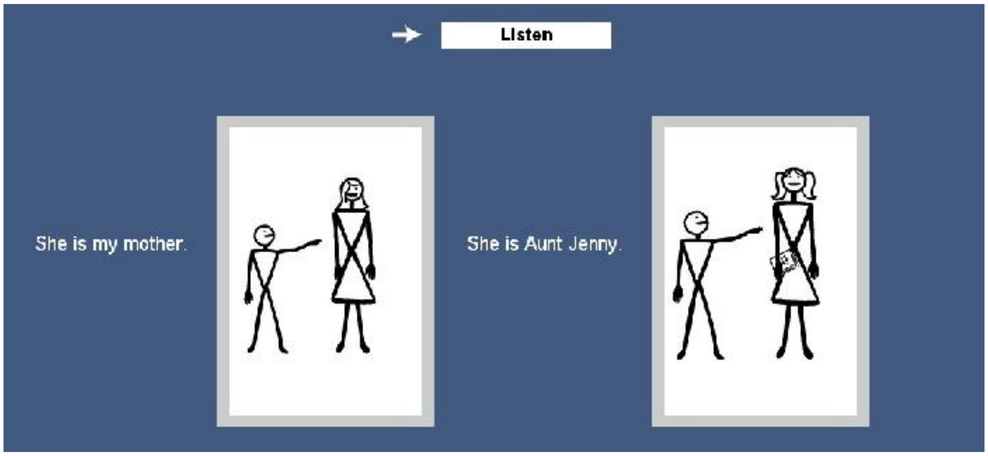
c. syntax: sentence structure

d. guessing: intuition

e. phonology: sound

Q9. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you entered this page, what did you do?



1. ***_______ Ruled out the sentence that doesn't match the Chinese sound.***
2. ***_______ Clicked the "Listen" button first.***
3. ***_______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***
4. ***_______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***

1. _______ Ruled out the sentence that doesn't match the Chinese sound.

Which strategy was used if the learner picked this response?

a. semantics: meaning
b. noticing: pay attention to distinctive features
c. elimination: deletion
d. syntax: sentence structure
e. phonology: sound

2. _______ Clicked the "Listen" button first.

Which strategy do you believe learners used if they selected this response to this question?

a. guessing: intuition

b. semantics: meaning
c. syntax: sentence structure
d. repetition: try multiple times
e. prediction: tell in advance

3. _______ *Clicked the "Listen" button twice because the sound was not heard clearly at the first time.*

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. semantics: meaning
c. repetition: try multiple times
d. elimination: deletion
e. guessing: intuition

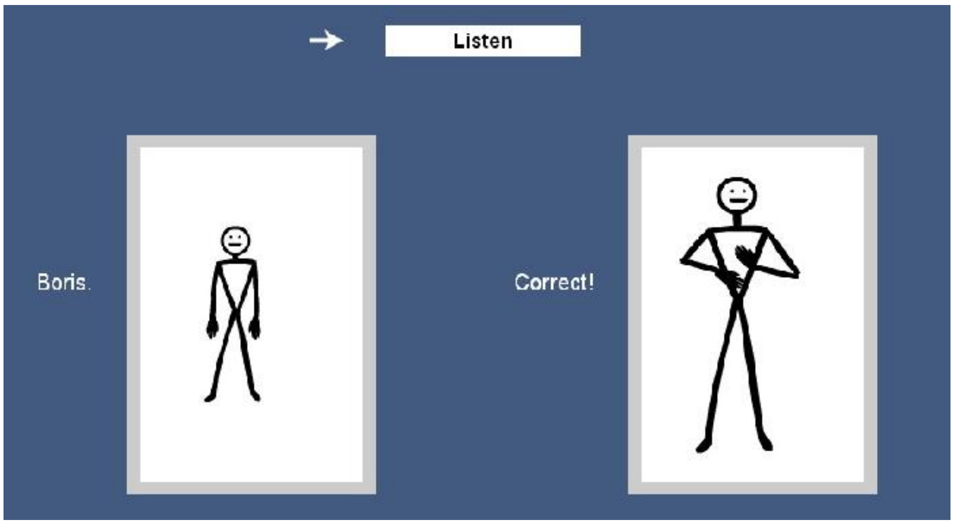
4. _______ *Guess what each sentence sounds like in Chinese before clicking the "Listen" button.*

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. prediction: tell in advance
c. syntax: sentence structure
d. semantics: meaning
e. phonology: sound

Q10. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



1. ***______ Looked for the English sentence that sounded similar to the Chinese sound.***
2. ***_______ Looked for the English sentence that was similar in length to the Chinese sound.***
3. ***_______ Looked for the animation that matched the meaning of the Chinese sound.***
4. ***_______ Clicked the "Listen" button again because the sound was not heard clearly before.***

1. ***______ Looked for the English sentence that sounded similar to the Chinese sound.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. elimination: deletion
b. syntax: sentence structure
c. noticing: pay attention to distinctive features
d. semantics: meaning
e. guessing: intuition

2. _______ Looked for the English sentence that was similar in length to the Chinese sound.

Which strategy do you believe learners used if they selected this response to this question?

a. prediction: tell in advance
b. semantics: meaning
c. repetition: try multiple times
d. phonology: sound
e. elimination: deletion

3. _______ Looked for the animation that matched the meaning of the Chinese sound.

Which strategy was used if the learner picked this response?

a. elimination: deletion
b. phonology: sound
c. syntax: sentence structure
d. guessing: intuition
e. repetition: try multiple times

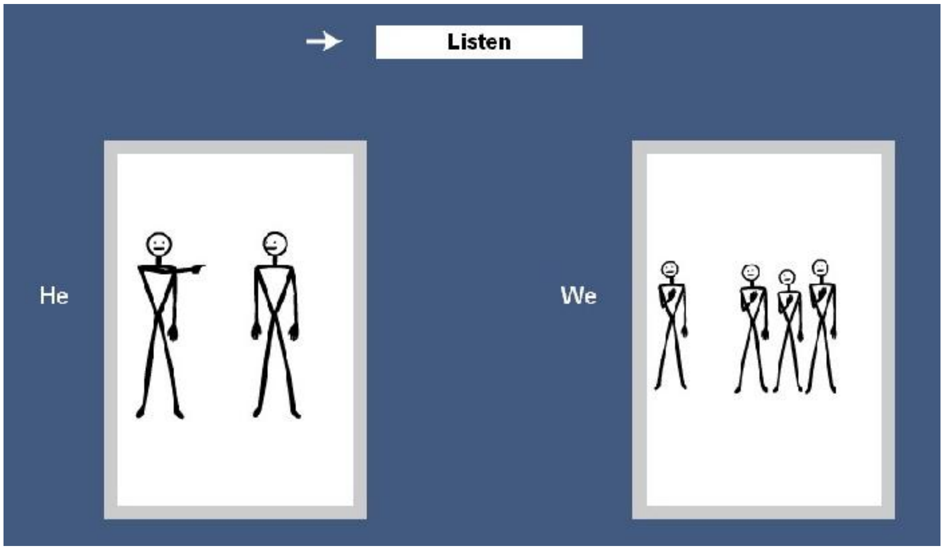
4. _______ Clicked the "Listen" button again because the sound was not heard clearly before.

The learner picked this response, which strategy do you think they used?

a. guessing: intuition
b. semantics: meaning
c. repetition: try multiple times
d. syntax: sentence structure
e. prediction: tell in advance

Q11. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from Testing Phase. When you listened to the sound "Tā," which clue helped you the most?



1. ________ ***I don't know why, but I just know the answer.***
2. ________***"He" means "Tā."***
3. ________ ***"Tā" refers to a person neither I nor you.***
4. ________ ***The animation that refers to many people must have a "men" sound so the other animation must be right.***

1. ________ I don't know why, but I just know the answer.

The learner picked this response, which strategy do you think they used?

a. guessing: intuition
b. syntax: sentence structure
c. elimination: deletion
d. semantics: meaning
e. prediction: tell in advance

2. ________“He” means “Tā.”

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. repetition: try multiple times
b. semantics: meaning
c. elimination: deletion
d. phonology: sound
e. noticing: pay attention to distinctive features

3. ________ “Tā” refers to a person neither I nor you.

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning
b. guessing: intuition
c. repetition: try multiple times
d. syntax: sentence structure
e. prediction: tell in advance

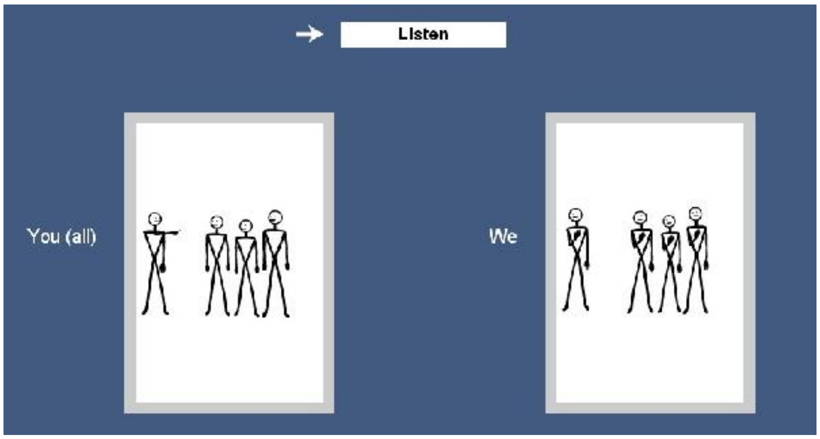
4. ________ The animation that refers to many people must have a “men” sound so the other animation must be right.

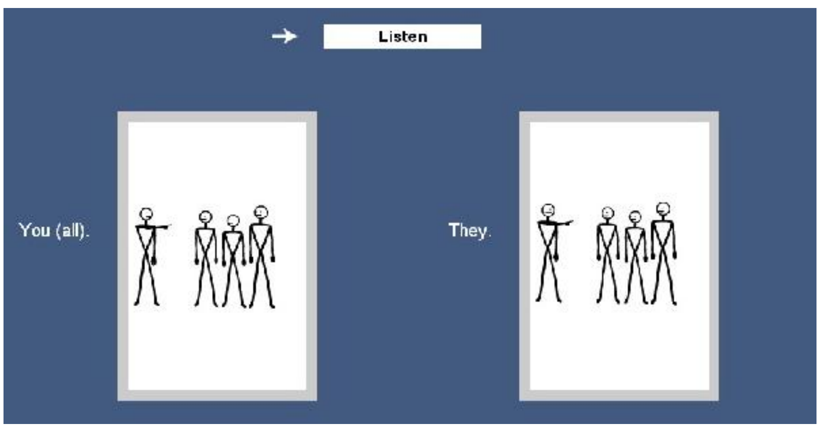
Which strategy was used if the learner picked this response?

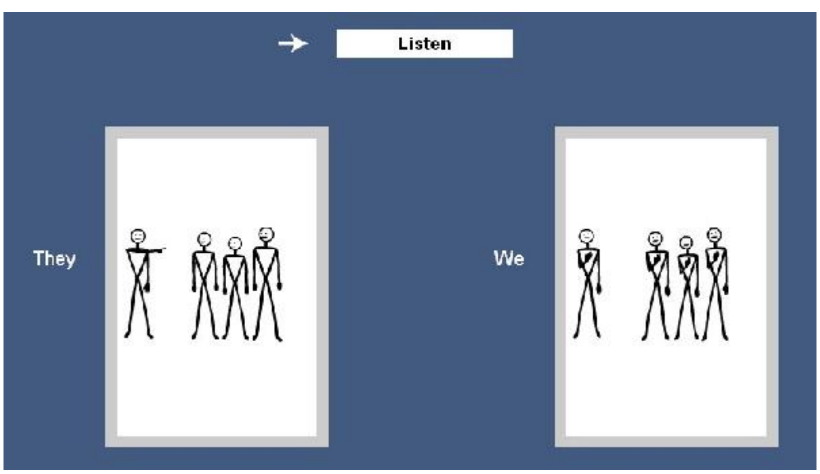
a. guessing: intuition
b. elimination: deletion
c. syntax: sentence structure
d. semantics: meaning
e. repetition: try multiple times

Q12. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







1. ________ ***The number of people in all animations was the same.***
2. ________ ***There was a sound "men" in every animation.***
3. ________ ***On each slide, the beginning sound of the two animations was different.***
4. ________ ***On each slide, the people on the left in the two animations had different gestures.***

1. ________ ***The number of people in all animations was the same.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. phonology: sound
b. syntax: sentence structure
c. elimination: deletion
d. guessing: intuition
e. repetition: try multiple times

2. ________ ***There was a sound "men" in every animation.***

Which strategy was used if the learner picked this response?

a. guessing: intuition
b. phonology: sound
c. repetition: try multiple times
d. semantics: meaning
e. syntax: sentence structure

3. ________ ***On each slide, the beginning sound of the two animations was different.***

The learner picked this response, which strategy do you think they used?

a. syntax: sentence structure
b. prediction: tell in advance
c. phonology: sound
d. elimination: deletion
e. semantics: meaning

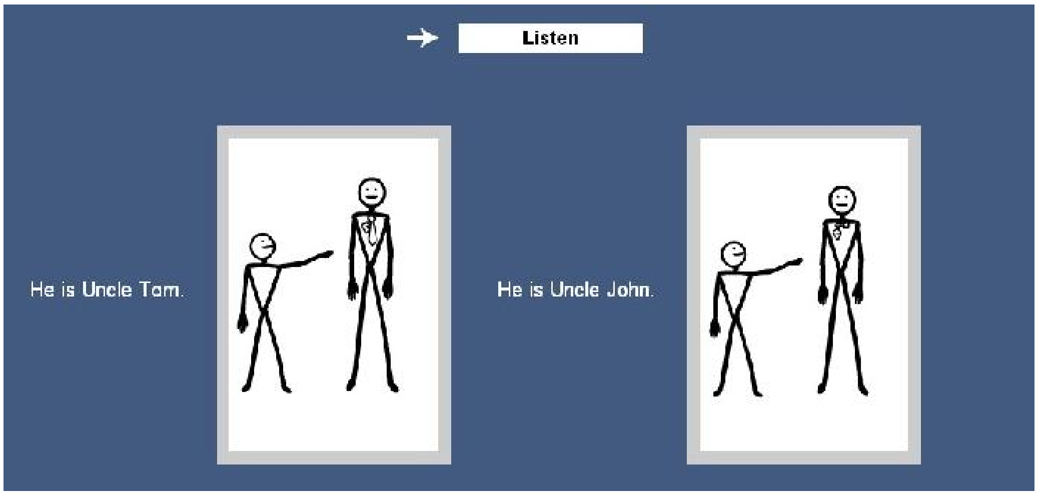
4. ________ On each slide, the people on the left in the two animations had different gestures.

Which strategy do you believe learners used if they selected this response to this question?

a. syntax: sentence structure
b. phonology: sound
c. prediction: tell in advance
d. guessing: intuition
e. repetition: try multiple times

Q13. When you see these three answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you compared these animations, which clue helped you the most?



1. _________ The structure of English sentence was similar to the Chinese one.
2.________ I knew the meaning of the animation and its Chinese sound.
3. ________ The English sentence sounded similar to the Chinese sound.

1. _________ The structure of English sentence was similar to the Chinese one.

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. syntax: sentence structure
c. semantics: meaning
d. prediction: tell in advance
e. phonology: sound

2.________ I knew the meaning of the animation and its Chinese sound.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. repetition: try multiple times
c. semantics: meaning
d. elimination: deletion
e. guessing: intuition

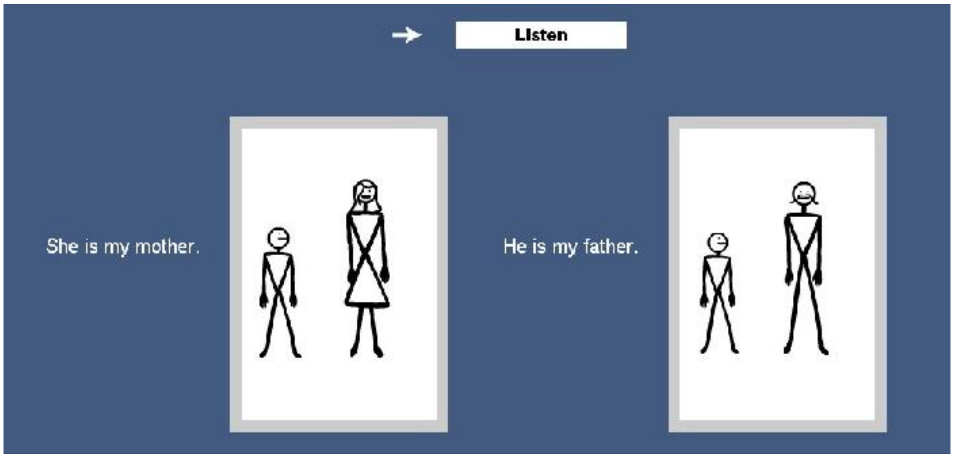
3.________ The English sentence sounded similar to the Chinese sound.

Which strategy do you believe learners used if they selected this response to this question?

a. noticing: pay attention to distinctive features
b. guessing: intuition
c. syntax: sentence structure
d. semantics: meaning
e. repetition: try multiple times

Q14. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you entered this page, what did you do?



1. ***_______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***
2. ***_______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***
3. ***_______ Clicked the "Listen" button first.***
4. ***_______ Ruled out the sentence that doesn't match the Chinese sound.***

1. ***_______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***

Which strategy was used if the learner picked this response?

a. syntax: sentence structure
b. elimination: deletion
c. prediction: tell in advance
d. semantics: meaning
e. phonology: sound

2. ***_______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. prediction: tell in advance
c. semantics: meaning
d. syntax: sentence structure
e. elimination: deletion

3. ***_______ Clicked the "Listen" button first.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. guessing: intuition
c. elimination: deletion
d. semantics: meaning
e. repetition: try multiple times

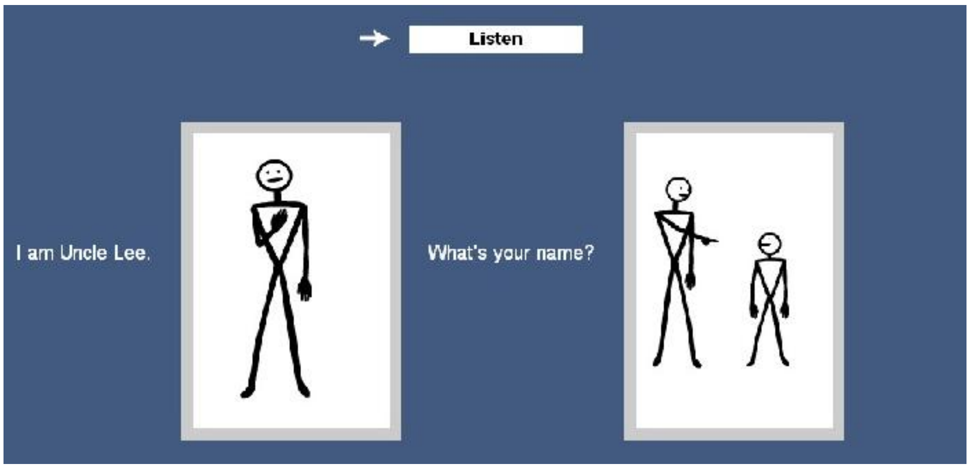
4. ***_______ Ruled out the sentence that doesn't match the Chinese sound.***

Which strategy do you believe learners used if they selected this response to this question?

a. elimination: deletion
b. prediction: tell in advance
c. semantics: meaning
d. syntax: sentence structure
e. noticing: pay attention to distinctive features

Q15. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



1. ***________ Looked for the English sentence that sounded similar to the Chinese sound.***
2. ***________ Looked for the English sentence that was similar in length to the Chinese sound.***
3. ***________ Clicked the "Listen" button again because the sound was not heard clearly before.***
4. ***________ Looked for the animation that matched the meaning of the Chinese sound.***

1. ________ Looked for the English sentence that sounded similar to the Chinese sound.

Which strategy was used if the learner picked this response?

a. noticing: pay attention to distinctive features
b. syntax: sentence structure
c. elimination: deletion
d. semantics: meaning
e. guessing: intuition

2. ________ Looked for the English sentence that was similar in length to the Chinese sound.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. semantics: meaning
b. prediction: tell in advance
c. repetition: try multiple times
d. syntax: sentence structure
e. elimination: deletion

3. ________ Clicked the "Listen" button again because the sound was not heard clearly before.

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning
b. repetition: try multiple times
c. syntax: sentence structure
d. guessing: intuition
e. phonology: sound

4. ________ Looked for the animation that matched the meaning of the Chinese sound.

The learner picked this response, which strategy do you think they used?

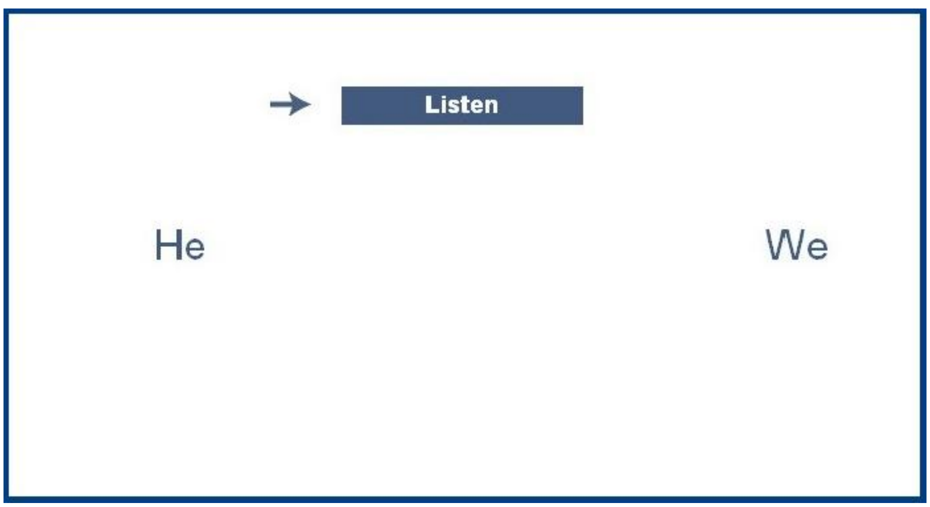
a. guessing: intuition
b. repetition: try multiple times
c. phonology: sound
d. syntax: sentence structure
e. elimination: deletion

(Rater) Strategy Identification Task—Control Group

The example below is part of a survey that was distributed to second language learners at the end of the online language game. The purpose of the survey is to collect the data that reflected which strategies learners apply during the game. In the survey, the learners are told to select the clue that most helps them solve the problems. This survey has no right or wrong answers; answers are only used for insights into the participant's learning style. The example is contained in this box immediately below.

Example:

Below is a picture from Testing Phase. When you listened to the sound "Tā," which clue helped you the most?



1.____✓____ "He" means "Tā."

2.________ The word that refers more than one person must have a "men" sound so the other word must be right.

3. ________ "Tā" refers to a person neither I nor you.

4. ________ I don't know why, but I just know the answer.

YOUR TASK, over the next few pages, is to help the researcher analyze the strategies the learners used during their clue-identification tasks in the survey.

In the example below, if you believe that when the learners select ***"He" means "Ta"*** is an example of selecting **<semantics: meaning>** strategy, you would place the letter "c" on the line next to the number "1", like this:

1. ___c___ "He" means "Tā."

Which strategy do you believe learners used if they selected this response to this question?

a. phonology: sound
b. elimination: deletion
c. semantics: meaning
d. prediction: tell in advance
e. noticing: pay attention to distinctive features

Begin the task below, now.

Instruction: Following are the definitions of three second language acquisition (SLA) strategies—phonology, semantics, and syntax and five cognitive strategies—Elimination, Guessing, Noticing, Repetition, and Prediction.

Please read these definitions carefully:

SLA Strategies

Phonology. Phonological strategy is measured when learners focus on distinguishing the features of **sounds**.

Semantics. Semantic strategy is measured when learners understand the **meanings** of symbols or image.

Syntax. Syntactic strategy is measured when learners focus on **sentence structures** or grammar rules.

Cognitive Strategies

Elimination. Elimination strategy is measured when learners **delete** an unwanted element.

Guessing. Guessing strategy is measured when learners believe that they made a decision based on **intuition** or took an action without thinking.

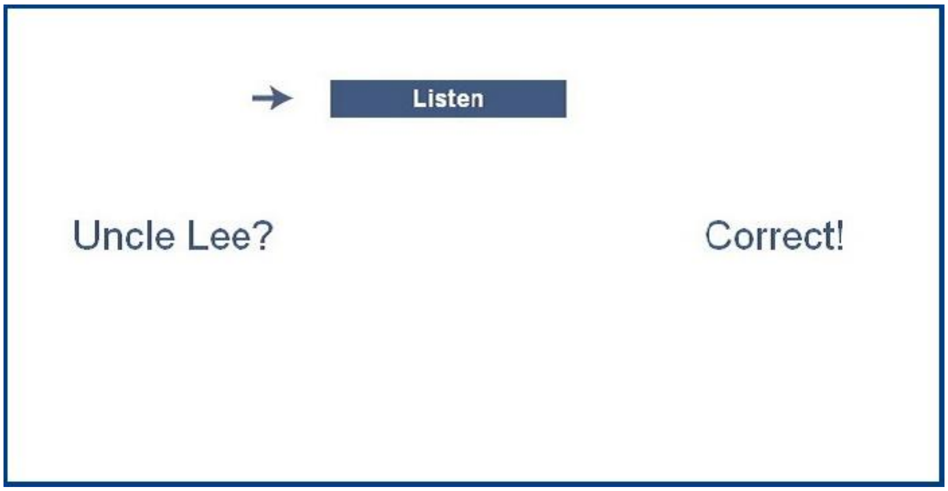
Noticing. Noticing strategy is measured when learners pay attention to **distinctive features** of things.

Repetition. Repetition strategy is measured when learners **try** the same action **multiple times** to confirm their hypotheses.

Prediction. Prediction strategy is measured when learners **tell** about something **in advance** of its occurrence by means of special knowledge or inference.

Q1. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you listened to the sound “Duì le!” which clue helped you the most?



1. _______“Correct!” means “Duì le!”
2. _______“Uncle Lee” means “Lǐbōbo” so the other sentence must be right.
3. _______“Duì le!” means “Matched already!”
4. _______ I don’t know why, but I just know the answer.

1. _______“Correct!” means “Duì le!”

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. phonology: sound
b. elimination: deletion
c. semantics: meaning
d. noticing: pay attention to distinctive features
e. syntax: sentence structure

2. _______***“Uncle Lee” means “Lǐbōbo” so the other sentence must be right.***

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning
b. guessing: intuition

c. elimination: deletion
d. syntax: sentence structure
e. repetition: try multiple times

3. _______“Duì le!” means “Matched already!”

The learner picked this response, which strategy do you think they used?

a. guessing: intuition
b. semantics: meaning
c. elimination: deletion
d. syntax: sentence structure
e. phonology: sound

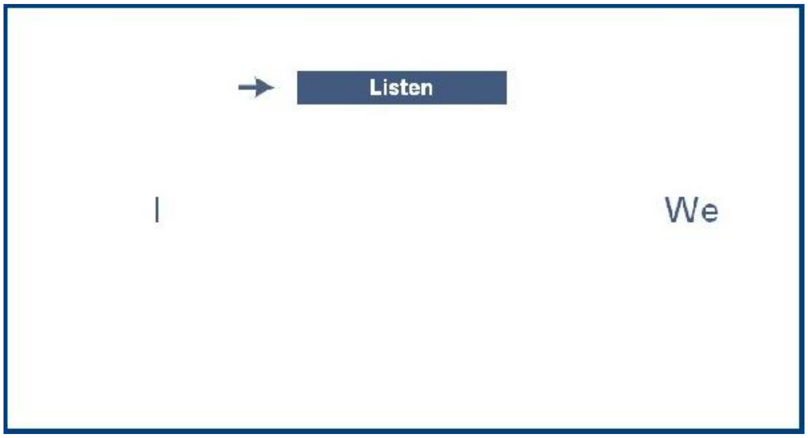
4. _______ I don’t know why, but I just know the answer.

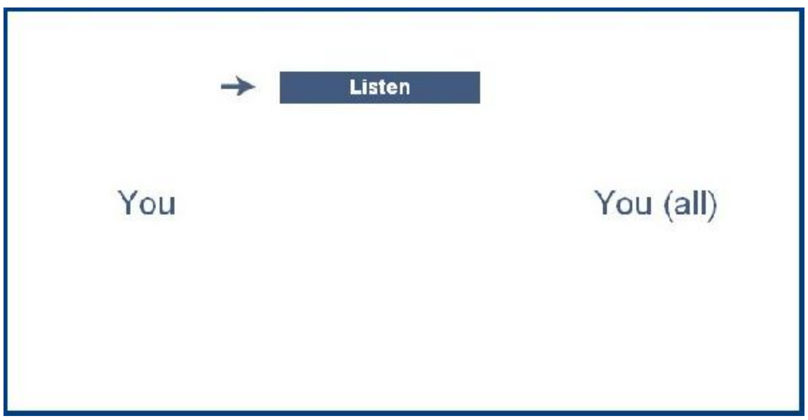
Which strategy was used if the learner picked this response?

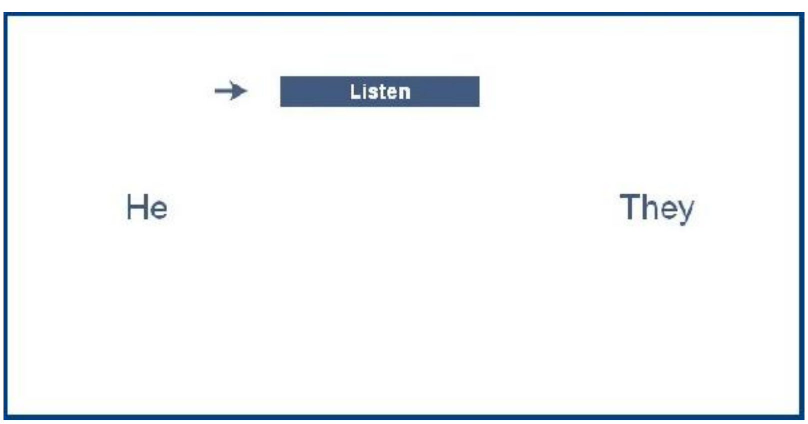
a. semantics: meaning
b. elimination: deletion
c. guessing: intuition
d. phonology: sound
e. syntax: sentence structure

Q2. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







1. _______ ***The word on the left means one person and the word on the right means more than one person.***
2. _______ ***There was an extra sound "men" in the word on the right.***
3. _______ ***The word on the left represented the singular person form while the word on the right represented the plural person form.***
4. _______ ***On each slide, the beginning sound of both words was the same.***

1. _______ ***The word on the left means one person and the word on the right means more than one person.***

The learner picked this response, which strategy do you think they used?

a. syntax: sentence structure
b. phonology: sound
c. repetition: try multiple times
d. elimination: deletion
e. guessing: intuition

2. _______ ***There was an extra sound "men" in the word on the right.***

Which strategy do you believe learners used if they selected this response to this question?

a. syntax: sentence structure
b. repetition: try multiple times
c. phonology: sound
d. prediction: tell in advance
e. semantics: meaning

3. _______ ***The word on the left represented the singular person form while the word on the right represented the plural person form.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. repetition: try multiple times
b. syntax: sentence structure

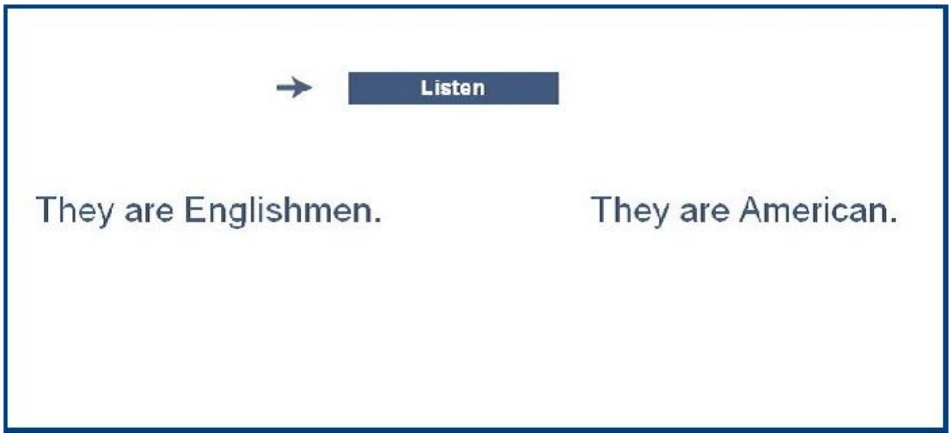
c. guessing: intuition
d. phonology: sound
e. elimination: deletion

4. _______ On each slide, the beginning sound of both words was the same.

Which strategy was used if the learner picked this response?
a. elimination: deletion
b. syntax: sentence structure
c. repetition: try multiple times
d. phonology: sound
e. semantics: meaning

Q3. When you see these three answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you compared these sentences, which clue helped you the most?



1. ________ The English sentence sounded similar to the Chinese sound.
2. ________ I knew what each word meant in Chinese.
3.__________ The structure of English sentence was similar to the Chinese one.

1. ________ The English sentence sounded similar to the Chinese sound.

Which strategy do you believe learners used if they selected this response to this question?

a. elimination: deletion
b. syntax: sentence structure
c. semantics: meaning
d. noticing: pay attention to distinctive features
e. repetition: try multiple times

2. ________ I knew what each word meant in Chinese.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. semantics: meaning
b. syntax: sentence structure
c. noticing: pay attention to distinctive features
d. repetition: try multiple times
e. elimination: deletion

3.________ The structure of English sentence was similar to the Chinese one.

Which strategy was used if the learner picked this response?

a. noticing: pay attention to distinctive features
b. semantics: meaning
c. syntax: sentence structure
d. guessing: intuition
e. phonology: sound

Q4. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture of Testing Phase. When you entered this page, what did you do?

1. ________ ***Clicked the "Listen" button first.***
2. ________ ***Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***
3. ________ ***Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***
4. ________ ***Ruled out the sentence that doesn't match the Chinese sound.***

1. ________ ***Clicked the "Listen" button first.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. semantics: meaning
b. elimination: deletion
c. guessing: intuition
d. syntax: sentence structure
e. repetition: try multiple times

2. ________ ***Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***

Which strategy was used if the learner picked this response?

a. syntax: sentence structure

b. repetition: try multiple times

c. elimination: deletion

d. semantics: meaning

e. prediction: tell in advance

3. ________ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.

The learner picked this response, which strategy do you think they used?

a. prediction: tell in advance

b. semantics: meaning

c. repetition: try multiple times

d. syntax: sentence structure

e. elimination: deletion

4. ________ Ruled out the sentence that doesn't match the Chinese sound.

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning

b. elimination: deletion

c. guessing: intuition

d. syntax: sentence structure

e. repetition: try multiple times

Q5. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?

1. ***________ Looked for the English sentence that was similar in length to the Chinese sound.***
2. ***________ Looked for the English sentence that sounded similar to the Chinese sound.***
3. ***________ Looked for the English sentence that matched the meaning of the Chinese sound.***
4. ***________ Clicked the "Listen" button again because the sound was not heard clearly before.***

1. ***________ Looked for the English sentence that was similar in length to the Chinese sound.***

Which strategy was used if the learner picked this response?

a. repetition: try multiple times
b. phonology: sound
c. prediction: tell in advance
d. semantics: meaning
e. guessing: intuition

2. ________ Looked for the English sentence that sounded similar to the Chinese sound.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. semantics: meaning
b. elimination: deletion
c. syntax: sentence structure
d. noticing: pay attention to distinctive features
e. guessing: intuition

3. ________ Looked for the English sentence that matched the meaning of the Chinese sound.

The learner picked this response, which strategy do you think they used?

a. phonology: sound
b. repetition: try multiple times
c. elimination: deletion
d. syntax: sentence structure
e. prediction: tell in advance

4. ________ Clicked the "Listen" button again because the sound was not heard clearly before.

Which strategy do you believe learners used if they selected this response to this question?

a. repetition: try multiple times
b. syntax: sentence structure
c. prediction: tell in advance
d. semantics: meaning
e. phonology: sound

Q6. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you listened to the sound "Nǐhǎo!" which clue helped you the most?

1. ________***"Nǐ" means "You" and "hǎo" means "do well!"***
2. ________***"Uncle Lee" means "Lǐbōbo" so it is unlikely to be correct.***
3. ________ ***I don't know why, but I just know the answer.***
4. ________ ***"Nǐhǎo!" means "Hello!"***

1. ________"Nǐ" means "You" and "hǎo" means "do well!"

Which strategy was used if the learner picked this response?

a. guessing: intuition
b. phonology: sound
c. semantics: meaning
d. repetition: try multiple times
e. prediction: tell in advance

2. ________"Uncle Lee" means "Lǐbōbo" so it is unlikely to be correct.

The learner picked this response, which strategy do you think they used?

a. elimination: deletion

b. phonology: sound
c. guessing: intuition
d. syntax: sentence structure
e. repetition: try multiple times

3.________ I don’t know why, but I just know the answer.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. guessing: intuition
c. elimination: deletion
d. phonology: sound
e. prediction: tell in advance

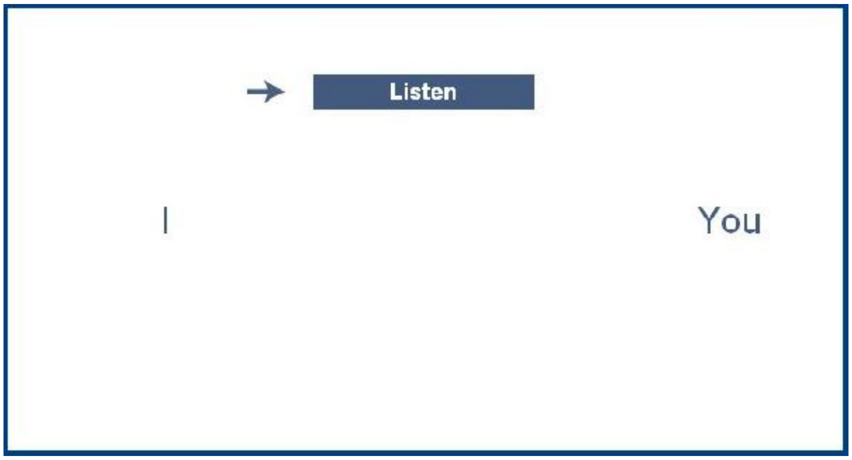
4.________ “Nǐhǎo!” means “Hello!”

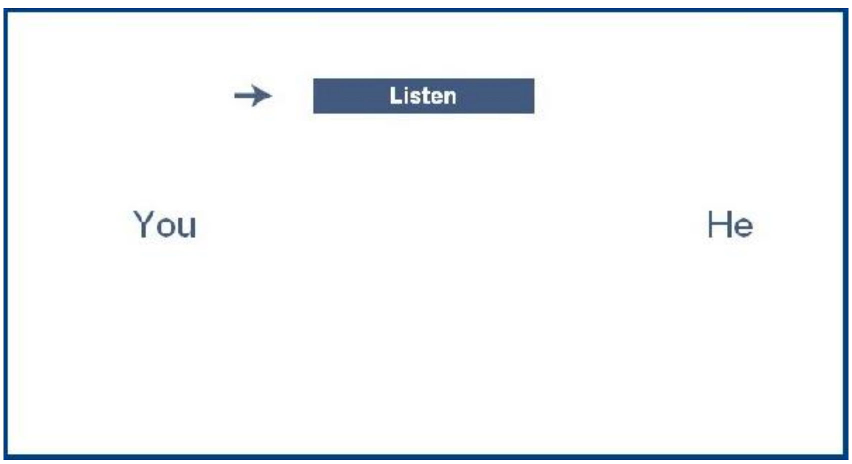
Which strategy do you believe learners used if they selected this response to this question?

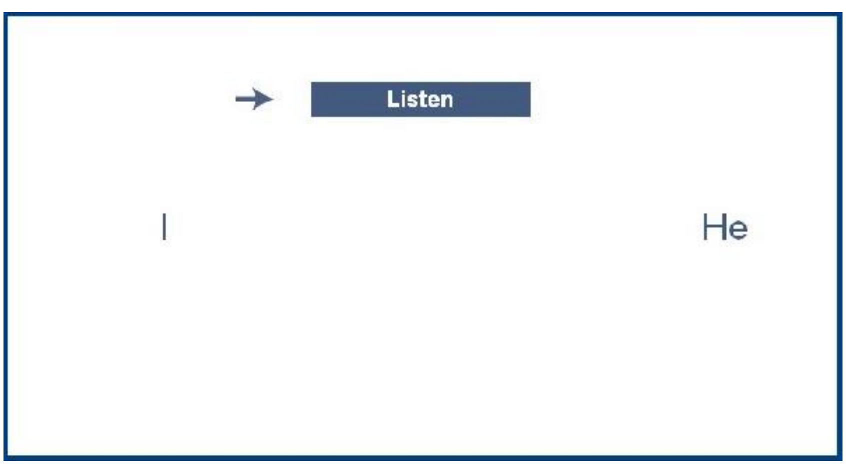
a. semantics: meaning
b. elimination: deletion
c. syntax: sentence structure
d. repetition: try multiple times
e. phonology: sound

Q7. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?







1. ________ ***Each word referred to different person.***
2. ________ ***On all slides, the Chinese sound of each word had only one syllable.***
3. ________ ***Each word referred to one person only.***
4. ________ ***On all slides, the Chinese sounds between two words were different.***

1. ________ ***Each word referred to different person.***

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. phonology: sound
c. syntax: sentence structure
d. guessing: intuition
e. elimination: deletion

2. ________ ***On all slides, the Chinese sound of each word had only one syllable.***

Which strategy was used if the learner picked this response?

a. elimination: deletion
b. phonology: sound
c. syntax: sentence structure
d. prediction: tell in advance
e. semantics: meaning

3. ________ ***Each word referred to one person only.***

Which strategy do you believe learners used if they selected this response to this question?

a. repetition: try multiple times
b. elimination: deletion
c. syntax: sentence structure
d. phonology: sound
e. semantics: meaning

4. ________ On all slides, the Chinese sounds between two words were different.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. phonology: sound

b. semantics: meaning

c. elimination: deletion

d. prediction: tell in advance

e. guessing: intuition

Q8. When you see these three answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you compared these sentences, which clue helped you the most?

1. ________ ***The structure of English sentence was similar to the Chinese one.***
2. _______ ***The English sentence sounded similar to the Chinese sound.***
3. _______ ***I knew what each word meant in Chinese.***

1. ________ *The structure of English sentence was similar to the Chinese one.*

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. phonology: sound
c. noticing: pay attention to distinctive features
d. repetition: try multiple times
e. elimination: deletion

2. _______ *The English sentence sounded similar to the Chinese sound.*

Which strategy was used if the learner picked this response?

a. syntax: meaning
b. elimination: deletion

c. noticing: pay attention to distinctive features

d. semantics: meaning

e. prediction: tell in advance

3. _______ I knew what each word meant in Chinese.

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times

b. semantics: meaning

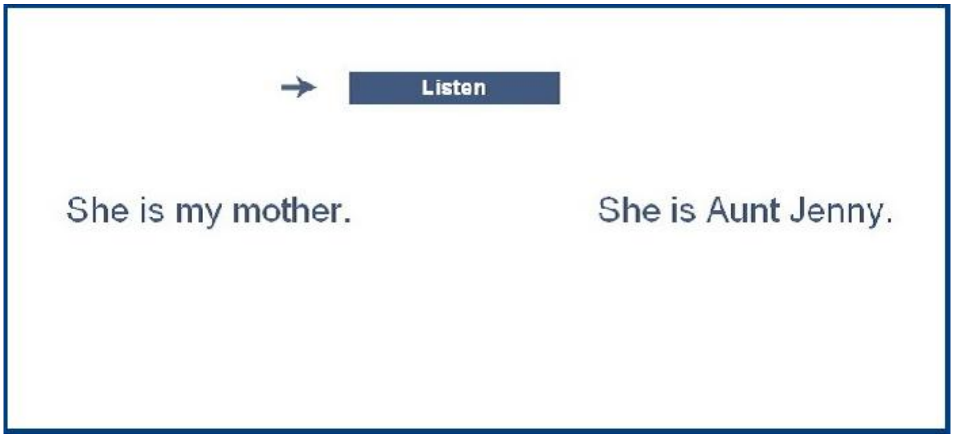
c. syntax: sentence structure

d. guessing: intuition

e. phonology: sound

Q9. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you entered this page, what did you do?



1. _______ Ruled out the sentence that doesn't match the Chinese sound.
2. _______ Clicked the "Listen" button first.
3. _______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.
4. _______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.

1. _______ Ruled out the sentence that doesn't match the Chinese sound.

Which strategy was used if the learner picked this response?

a. semantics: meaning
b. noticing: pay attention to distinctive features
c. elimination: deletion
d. syntax: sentence structure
e. phonology: sound

2. _______ Clicked the "Listen" button first.

Which strategy do you believe learners used if they selected this response to this question?

a. guessing: intuition
b. semantics: meaning
c. syntax: sentence structure

d. repetition: try multiple times
e. prediction: tell in advance

3. _______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. semantics: meaning
c. repetition: try multiple times
d. elimination: deletion
e. guessing: intuition

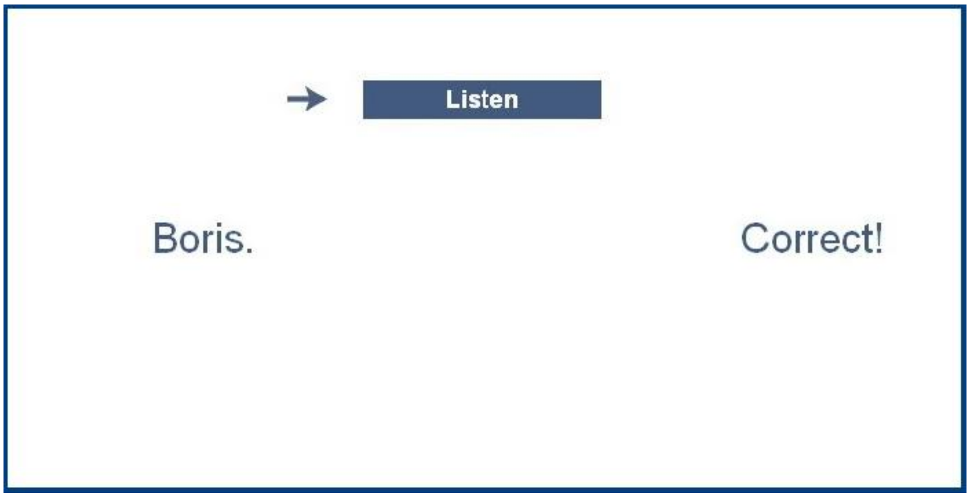
4. _______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. prediction: tell in advance
c. syntax: sentence structure
d. semantics: meaning
e. phonology: sound

Q10. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?



1. ***______ Looked for the English sentence that sounded similar to the Chinese sound.***
2. ***_______ Looked for the English sentence that was similar in length to the Chinese sound.***
3. ***_______ Looked for the sentence that matched the meaning of the Chinese sound.***
4. ***_______ Clicked the "Listen" button again because the sound was not heard clearly before.***

1. ***______ Looked for the English sentence that sounded similar to the Chinese sound.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. elimination: deletion
b. syntax: sentence structure
c. noticing: pay attention to distinctive features
d. semantics: meaning
e. guessing: intuition

2. _______ ***Looked for the English sentence that was similar in length to the Chinese sound.***

Which strategy do you believe learners used if they selected this response to this question?

a. prediction: tell in advance
b. semantics: meaning
c. repetition: try multiple times
d. phonology: sound
e. elimination: deletion

3. _______ ***Looked for the sentence that matched the meaning of the Chinese sound.***

Which strategy was used if the learner picked this response?

a. elimination: deletion
b. phonology: sound
c. syntax: sentence structure
d. guessing: intuition
e. repetition: try multiple times

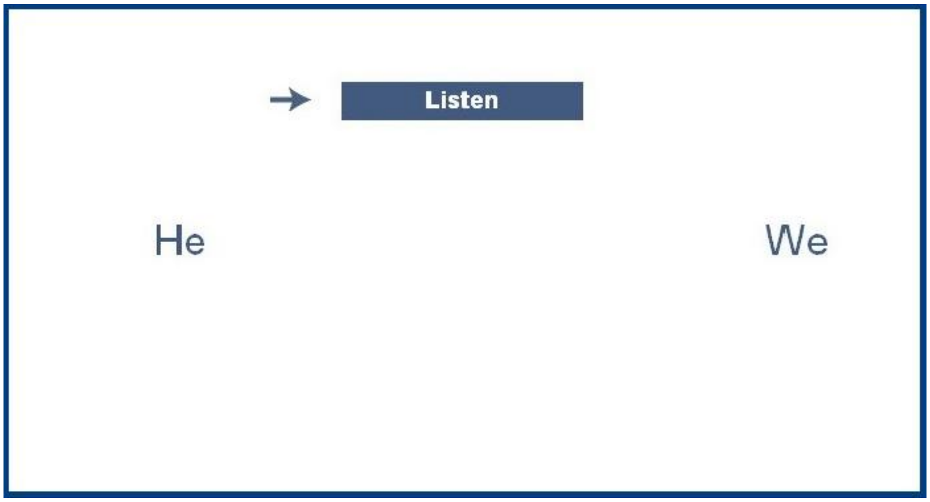
4. _______ ***Clicked the "Listen" button again because the sound was not heard clearly before.***

The learner picked this response, which strategy do you think they used?

a. guessing: intuition
b. semantics: meaning
c. repetition: try multiple times
d. syntax: sentence structure
e. prediction: tell in advance

Q11. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from Testing Phase. When you listened to the sound "Tā," which clue helped you the most?



1. ***________ I don't know why, but I just know the answer.***
2. ***________"He" means "Tā."***
3. ***________ "Tā" refers to a person neither I nor you.***
4. ***________ The word that refers to more than one person must have a "men" sound so the other word must be right.***

1. ________ I don't know why, but I just know the answer.

The learner picked this response, which strategy do you think they used?

a. guessing: intuition
b. syntax: sentence structure
c. elimination: deletion
d. semantics: meaning
e. prediction: tell in advance

2. ________"He" means "Tā."

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. repetition: try multiple times
b. semantics: meaning
c. elimination: deletion
d. phonology: sound
e. noticing: pay attention to distinctive features

3. ________ "Tā" refers to a person neither I nor you.

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning
b. guessing: intuition
c. repetition: try multiple times
d. syntax: sentence structure
e. prediction: tell in advance

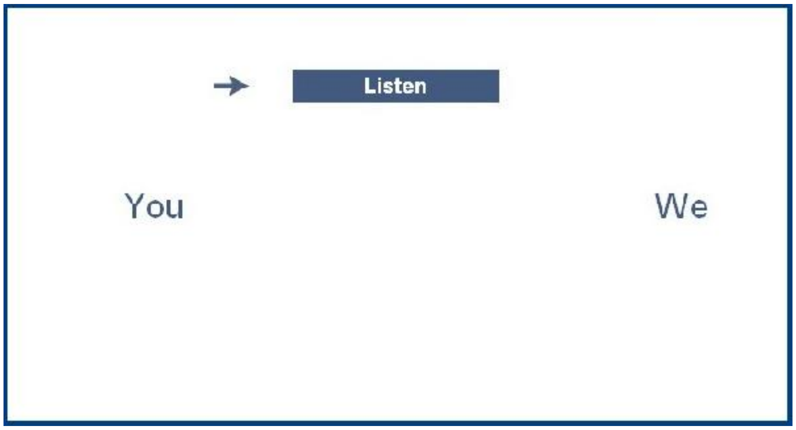
4. ________ ***The word that refers to more than one person must have a "men" sound so the other word must be right.***

Which strategy was used if the learner picked this response?

a. guessing: intuition
b. elimination: deletion
c. syntax: sentence structure
d. semantics: meaning
e. repetition: try multiple times

Q12. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below are pictures from the Testing Phase. From these three slides, what was the first thing that stood out to you?



1. ________ ***On each slide, both words meant more than one person.***
2. ________ ***There was a sound "men" in every word.***
3. ________ ***On each slide, the beginning sounds of both words were different.***
4. ________ ***On each slide, the words referred to different person.***

1. ________ ***On each slide, both words meant more than one person.***

Which strategy do you believe learners used if they selected this response to this question?

a. phonology: sound
b. syntax: sentence structure
c. elimination: deletion
d. guessing: intuition
e. repetition: try multiple times

2. ________ ***There was a sound "men" in every word.***

Which strategy was used if the learner picked this response?

a. guessing: intuition
b. phonology: sound
c. repetition: try multiple times
d. semantics: meaning
e. syntax: sentence structure

3. ________ ***On each slide, the beginning sounds of both words were different.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. prediction: tell in advance
c. phonology: sound
d. elimination: deletion
e. semantics: meaning

4. ________ On each slide, the words referred to different person.

The learner picked this response, which strategy do you think they used?

a. syntax: sentence structure

b. phonology: sound

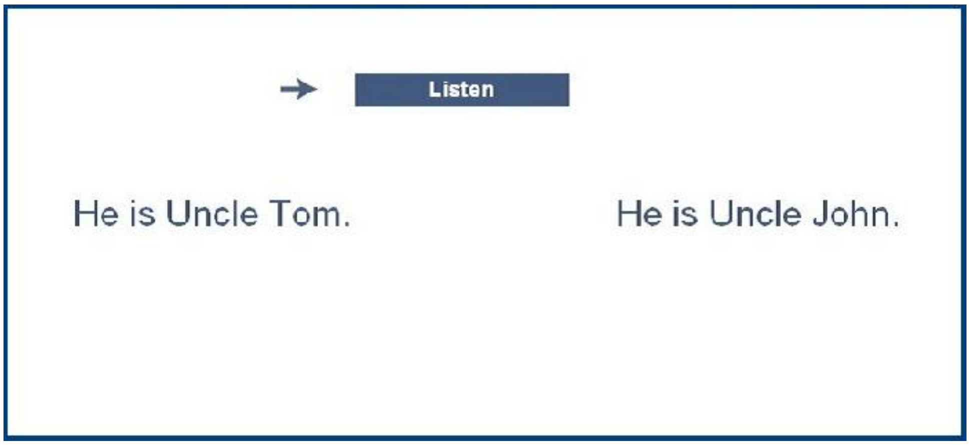
c. prediction: tell in advance

d. guessing: intuition

e. repetition: try multiple times

Q13. When you see these three answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you compared these sentences, which clue helped you the most?



1. __________ The structure of English sentence was similar to the Chinese one.
2.________ I knew what each word meant in Chinese.
3. ________ The English sentence sounded similar to the Chinese sound.

1. __________ The structure of English sentence was similar to the Chinese one.

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. syntax: sentence structure
c. semantics: meaning
d. prediction: tell in advance
e. phonology: sound

2.________ I knew what each word meant in Chinese.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. repetition: try multiple times

c. semantics: meaning
d. elimination: deletion
e. guessing: intuition

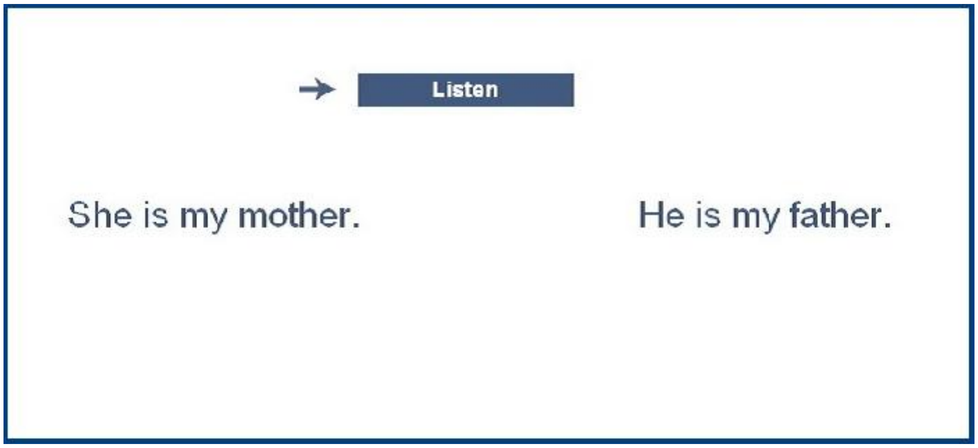
3.________ The English sentence sounded similar to the Chinese sound.

Which strategy do you believe learners used if they selected this response to this question?

a. noticing: pay attention to distinctive features
b. guessing: intuition
c. syntax: sentence structure
d. semantics: meaning
e. repetition: try multiple times

Q14. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. When you entered this page, what did you do?



1. ***_______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***
2. ***_______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***
3. ***_______ Clicked the "Listen" button first.***
4. ***_______ Ruled out the sentence that doesn't match the Chinese sound.***

1. ***_______ Guess what each sentence sounds like in Chinese before clicking the "Listen" button.***

Which strategy was used if the learner picked this response?

a. syntax: sentence structure
b. elimination: deletion
c. prediction: tell in advance
d. semantics: meaning
e. phonology: sound

2. ***_______ Clicked the "Listen" button twice because the sound was not heard clearly at the first time.***

The learner picked this response, which strategy do you think they used?

a. repetition: try multiple times
b. prediction: tell in advance
c. semantics: meaning
d. syntax: sentence structure
e. elimination: deletion

3. ***_______ Clicked the "Listen" button first.***

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. syntax: sentence structure
b. guessing: intuition
c. elimination: deletion
d. semantics: meaning
e. repetition: try multiple times

4. ***_______ Ruled out the sentence that doesn't match the Chinese sound.***

Which strategy do you believe learners used if they selected this response to this question?

a. elimination: deletion
b. prediction: tell in advance
c. semantics: meaning
d. syntax: sentence structure
e. noticing: pay attention to distinctive features

Q15. When you see these four answer options, which SLA or cognitive strategy do you think the learners would apply?

Below is a picture from the Testing Phase. After you clicked the listen button, what did you do next?

1. ________ ***Looked for the English sentence that sounded similar to the Chinese sound.***
2. ________ ***Looked for the English sentence that was similar in length to the Chinese sound.***
3. ________ ***Clicked the "Listen" button again because the sound was not heard clearly before.***
4. ________ ***Looked for the sentence that matched the meaning of the Chinese sound.***

1. ________ ***Looked for the English sentence that sounded similar to the Chinese sound.***

Which strategy was used if the learner picked this response?

a. noticing: pay attention to distinctive features
b. syntax: sentence structure
c. elimination: deletion
d. semantics: meaning
e. guessing: intuition

2. ________ Looked for the English sentence that was similar in length to the Chinese sound.

If the learner picked this as the correct answer, which strategy do you believe they used to respond to this question?

a. semantics: meaning
b. prediction: tell in advance
c. repetition: try multiple times
d. syntax: sentence structure
e. elimination: deletion

3. ________ Clicked the "Listen" button again because the sound was not heard clearly before.

Which strategy do you believe learners used if they selected this response to this question?

a. semantics: meaning
b. repetition: try multiple times
c. syntax: sentence structure
d. guessing: intuition
e. phonology: sound

4. ________ Looked for the sentence that matched the meaning of the Chinese sound.

The learner picked this response, which strategy do you think they used?

a. guessing: intuition
b. repetition: try multiple times
c. phonology: sound
d. syntax: sentence structure
e. elimination: deletion

APPENDIX 5

Predicting Vocabulary Test Scores through Listening Tests

A stepwise regression analysis was performed to examine whether a learner's listening comprehension test scores can predict his/her vocabulary application test score. The results show that adults' vocabulary test score was strongly positively correlated with their two listening test scores.

Correlations between Adults' Vocabulary Test and Two Listening Tests

	Total Scores	
Variable	Pearson's *r* correlation	Spearman's *rho* correlation
Listening Test I	.304**	.240*
Listening Test II	.379**	.414**

$^{*}p < .05$, $^{**}p < .01$, two-tailed.

The results show that children's vocabulary test score was also strongly positively correlated with their two listening test scores.

Correlations between Children's Vocabulary Test and Two Listening Tests

	Total Scores	
Variable	Pearson's *r* correlation	Spearman's *rho* correlation
Listening Test I	.294*	.454**
Listening Test II	.587**	.614**

$^{*}p < .05$, $^{**}p < .01$, two-tailed.

The results show that the variables of adults' two listening comprehension test scores predicted the vocabulary test scores, after controlling the items on listening test one (β =.224, p <.05) and listening test two (β = .313, p <.01). The listening test one and listening test two contributed 16.2% of the variation in the students' total scores.

Summary of Stepwise Regression for the Adults' Vocabulary and Listening Test Scores

Variable entered	Adjusted R^2	R square change	F	Standardized coefficient *Beta*	t	p
Listening Test 1	.162	.047	7.983	.224	2.019	.047*
Listening Test 2	.125	.137	11.404	.313	2.819	.006**

Stepwise solution was used. * $p < .05$, ** $p < .01$

The results show that only one of children's listening comprehension test scores could predict the vocabulary test scores, after controlling the items on listening test one (t= 5.755, p<.01). The listening test two contributed 33.4% of the variation in the students' total scores.

Summary of Stepwise Regression for the Children's Vocabulary and Listening Test Scores

Variable entered	Adjusted R^2	R square change	F	Standardized coefficient *Beta*	t	p
Listening Test 2	.334	.345	33.119	.587	5.755	.000**

Stepwise solution was used. * $p < .05$, ** $p < .01$

APPENDIX 6

Correlation between Actions and Thoughts

Pearson's *r* and Spearman's *rho* were performed to examine whether a learner's self-report strategy can reflect his/her actual action. The results show that adults' total number of clicks in the Learning Phase was strongly positively correlated with their selection of Repetition Strategy ($r = .388$).

Correlations between Adults' Selected Strategy and Action on Repetition

	Total Number of Clicks	
Variable	Pearson's *r* correlation	Spearman's *rho* correlation
Learning Phase	.388**	.248*
Practice Phase	-.008	.117

$^{*}p < .05$, $^{**}p < .01$, two-tailed.

The results show that children's total number of clicks in Learning and Practice Phase is not correlated with their selection of Repetition Strategy.

Correlations between Children's Selected Strategy and Action on Repetition

	Total Number of Clicks	
Variable	Pearson's *r* correlation	Spearman's *rho* correlation
Learning Phase	.127	.200
Practice Phase	-.126	-.045

$^{*}p < .05$, $^{**}p < .01$, two-tailed.