THE IMPACT OF ADDITIONAL TIME AND PRODUCTION BETWEEN STIMULI ON ADULT LANGUAGE LEARNING

By

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I. Abstract

This study followed up on a previous experiment, wherein adults were unable to learn a particular type of language sound rule (a Type II phonological rule), which infants were readily able to learn. As in the earlier study, adults participated in a familiarization phase, where they heard nonsense words that followed the rule in question, and a test phase where they had to judge new nonsense words as to whether they fit or did not fit the pattern of the familiarization words. Two factors that might improve learning were part of the familiarization phase of the current experiment (1) addition of time between familiarization words, (2) plus vocal production of each familiarization word. Twenty-five total adults participated, but the results did not indicate any improvement in the participants' ability to learn the Type II phonological rule based on the manipulated factors. Possible reasons for differences between infant and adult language learning are discussed.

II. Introduction

It has been observed that humans learning first or second languages during infancy or very early childhood are much more likely to reach native-like proficiency than those who learn a language later in life as adults. It seems that different properties of language are more sensitive to this age-learning constraint than others. For instance, one is always able to learn new words and add them to their mental lexicon at any point in their lives; however, learning sound patterns and rules is only feasible at an early age (Jusczyk, 2002). Infants are extremely fast learners and are able to distinguish their native language from other languages that have the same rhythmic patterns as early as 5 months of age. Babies are also born with no prior knowledge at all, and are able to intake all sounds that they hear. However, as they grow older infants begin to block out sounds that are not important in their native language—for instance, Japanese has no separate /l/ and /r/ sounds, but rather one alveolar consonant that lies somewhere in between these two (Best & Strange, 1992). A Japanese infant may be able to hear the difference between /l/ and /r/ at birth, but after about 10-12 months, they begin to only discriminate sounds that are relevant to their native language. Because the /l/ and /r/ sounds are not different in their language, these will become grouped together and make it difficult for an adult Japanese speaker to hear the difference between the two in a language that does discriminate between the two, such as English. Similarly, infants become familiar with which sound sequences are legal of their language during a similar period (Jusczyk, 2002).

If infants are so good at learning about the sound patterns of their native language, then it is crucial for them to have exposure to a language early on in order to learn which sounds are relevant to their native language. The overall final level of proficiency in learning the language also shows to be greatly affected by age. For example, a study was done on immigrant families

who moved to the United States (Collier, 1987). Children of these families who were immediately immersed into U.S. public schools were split into three age groups depending on the age of which they arrived to the country, and then their language learning was analyzed. The different age-of-arrival groups were 5-7 years old, 8-11 years old, and 12-15 years old. It was found that the oldest group of children, the 12-15 year olds, was the overall slowest group of learners. However, it was also found that the fastest learners were actually the 8-11 year olds, rather than the youngest group. The researchers speculated that this may be due to their motivation for learning; 8-11 year olds have a better understanding of what is going on than 5-year olds and will most likely be more motivated than young children to want to learn the new language that they have been immersed in. Moreover, they are still younger and have not reached the age of puberty, which the Critical Period Hypothesis speculates is the age at which language learning slows. Therefore, they are more likely to be faster at learning language than the 12-15 year olds.

Another study done on immigrants found that those who learned English at an earlier age had less of an accent in their speech than those who learned at a later age (Oyama, 1976). However, older learners were still able to learn; just like in Collier's study (1987). This indicates that there is not as strong of a cut-off age for second language acquisition as there appears to be for first language acquisition. As Oyama (1976) states, second language acquisition appears to adhere to a "sensitive period" rather than a "critical period". While typical adults can still learn language after puberty, they will almost never reach a native-like proficiency.

With so much research indicating that infants and young children are not only better at learning language, but also better at mastering native-like proficiency, it is important to ask why that is. Why are there some language properties that are so constrained by age in regards to

learning, and what are adults doing differently than infants and young children when attempting to learn such properties? Perhaps, in order to achieve native-like proficiency, adults need to begin learning in the same manner that infants do.

Past research has shown that infants are remarkable at making generalizations across even small sets of language-like data, and are able to pick up on phonological rules that are extremely difficult for adults to learn. Two types of phonological rules specifically, Type II rules and Type IV rules, have been used in these studies to compare infants' ability to learn them to adults' ability to learn the rules. The Type II rule under investigation here requires that both consonants in a two syllable CVCV word are produced with the same voicing phonological feature. For instance, either both consonants are produced with vocal cord vibrations (e.g., *boda*) or both without (e.g., *pota*). Using the headturn preference procedure, infants were seen to learn these rules and generalize over a set of language-like data from only four input words (Gerken & Knight 2015).

Adults were tested to see if they were able to learn the Type II phonological rule as well as infants. Adults were given a thirty minute experiment which was divided into two phases—a familiarization phase and a test phase. Participants were told that their tasks were to first carefully listen to native speakers (named "Qixians") of an alien language [the familiarization phase]; and then told to listen to more speakers and catch "spies" from a rival colony attempting to pass for native Qixians [the test phase]. They were told that spies would make grammatical mistakes that native Qixians would not; therefore, they had to listen very attentively to the native speakers in order to catch the differences between them and the spies. Unknown to the participants, the familiarization phase was comprised of made-up, two syllable CVCV words that followed the Type II phonological rule. The test phase consisted of more made-up CVCV words

in which some followed the Type II rule and some did not. The “spies” were the speakers that did not follow the rule, while native Qixian speakers did follow it. Therefore, if participants only chose speakers who did not follow the rule as spies, then they demonstrated that they were able to differentiate between consistent and inconsistent words and had learned the Type II phonological rule. However, results showed that adults were unable to differentiate consistent words from inconsistent ones, and had not learned the Type II rule.

The second type of phonological rule that was tested by adults was the Type IV phonological rule. This type of rule is said to follow a sort of family resemblance structure, in that all words following the rule have to share some characteristics, but not all. The Type IV phonological category consists of three properties: 1) Consonant one is made with vibrating vocal cords, 2) Consonant two is made with vibrating vocal cords, and 3) the first vowel is made with the tongue placed at the front of the mouth. In order for a word to be consistent with the Type IV category it is not necessary for it to contain all three properties, but the word needs to contain at least two out of the three. Adults were tested with the same experiment as before, except that the familiarization stimuli were words that followed the Type IV rules. The test words remained the same. Results showed that adults were able to make the Type IV generalization and learn this type of rule.

In natural language, both Type II and Type IV linguistic rules occur as well as several other types of rules. However, Type II rules occur more frequently than Type IV rules. Therefore, it is puzzling that infants are able to make Type II generalizations using only four input words, but adults struggle to simply learn the Type II rule at all. This could be due to a variety of factors, but one hypothesis is that adults try to generalize across all input while infants tend to look at word per word at an individual level. With no previous bias to cloud their judgment or explicitly

conscious attempts to learn a rule, infants take in one word at a time and implicitly acquire language knowledge. In order to find better ways to teach adults second languages, it is hypothesized that it would be most efficient to drive them into a more infant-like mode of learning. Isolating factors that could potentially accomplish this is crucial to learning which elements are most important and effective in language acquisition. Consequently, adults must be tested to see which factors have an impact on their language learning.

In the work presented in this study, the factor of time in regards to the familiarization stimuli was manipulated for adults. If the amount of time between each word in the familiarization phase of the experiment is lengthened and adult participants repeat each individual stimulus word in the elongated silence, then adults will be forced to analyze input one by one and will be driven into a more infant-like manner of learning. In addition to the time manipulation, adults were instructed to repeat each stimulus word given to them in the elongated silence between each word. Not only would this help ensure that adults are focusing mainly on each individual stimulus word as it is given to them, it would also give them the opportunity to physically produce the word. Since phonological rules are being learned, it would help the adult understand what to focus on if they are able to feel how their vocal cords are behaving during production. This hypothesis was tested to see if manipulating this time and vocal production factor assisted adults in learning the Type II phonological rule.

III. Method

Participants

Twenty-five adults were recruited through the department of Psychology at the University of Arizona to participate in this study. The Psychology Experiment Tracking System

website was used to recruit participants. Timeslots were put up by the research assistant and those who wished to participate for class credit or extra credit would sign up. If they met all criteria, then the participant would be scheduled. Only one participant would be run at a time for this study. The criteria that the participants needed to meet were that they be at least 18 years of age and be a native speaker of English. All the participants provided their written consent, following the approved procedures of the institutional review board of the university.

There were 25 total participants, where twenty where female and five were male. Participants ranged from ages 18 to 30, with the average age being 18 years. While all subjects were native English speakers, 12 participants had been exposed to a second language before, and 7 had been exposed to three or more languages.

Materials

The familiarization stimuli contained 77 alien two-syllable, CVCV words following the Type II phonological rule. The factor that was being manipulated for this study was the time in between each individual stimulus word. In the original study, the stimuli were presented back to back with virtually no gap in between, just enough of a pause for the participant to determine that they were individual words. In this study, the time between the presentation of one stimulus word and the presentation of the next word was lengthened to 2 seconds. All participants received the same familiarization stimuli.

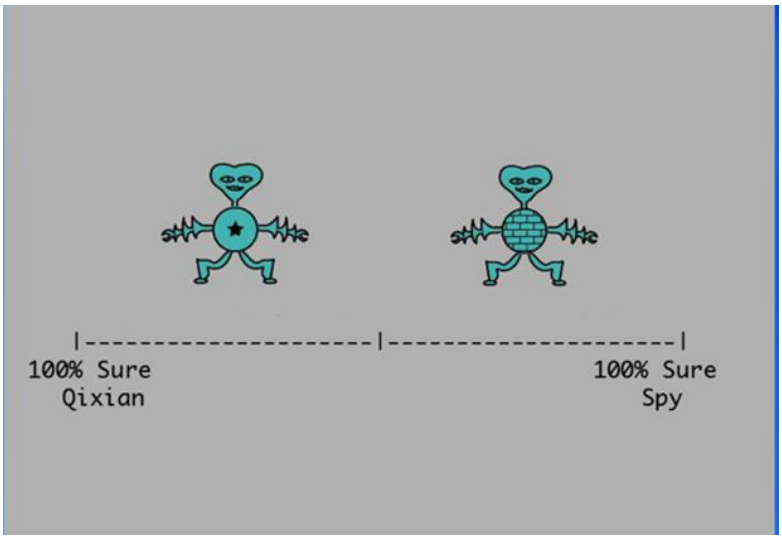
The test phase consisted of 30 more two-syllable, CVCV, made-up words. Some of these words followed the Type II phonological rule, and some did not. These words were presented in different orders for each participant. All stimuli, whether part of the familiarization phase or test phase, were spoken by the same female speaker and were presented electronically to each

participant through a pair of headphones. Participants were permitted to adjust the volume as needed.

Procedure

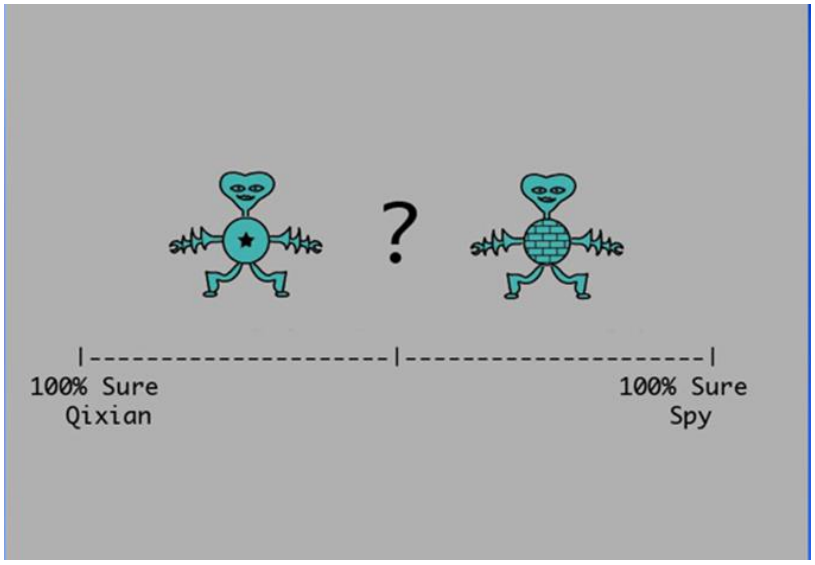
After filling out all necessary consent forms, the recruited adults participated in an electronically-delivered experiment split into a familiarization phase and a test phase. The instructions were displayed on the computer screen, and also read aloud by the research assistant. These instructions were as follows:

> "You have been hired by the Qixian colony, on the planet Zrbl, to catch spies from a nearby rival colony. The spies are often well-disguised, but they have not mastered the Qixian dialect, so you will be able to tell them apart by paying careful attention to what they say.
>
> As part of your training, you will need to learn what a grammatical word in Qixian sounds like so that you can tell when a spy speaks ungrammatically. As your first task, you will witness a conversation among a group of native Qixians. Pay close attention—this is the only information you will get about the rules of the Qixian dialect! You will need it to distinguish native Qixians from non-Qixian spies later! To help you concentrate, repeat each word in the silence that follows it. This will help you later on.
>
> After you finish training by hearing the Qixian conversation, you will be identifying Qixians and Spies. For this task you will hear individual words, half spoken by native Qixians and half spoken by Spies. On the screen you will see the following image:



After you hear each word, click somewhere on the horizontal line based on how likely you think it is that the speaker is a Qixian or a Spy. The left end corresponds to Qixians, the right end corresponds to Spies.

Your score for each sentence will depend on how far you are from the correct end. For example, if the word is grammatical in Qixian, you will get the highest score by clicking on the far left and the lowest by clicking on the far right. If it is ungrammatical, the reverse is true. Note: Your response will not register until the sentence is finished and the "?" appears in the center of the screen:



But first listen to how words spoken in the Qixian dialect sound in this conversation among native Qixians.

Ready?

Press <space> to begin."

The participants were given a familiarization phase where all stimuli followed the Type II phonological rule. After each word there was a silence where the participant was instructed to repeat the stimulus word they had just heard. Participants were informed that all of the familiarization stimuli were grammatical in the alien Qixian language, thus they were to pay close attention to those words.

After the familiarization phase was over, another screen popped up informing the participant that they were done with the listening-and-repeating task and would now have to catch the spies. The screen read as follows:

"Great! You have just learned what grammatical Qixians sound like! Now you will be asked to identify single words as Qixians or Spy.

Remember, Spies speak ungrammatically!

Ready?

<Press space bar to begin test phase>"

When participants were ready to begin, they clicked the button as instructed. The test stimuli were then presented one at a time, and did not move on from one word to the next until the participant had indicated whether they believed the speaker of the word to be a native Qixian or a spy. Qixian speakers were consistent with the Type II rules while the spies were inconsistent. Examples of consistent versus inconsistent words are: *boda, goba, pita* versus *bifa, gosa, piva*.

Once completely finished with the experiment, the participants were given a quick questionnaire where they had to write what they believed made the Qixian words grammatical. After that was complete, the participants were given a debriefing by the research assistant regarding the actual purpose of the study and the future benefits that results could achieve.

IV. Results

The data of each individual participant were analyzed to see when they deemed the speaker to be a native Qixian. If participants chose Qixian for those words consistent with the Type II phonological rule, then they were demonstrating that they were able to differentiate between consistent and inconsistent words, and thus learning the phonological rule.

However, results indicated that participants were not differentiating between consistent words and inconsistent words. Table 1 shows the average number of words for which the participants selected Qixian. Words that are consistent with the Type II rule, and therefore are the ones that would correctly be labeled as Qixian, are the even numbered columns: CN2, CN4, NN2, and NN4. Words that are inconsistent with the rule that should have been labeled correctly as spy are the odd numbered columns: CN1, CN3, NN1, and NN3. Since the table shows how

many words (on average) the participants selected Qixian for, there should be a higher number of Qixians for the even numbered columns.

Table 1: Average Number of Qixian Selections for all Test Stimuli

	CN1	CN2	CN3	CN4	NN1	NN2	NN3	NN4
Average Number of Qixian Selections	1.92	2.93348	2.36	2.4	2.24	1.88	1.96	1.97328

Table 2: Average Qixian Selections and Differences between Voice Consistent and Voice Inconsistent Stimuli

	Average Voice Consistent	Average Voice Inconsistent	Average Differences
Average Number of Qixian Selections	2.30	2.12	0.18

Table 2 shows the average number of voice consistent Qixian selections (average of the even-numbered columns), as well as the average voice inconsistent (odd-numbered columns) Qixian selections, and then the average difference between the two averages. The total number of times that Qixian was selected for consistent words on average was 2.30, while the total average times that Qixian was selected for inconsistent words was 2.12. This is a difference of 0.18. A paired sample t-test ($p < 0.05$) was conducted to compare the average number of Qixian selections in voice consistent and voice inconsistent words. The results of the test showed that there was not a significant difference in the scores for voice consistent ($M = 2.30$, $SD = 0.75$) and voice inconsistent ($M = 2.12$, $SD = 0.56$) words; $p = 0.294$. This demonstrates that adults still do not seem to be learning. In fact, these numbers are nearly identical to the original experiment that

tested adults' ability to learn Type II rules, but without any time in between individual familiarization stimuli or repetition. In the original study, the number of times that Qixian was selected on average for voice consistent words was 2.42, while the total average for inconsistent words was 2.16, and the difference between the averages was 0.27. These results were not significant, and there was no improvement in these old results to the results of this study. Therefore, there was not an improvement in the adult's ability to learn Type II rules. The hypothesis that lengthening the time and adding vocal production between the presentations of one familiarization stimulus from another will improve adult second language learning abilities remains unsupported.

V. Discussion

The results of this study suggest that increasing the time and adding vocal production between each individual familiarization stimulus and having the participant repeat each one in the silence after its presentation, is not a strong enough factor that can drive adults into a more infant-like manner of thinking and learning on its own. The idea behind the hypothesis tested was that adults would be forced to pay more attention to each individual stimulus if they had to repeat it and then wait for the next one, rather than have all familiarization stimuli thrown at them back-to-back. If focused on one alien word at a time, it could potentially be easier for adults to hear the similarities in the sounds of the word—in this case the same voicing feature between the consonants. They could then see that the word given after the one which they had just attentively analyzed shared that same phonological feature similarity. Moreover, they are not only forced to pay attention to one individual stimulus at a time, but they are also producing the word. Therefore, they should feel that their vocal cords are either vibrating for both consonants of the word, or not vibrating for either one. Because of the way that infants focus on only what is

presented to them at a time, they are able to quickly pick up rules and make generalizations from less data (Gerken, Dawson, Chatila, & Tenenbaum, 2014). In the case of Type II rules, they were able to make generalizations after having only just four input words.

However, this hypothesis was not supported by the resulting data of the study. While the idea was to focus attention on individual familiarization stimulus input, it does not completely prevent adults from analyzing across all input they receive. Many previous studies have shown that adults have a tendency to be biased when it comes to language input, and this could have influenced how adults responded to the familiarization words they were receiving in this test. Culbertson, Smolensky, and Legendre (2012) conducted a study showing how statistical learning in regards to linguistics can be limited and influenced by preexisting syntactic biases stemming from adult's expectation of a language pattern: "Prior biases can be conceived of as a learner's expectations about how a system is structured, and may in principle be learned or not, and may be domain-general or specific to language." (Culbertson, Smolensky, & Legendre, 2012). It is possible that if these biases exist, then they may also influence other linguistic areas of learning, such as phonological learning. Consequently, if adults try to analyze over a complete set of linguistic data they may end up looking for something—for example, a phonological rule—that is familiar to them and that they have already learned. Since the Type II rule that was being tested in this study is not an actual phonological requirement of English, their native language, these adults would most likely overlook or disregard this phonological input. A quote by from Birdsong's *Second Language Acquisition and the Critical Period Hypothesis* further explains this phenomenon about adult language learning bias:

> "If language is represented as innate abstract principles and there is a critical period for language acquisition, then L2A during the critical period should resemble first language

> acquisition (L1A) because both processes are governed by the learner's access to those principles. Therefore, L2A during the critical period should show little or no effect of transfer from the first language because direct access to UG [Universal Grammar] should override cognitive intervention in the process of constructing the system of rules for the second language. **Learning after the critical period, however, would reflect elements of the first language because general cognitive resources would be recruited to construct the linguistic system, and they would naturally begin with the linguistic structures already in place.**" (Birdsong, 1999).

If the bias that Birdsong and other researchers have supported is applicable to phonological learning in adults, then perhaps the increase of time between each stimulus presentation was not enough to override such native language bias. The manipulation of time between stimuli in this study was designed to drive adults to focus on one input at a time like infants; however, while it may have achieved drawing attention to each individual familiarization word, it was unable to account for native language bias. Infants who are learning language have yet to acquire such bias because they have no other prior knowledge to fall back on; they are blank slates absorbing new information. Therefore, while the infants may focus on individual stimuli, they also do not have anything else to compare it to or any other native information to override what they may intake as significant data. Because adults do have such prior knowledge bias, they may disregard the phonological information even when forced to focus attentively on it.

In addition, adults transcend through a "sensitive period" of language learning, wherein their ability to learn second language phonology declines with age—such is supported by Oyama's 1976 study on accents. While such a sensitive period does not have as harsh of a cut-off

in second language learning as does the critical period in first language acquisition, it still impacts an adults' ability to learn new phonological rules. In Oyama's study, only children were able to pronounce words with native-like proficiency as they learned their second language; adults were not seen to achieve such pronunciation. Therefore, adults may be hindered in their attempts to learn a second language because they are not only biases, but they also exceed an age-related limitation.

Another factor that could have limited adult's ability to learn the Type II phonological rule is the CV hypothesis, discussed in a recent 2016 study by Gonzalez-Gomez & Nazzi:

> "The CV hypothesis proposes that vowels have more weight in encoding information about the prosodic and syntactic structures, while consonants have more weight in encoding information about lexical identity. Thus, consonants would play a more important role in word identification and vowels in extracting grammar-like generalizations." (Gonzalez-Gomez & Nazzi, 2016).

This study was conducted to investigate when infants begin to acknowledge non-adjacent regularities in phonotactics within a word, which is essential for language acquisition. However, if the CV hypothesis holds true for infant language acquisition, it may also impact how adults pick up on phonotactics of a second language. In this way it can be applied to adult second language learning, wherein the adults would be accustomed to using vowels when determining grammaticality.

Participants in this Type II phonological learning study were instructed to catch spies by determining whether the alien word was grammatical in the alien language. Implicitly, this may have drawn their attention to vowels over consonants in the stimuli. All stimuli in the

experiment, both in the familiarization and test phases, ended in the vowel /a/. A questionnaire was given to participants after they completed the experiment, in which they were asked what they believed all the Qixian words had in common and what made them grammatical. Nearly all participants had a response that pointed out the ending vowel of the stimuli. The CV hypothesis could explain why participants were so focused on this vowel sound rather than the consonants, even when this vowel did not aid them in differentiating between consistent (Qixians) or inconsistent (spies) words.

VI. Conclusion

The hypothesis tested in this experiment stated that if adults were compelled to focus on each individual familiarization stimuli by increasing the time in between the presentations of each stimulus and having the participant verbally produce each word in the elongated silence, then they would be driven into an infant-like state of learning and, therefore, better learn the Type II phonological rule. However, results did not show any improvement in the learning of the rule by adults and the hypothesis was unsupported.

While the study did not yield results supporting the hypothesis, it did determine that the addition of time and verbal production between familiarization stimuli was not a strong enough factor to aid adults in second language learning. This leaves many other factors up for examination. Continuing to manipulate different individual elements of this phonological learning task can determine factors that strongly impact adult second language learning; once these factors are identified, they can aid in finding better ways to teach second languages in the future.

The instructions given to participants in this study should also be changed for the future. Instructing adults to differentiate between “grammatical” and “ungrammatical” speakers could potentially be the reason for their subconscious focus on the vowel sounds rather than sounds differentiating the actual Type II phonological rule. If the CV hypothesis is applicable to adult second language learning, then changing the instructional wording may stop such subconscious vowel assumptions.

To assist adult language learners in the future, many more studies need to be conducted in order to find strong factors that aid in phonological, as well as other linguistic elements, learning. For now, data shows that an increase of time in between familiarization stimuli is not an effective element on its own in doing so. This research complements other research on the critical period hypothesis in regards to second language learning, and adult language bias to their familiar linguistic structures (Birdsong, 1999). Native language elements prove to have a significant impact on any future language learning after the learner passes the boundary of the critical age.

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