

## Temporal analysis of L2 one-syllable word and nonword repetition: Exploratory case studies.

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### Abstract

This paper reports the results of three case studies of immediate repetition and measurements of temporal features, particularly response duration and latency with second language learners. The purpose of this exploratory experiment was to determine if we could find a relationship between duration and latency at the individual participant level, using both real words and nonwords. Secondly, spectrographic analysis of responses is a highly labor intensive activity, which makes measurement of responses difficult in larger studies. An exploratory experiment would indicate the potential of measuring responses in larger studies. Finally, we sought to find phonotactic effects at the individual level. Combining the three cases together we found consistent evidence that both duration and latency were related to errors and that nonword stimuli were more difficult to produce than real-word stimuli. This paper also reflects on future investigation of temporal analysis with immediate repetition.

**Key words** : repetition, phonological memory, probabilistic phonotactics, duration, latency.

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It is generally accepted that difficult words take longer to produce and produce more errors in a number of experimental paradigms<sup>3, 4, 11, 16</sup>. By "difficult words," we mean more difficult to pronounce words, words of a lower frequency of use, unfamiliar words, words that have similarity to many other words, or nonwords. These phenomena may indicate that difficult words require more mental resources to process the word before repeating it, or it may simply be that less frequently used words are also more difficult to say. The measure of the time between hearing and saying a word is referred to as "latency." Thus in a repeating task the duration of a response and the latency of the response are potential indicators of mental processing.

It has now been well established that the log frequency of word usage (the relative frequency of use of a word) effects both the duration and latency when repeating the word. In recent decades, experimental research has

moved beyond frequency of usage on to the frequency of the sound units in words (sublexical), a field referred to as phonotactics (literally, sound-counting). Thus, when we speak of probabilistic phonotactics, we are speaking of the relative probability of a particular phoneme or syllable occurring after another phoneme or syllable. Studies in phonotactics have found that for both typical hearing adults and hearing-impaired adults speed of word recognition is related to phonotactic probability<sup>17</sup>, word acquisition in children<sup>15</sup>. Such research suggests that how rapidly we process a word we hear or read has more to do with our familiarity with the sound combinations of the word than with our familiarity with the word's meaning. It has even been found that infants respond to phonotactic differences in stimuli<sup>8</sup>.

These reported phenomena tend to be found in large studies where data from a number of participants are brought together. This leaves open the question

whether it is possible to find frequency-related effects in individual case studies. The present study seeks to explore this question.

A second goal of this study is to explore temporal features, duration and latency of responses, within the immediate repetition paradigm, specifically with adults in a cross language condition. Immediate repetition of nonwords is a simple task that can be used with a wide range of ages, language backgrounds and abilities. It is non-invasive, simple to administer and seems to tap mental processes that are of importance to language learning. It is of some interest to learn more about the underlying nature of nonwords.

In a previous study, it was established that immediate repetition of nonwords (pseudowords) was predictive of foreign language learning performance in young adults<sup>12)</sup>. In the present experiment, immediate repetition of nonwords again were used, however the stimuli were a mixture of well-known one-syllable real L2 words (English) and one-syllable non-words (English). The choice of single syllable stimuli was to investigate temporal features in their simplest form. Based on previous studies<sup>9)</sup> it was assumed that single syllable stimuli would minimally challenge the mental processing of the participants in the present study, thus if any effect were found further study along these lines would be justified. It was anticipated that real L2 word stimuli would therefore be repeated with slightly less latency and less duration than the nonwords, and that there would be greater errors with nonwords than with real words. To our knowledge, in the large literature reporting on nonword experiments, there are no studies analyzing temporal features (latency and duration) with the immediate repetition paradigm.

### Methodology

*Participants.* Three female volunteers, age 17-18, all attending the same university English courses. Volunteers received no compensation, nor any course credit for participation. Participants were fully informed of the purpose of the experiment and informed that they could stop participating at any time.

Following the initial interview, volunteers were given a two week period to reconsider their participation. At a subsequent interview, volunteers were again advised of the details of the experiment and the conditions of their participation, in accordance with accepted informed consent procedures. (see end notes for further details).

*Stimuli.* Eleven one-syllable words and nine one-syllable nonwords were presented during the session. One of these nonwords was presented twice. Stimuli were presented in a pseudo-random order. Prior to the presentation of this one-syllable repetition task, participants completed an immediate repetition task of a variety of multisyllable nonwords. After each stimuli a silent pause was inserted of greater length than the stimuli to accommodate responses. Stimuli were recorded from a male native speaker of English speaking at a typical speech rate.

Stimuli were created to be pronounceable, English-like words: that is, possible words in English. This was accomplished in most cases by mixing onsets and rhymes of real words, or by changing the offset. For example, the words *bark* and *first* could be altered to make the nonwords: *barst*, *bast*, *birk*, *firk*, etc. Although it may seem counterintuitive, the stimuli created for this experiment actually had higher phonotactic probabilities on average than the real words did. For nonwords the sum of position-specific probabilities was 0.2368625 and the sum of biphone probabilities was 0.0190125; whereas for real words the respective sums were 0.179118182 and 0.014145455. For the stimuli in this experiment we have conflicting predictions: based on probabilistic phonotactics we would anticipate more errors and longer duration and latency for real words than nonwords, but based on typical nonword results we would anticipate more errors and longer duration and latency for nonwords.

*Procedure.* Stimuli were present from a computer with loud speakers, which were directed at the participant. A microphone was clipped to the participant's clothing at a distance of approximately 15 cm from the mouth. Recording of the session was made using a minidisc recorder, which recorded both the stimuli and the responses. Participants were instructed to repeat each

word as accurately as possible.

*Analysis.* The minidisc recordings of the sessions were digitized and then analyzed using CoolEdit 2000 software. Durations were measured from the initial increase of sound response found on the spectrogram until the offset of response. Latency was measured as the difference between stimuli onset and response onset times. The analysis of item using a spectrogram is extremely labor intensive, so only a small number of stimuli are reasonable. Each item was also scored for accuracy of pronunciation. Note that for participant B two responses to nonwords were unintelligible and were not included in the analysis.

**Results**

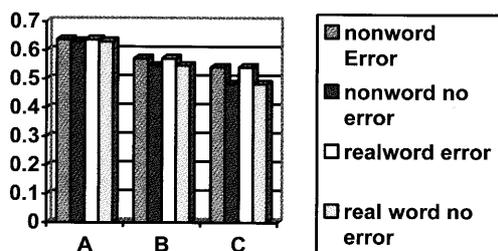
Figure 1 shows the scores for each of the three participants. The three participants are referred to as A, B, C.

Figure 1.

	A	B	C
Number of items	20	18	20
score- all 1 syll stim	14	9	7
num of errors	7	9	13
Percent correct	65%	50%	35%
Score- nonwords	4	3	1
Score- real words	10	6	6

The three participants clearly had more errors on nonwords than on real words, as anticipated. However, although single syllable stimuli were used a surprisingly high percentage of errors were made.

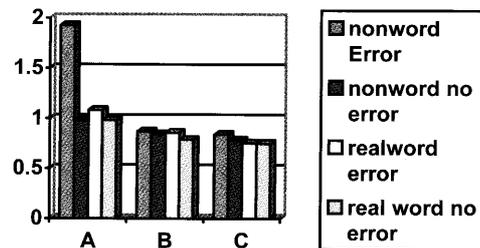
Figure 2. Duration of Responses



As can be seen in figure 2, responses for both nonword and real word stimuli with errors had longer duration than did responses that did not have errors. Participant

A showed only slight differences between responses with errors and correct responses, while Participants B and C showed greater differences. Nevertheless, in all three cases and for each condition responses with errors had longer durations on average. Again, there is a general pattern of nonwords having greater duration than real words. In figure 3 are the response latencies.

Figure 3. Latency of Responses



As can be seen in figure 3, latency shows the similar pattern as we saw with duration of responses. Again, in all cases and all conditions, errors had greater latency than responses without errors, and nonword latency was generally greater than real word latency on an individual basis.

The Friedman Test including all three participants with each of the four conditions was significant (chi-square 8.2, *df* 3, asymp. Sig = .042054). However, as this is a very small exploratory experiment, even a marginally significant effect is confirming, given the small sample.

As noted earlier, according to the literature on probabilistic phonotactics responses to real words should have been longer and more delayed than responses to nonwords. The experiment found the opposite- real words had fewer errors and shorter duration and latency than for nonwords. No correlation was found between phonotactic probabilities of stimuli and duration or latency times.

In fact, an inverse relationship was found between probabilistic phonotactics and errors-- words and non-words with errors actually had a slightly higher average probabilities than stimuli without errors. This was the case for all three participants. Also, this was the case for not only position and biphone probabilities, but also for initial and final biphone probability averages.

Several other observations should be noted. Average duration of all responses was 0.580933, whereas average duration of stimuli was 0.64205. Average response duration of all three cases together for nonwords was 0.606431 and real words 0.565236. On the surface this would indicate that nonwords were more challenging than real words. However, average stimulus duration was 0.7145 for nonwords and 0.5696 for real words. We might ask if differences in stimuli length contributed to the finding that nonwords were produced more slowly. As noted above, responses were of shorter duration than stimuli, so if we subtract the response times from the stimulus times we can better see the delay between responses to each type of stimuli. The average difference between participant response duration and average nonword stimulus duration was 0.108069, while the difference between average response duration and average real-word stimulus duration was only 0.004364-- indicating that a much greater portion of the delay was due to nonword responses. Although real-word stimuli tended to be of shorter duration, the difference between stimuli duration and response duration was slight, while the difference between nonword stimuli and response was much larger. We can, then, assume that the findings were not due to less duration of the real-word stimuli.

Interestingly, using the average differences between stimuli and response, we find that this metric predicts order of performance on the task. ("difference to stimuli" and "score": A= -0.01105, 14; B= 0.09155, 9; C= 0.10285, 6.). Could general proximity to the stimuli indicate the accuracy of performance? While this would be an interesting possibility, the present study only indicates this relationship for real words and not for nonwords. In any event, this intriguing possibility must be evaluated by a much larger and more controlled experiment. As oppose to duration responses, latency of responses showed a surprising result-- generally longer latency was associated with better performance between participants. We have no immediate explanation for this trend. However, the experiment did find, as anticipated, that in all cases errors had longer latency on average than responses with no errors, and this finding applied in each individual case.

## Discussion

Even in such a simple task as immediate repetition of single syllable words, L2 nonwords had greater latency and longer duration than L2 real words for all three participants. Responses that had errors had greater latency and longer duration than responses that did not have errors, and this was true for both real words and for nonwords. Interestingly, individual duration times were inversely related to performance-- better performance came from generally longer response times. Thus, duration and latency at the individual level in this experiment were not absolute measures; rather, differences in duration and latency were relevant only in relation to each individual's performance. Also, the match between longer duration and latency is not consistent at the item level; rather it is only when times are averaged that duration and latency effects were observed. This was a disappointing finding, as it would have been convenient for future research if these timings consistently indicated if error had occurred. Whether or not this lack of strong correspondence was due to the small size of the study or to the simplicity of the stimuli will require further experiments to determine.

All three participants repeated words faster on average than the rate of the stimuli, which may have been due to using single syllable stimuli-- perhaps multisyllable stimuli would produce a different relationship. Given the brevity of the stimuli, their relative simplicity, that stimuli were from a nonnative language, and the simplicity of the repetition task, it is somewhat surprising that these young adults would demonstrate such clear individual effects. Also, it should be kept in mind that accurate performance on repeating of words was relatively poor. Participants did less well on nonwords than on real words, just as would be predicted by phonological familiarity, but not as predicted by phonotactic probability.

In the literature on phonotactics and nonword repetition the error rates for native speaking adults is very low and the consequent phonotactic effects are extremely slight. In contrast, the non-native speaking adults in this

study had fairly high error rates were relatively large. As this was an exploratory experiment standardized measures of L2 vocabulary were not included; however, future experiments will obviously benefit from including additional measures. That said, the present experiment does indicate that duration and latency of responses are of interest and potentially valuable.

The possibility that the raw duration of the stimuli may have more impact on repetition task performance than the familiarity with the phonological structure of the stimuli was not supported by these case studies. In each of the three case studies the average duration of nonword stimuli produced correctly was greater than the average duration of the stimuli that were produced incorrectly-- the very opposite of the expected stimulus duration effect. In this experiment, real word stimuli were of slightly shorter duration than nonword stimuli. However, an error analysis of the differences in response duration to each type of stimuli showed that for real words errors were associated with slightly longer stimuli, but nonword errors were associated with slightly shorter stimuli. Furthermore, analysis of differences in duration of response to the duration of stimuli indicated that results were not due to the length of stimuli, rather the difficulty of nonwords contributed much of the difference.

On the other hand, real word stimuli did show a stimulus duration effect-- real words produced with errors followed stimulus words that on average had longer duration, while repetition responses with no errors followed stimulus words with shorter duration. This mixed result is somewhat confusing, in that one would assume that nonword stimuli would require more processing, yet the words which had errors were stimuli of less duration, presumably easier words. One can only conclude from this that the challenge of these words to simple repetition was not the duration of the stimulus words, but the phonological combination in those words.

The more standard explanation as to why nonwords are more difficult to repeat than real words is that they lack meaning and thus only phonological cues are available for maintaining the word in the mind long enough to

repeat it. Another scenario might go as follows: as the nonwords do not have a meaning, the process of trying to identify a word continues longer, because finding something which is not there takes longer than finding something which is there. This would result in a slightly delayed response and a greater number of errors. Such a scenario requires, however, that all words we hear (real or nonwords) are automatically lexically processed, otherwise there would be no taxing of resources and no delay in response time for the unknown words. The situation with the real words in this study was that they were well known words, with little duration differences, thus the error producing words must have been more difficult to hear and/or to pronounce. Unfortunately, the data does not support a phonotactic explanation, leaving us to conclude that some other factor makes the nonwords more difficult to process.

An alternative explanation for the results could come from a fairly unexplored area-- L2 phonological sensitivity. With children learning L1, there is an established pattern whereby whole words are learned unanalyzed, then in later stages syllables and phonemes become salient<sup>1)</sup>. In the case of L2 learners, their phonological sensitivity in L2 may not operate effectively beyond the whole word level. This explanation, though speculative, would also explain why this experiment did not find strong probabilistic effects-- if the participants were not advanced enough in L2, then their phonotactic knowledge would be too low to have a facilitative effect. The relatively high error rate for these participants lends support to this observation. Again, this is a matter for further investigation.

## Conclusion

The present study, though very small, did find individual effects on duration and latency of responses. Although these effects were only observable after averaging of data, this remains an important finding. This experiment has demonstrated that further experimentation with temporal features of responses is justified. An experiment with a larger set of stimuli, utilizing di-syllable and multisyllable stimuli, and a larger number of participants is planned.

Also, a less labor-intensive method of measuring response duration and latency must be explored. A voice key method may be a practical solution in future experiments.

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### Notes

All phonotactic probabilities were computed using the web-based Phonotactic Probability Calculator, which can be accessed at <http://www.people.ku.edu/~mvitev/PhonoProbHome.html>.

To use this calculator all stimuli must be converted to Klatese transcription. The following are the transcriptions of the stimuli used in this study listed by standard spelling then in transcription: barst, barst; tem, tEm; bint, bInt; cup, k<sup>^</sup>p; tree, tri; door, dor; kyst, kaist; clean, klin; glast, gl@st; big, bIg; kind, kaind; drems, drImz; coor, kur; boost, bust; glad, gl@d; grape, grep; deem, dim; green, grin; day, deI.

Parts of this study are the result of S.Snyder's doctoral

studies at Macquarie university. The ethical approval for this and other experiments came from the Ethics review committee at Macquarie university. Ethical approval requires the strictest of standards to prevent coercion and to ensure safe and free participation. Participants responded to an announcement requesting volunteers. Volunteers had to respond of their own free will. After the initial interview, a delay was imposed to give them an opportunity to reconsider. Another meeting was scheduled only if the person volunteered a second time. A full description of the experiment was given at each meeting and it was emphasized that volunteers could quit at any time and that they would receive no money or other benefit from participation. The present research is drawn from a portion of that doctoral study on phonological training.

## 第二言語一音節語反復法による時間分析：

試行的ケーススタディーを通して

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### 要 約

本稿は、第二言語学習者による即時反復法についての3つのケーススタディーと時間的計測結果について報告し、特に反応持続時間と遅延について考察した。本稿における試行的ケーススタディーは、一音節語と一音節非語を刺激語として用い、被験者の個々のレベルにおいて持続時間と遅延との間に相関性が存在するという仮説について明らかにすることを目的とした。スペクトログラフによる反応分析は極めて複雑なプロセスを必要とするため対象サイズの大きい実験分析は忌避されがちであるが、一音節語と一音節非語を反復し時間分析するという方法の有効性が示唆されたことにより分析対象の可能域が広げられた。さらに、個人レベルにおける音素配列効果の抽出も試みた。3つのケースを統合的に考察した結果、持続時間・遅延ともにエラーとの相関を持ち、一音節非語の発語は一音節非語の発話よりも困難を伴うという一致した特徴が確認された。また今後の展望として、即時反復法による時間考察についてさらなる研究考察が進められるべきであると示唆するに至った。

キーワード：反復，音韻記憶，確率的音素配列論，持続時間，遅延