Primacy and Recency in Nonword Repetition

Prahlad Gupta
Department of Psychology
University of Iowa
Iowa City, IA 52242

March 8, 2003

Address correspondence to:

Prahlad Gupta
Department of Psychology
University of Iowa
Iowa City, IA 52242
Phone: (319) 335-2908
Fax: (319) 335-0191
Email: prahlad-gupta@uiowa.edu

Memory, in press

Abstract

An increasing body of evidence suggests that nonword repetition is related to immediate serial memory (e.g., Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1993). One possible account of this relationship is that a nonword is processed like a list when it is first encountered. If this is the case, it should be possible to detect serial position effects in repetition of single nonwords. Three experiments tested this prediction. Experiment 1 examined whether there would be syllable serial position primacy and recency effects in repetition of polysyllabic nonwords, and obtained both primacy and recency effects. Experiments 2 and 3 showed that these effects were not due to the controlled duration of the nonwords or the requirements of concurrent articulation or the procedure by which nonwords were created.

Primacy and Recency in Nonword Repetition

Recent thinking has emphasized the relationship between the processing and learning of nonwords (i.e., novel phonological forms), and a variety of memory mechanisms including verbal short-term memory, procedural memory, and declarative memory (e.g., Baddeley et al., 1998; Gupta & Dell, 1999; Gupta & Cohen, 2002). With respect to verbal short-term memory in particular, a great deal of recent evidence indicates that immediate serial recall is related to nonword repetition and word learning, which are also related to each other (for review, see Baddeley et al., 1998). It seems intuitively obvious why there might be a relationship between nonword repetition and word learning; after all, every known word was once a nonword to the learner, so greater facility in processing nonwords would be expected to lead to greater facility in eventually learning them. But what is the relationship between nonwords and immediate serial memory? One possibility is that a nonword is literally processed like a list when it is first encountered; this would provide a simple explanation of the relationships observed between immediate serial recall and nonword repetition. How might we examine such a hypothesis?

One of the hallmark characteristics of performance in immediate serial recall tasks is the presence of primacy and recency effects. If serial ordering mechanisms similar to those underlying immediate serial recall are operative in the repetition of nonwords, we would expect to observe such serial position effects in repetition of the sequence of sounds comprising nonwords. The present work therefore aimed to examine the existence of syllable primacy and recency effects in repetition of individual polysyllabic nonwords.

EXPERIMENT 1

A nonword repetition task was prepared, in which the participant listened to four-syllable nonwords one at a time and was required simply to repeat each nonword immediately following its presentation. The aim was to test for the presence of syllable primacy and recency effects in repetition of these nonwords. To provide a manipulation check for primacy and recency effects, an immediate serial recall task was also prepared, in which the participant listened to lists of four monosyllabic words, and was required to recall each list in correct serial order immediately following its presentation. To equate the tasks as closely as possible, the nonword stimuli for the nonword repetition task were constructed so as to be the concatenation of the four words that comprised one of the lists in the immediate serial recall task. The spoken duration of the two types of stimuli (lists and nonwords) was also equalized. Additionally, to minimize the use of rehearsal and any possible differences in rehearsal across tasks, participants were required to engage in concurrent articulation during stimulus presentation in both tasks.

Method

Twenty undergraduate students at the University of Illinois participated in this experiment for course credit. Each participant performed a nonword repetition task and an immediate serial recall task.

A set of 30 nonwords was created, each nonword being the concatenation of four monosyllabic words (e.g., *antriskoldate*, composed of *ant*, *risk*, *old*, and *ate*). A set of 30 four-word lists was created, with the words in each list corresponding to the syllables in one of the nonwords (e.g., the list {*ant*, *risk*, *old*, *ate*}). A further set of 30 nonwords and corresponding lists was also created with approximately the same distribution of onsets as the first set. Two groups of stimuli were then created for presentation to participants by combining the 30 nonwords from one set with the 30 non-corresponding lists from the other set, and vice versa.

Stimuli in the nonword repetition task were presented auditorily. Stress was placed on either the second or third syllable, as is typical for phonotactically legal four-syllable wordforms of English. The lists of words in the immediate serial recall task were also presented auditorily. Each list was presented with a typical list-like intonation, i.e., with each list item receiving equal stress.

The words used in the 60 lists for the immediate serial recall task were recorded individually as digitized sound by a female native speaker of American English, who pronounced each word with a uniform stress contour. Each list was created by digitally splicing together the four words comprising it, modifying each word to be 740 milliseconds in spoken duration without altering its pitch (SoundEdit 16 Users Guide [Computer software], 1997), and incorporating a 10 millisecond pause following each word. The total duration of each list was therefore 3000 milliseconds. Each of the 60 nonword stimuli for the nonword repetition task was also recorded by the same speaker as digitized sound. Each stimulus was modified to be 3000 milliseconds in spoken duration, also using the SoundEdit software.

Each participant performed both tasks. The order of presentation of tasks was counterbalanced across participants. The two groups of stimuli (each group consisting of 30 nonwords and the non-corresponding set of 30 lists) were also counterbalanced across participants. Stimuli in both tasks were presented auditorily by computer. In addition to the primary task of repeating each nonword or list, participants were required to concurrently and repeatedly articulate the nonword *kwelstry* silently, during presentation of each nonword or list. Participants' responses in the two primary tasks were scored syllable-by-syllable for nonwords and word-by-word for lists such that a syllable or word was scored as correct only if it was correctly repeated in the correct serial position.

Results and Discussion

Primacy was assessed by comparing first serial position accuracy with second serial position accuracy. Recency was assessed using two measures: by comparing final (fourth) serial position accuracy with penultimate (third) serial position accuracy (Recency1); and by comparing final serial position accuracy with middle serial position accuracy, which for four-element sequences corresponds to the mean of the second and third serial positions (Recency2). A significant difference in either the Recency1 or Recency2 comparison was taken to denote a recency effect.

Figure 1 plots the results of Experiment 1 broken down by recall type (nonword repetition or word immediate serial recall) and serial position. The results were subjected to a 2-way ANOVA (recall type x serial position). Planned comparisons were made corresponding to the Primacy, Recency1, and Recency2 measures. There was a significant primacy effect as well as a significant recency effect for nonword repetition ($F1(1, 57) = 25.1, p < .0005$ for Pri-

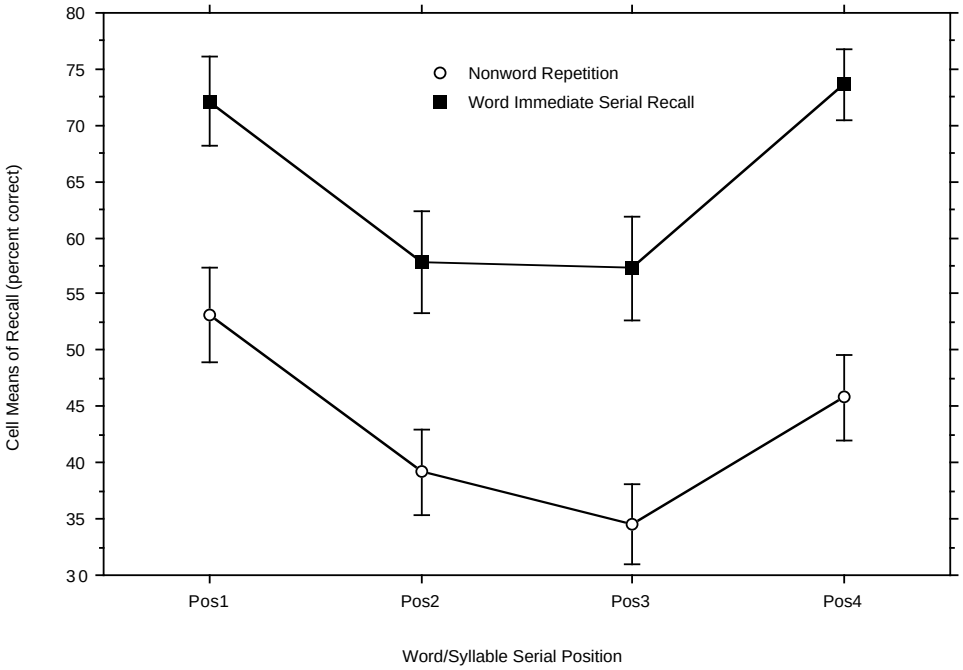

Figure 1: Results of Experiment 1

macy; $F1(1, 57) = 16.5, p < .0005$ for Recency1; $F1(1, 57) = 13.8, p < .001$ for Recency2; $MSE = 78.0$ for all comparisons). Primacy and recency were also significant for word immediate serial recall, confirming the ability of the present experimental procedure to detect such effects in list recall ($F1(1, 57) = 26.4, p < .0005$ for Primacy;$F1(1, 57) = 34.2, p < .0005$ for Recency1; $F1(1, 57) = 44.3, p < .0005$ for Recency2; $MSE = 78.0$ for all comparisons). The results were also subjected to an item analysis, with the syllables/words at different serial positions treated as the random variable. Planned comparisons were made corresponding to the Primacy, Recency1, and Recency2 measures. Both primacy and recency were significant for nonword repetition ($F2(1, 472) = 13.4, p < .0005$ for Primacy; $F2(1, 472) = 9.0, p < .005$ for Recency1; $F2(1, 472) = 7.6, p < .01$ for Recency2) as well as for word immediate serial recall ($F2(1, 472) = 14.1, p < .0005$ for Primacy; $F2(1, 472) = 18.4, p < .0005$ for Recency1; $F2(1, 472) = 23.7, p < .0005$ for Recency2; $MSE = 439.5$ for all comparisons).

The present results provide preliminary evidence of syllable serial position primacy and recency effects in nonword repetition. Additionally, the primacy and recency effects were closely similar to those in the word immediate serial recall task that was included as a manipulation check. However, these serial position effects were obtained using nonword stimuli whose duration had been stretched to 3 seconds; it seems plausible that stretching them to this duration might have made them more "list-like", thus inducing serial position effects that would not otherwise have obtained. Alternatively or additionally, the nonwords might have sounded unnatural, and participants might therefore have processed them differently than they would have at a normal duration. Experiment 2 aimed to examine these possibilities.

EXPERIMENT 2

Two nonword repetition tasks were administered to participants. In both tasks, participants were required to engage in silent concurrent articulation during presentation of stimuli, to prevent rehearsal and differences in rehearsal, as in Experiment 1. In one task, the stimuli presented were identical to those in Experiment 1. In the second task, the same nonwords were presented at their normal spoken durations. If primacy and recency were still obtained at the normal duration, this would indicate that they were not merely an artifact of duration in Experiment 1. Additionally, inclusion of the nonword repetition task from Experiment 1 served to test the replicability of the previous results.

Method

Twenty undergraduate students at the University of Illinois participated in this experiment for course credit. Each participant performed two nonword repetition tasks.

The stimuli for nonword repetition consisted of the two sets of 30 nonwords used in Experiment 1. Two versions of these nonwords were created. One version consisted of exactly the same 60 stimuli as used in Experiment 1, each of which had been stretched to a duration of 3 seconds, i.e., a "slow" speech rate. A second version of the 60 stimuli consisted of the original recordings from which the "slow" stimuli were constructed; that is, they consisted of the same nonwords spoken by the same speaker at their original recorded duration, i.e., at a "normal" speech rate. Two groups of stimuli were created for presentation to participants by combining the 30 nonwords from one set at the slow speech rate with the 30 nonwords from the other set at the normal speech rate, and vice versa.

Each participant performed two nonword repetition tasks, each comprised of presentation of 30 nonword stimuli. The only difference between the two tasks was that in one, the stimuli were the "slow" versions and in the other the stimuli were the "normal" versions. The order of presentation of the two nonword repetition tasks was counterbalanced across participants. The two groups of stimuli were also counterbalanced across participants. On each trial in both tasks, participants engaged in silent concurrent articulation during stimulus presentation. In each trial in the normal speech rate task, onset of the stimulus was delayed so that total trial duration was 3000 milliseconds, corresponding to the duration of a trial in the slow speech rate task. In each task, silent concurrent articulation was initiated at the beginning of the trial, so that the duration of concurrent articulation was constant across tasks. In all other respects, the procedure for each repetition task was identical to the procedure for the nonword repetition task in Experiment 1.

Results and discussion

Figure 2 plots the results broken down by nonword type (slow or normal) and serial position. The results were subjected to a 2-way ANOVA (nonword type x serial position). Planned comparisons were made corresponding to the Primacy, Recency1, and Recency2 measures, as in Experiment 1.

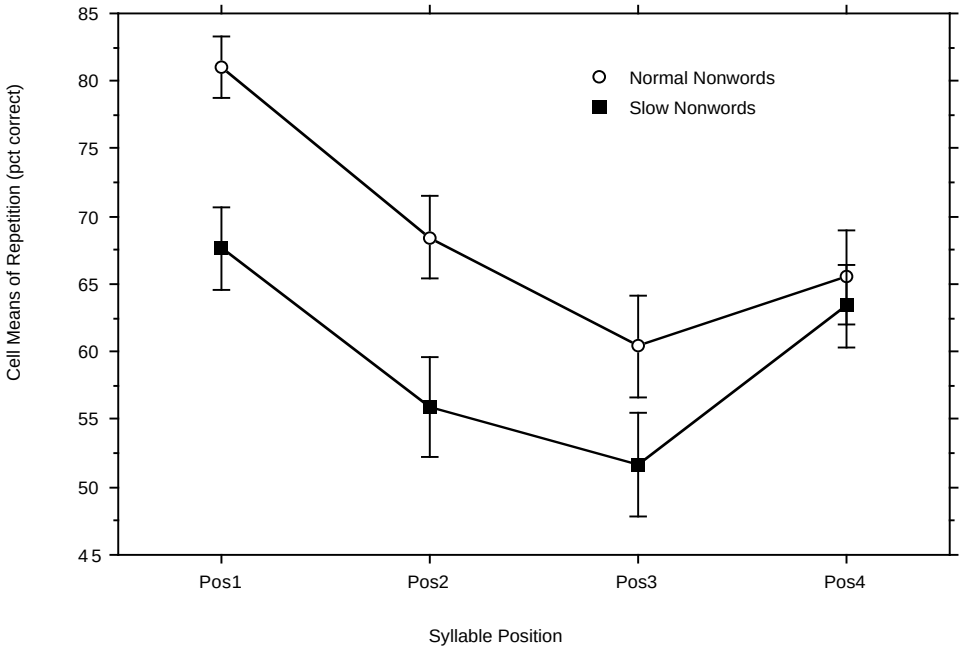

Figure 2: Results of Experiment 2.

There was significant primacy and recency for the normal stimuli ($F1(1, 57) = 31.7, p < .0005$ for Primacy; $F1(1, 57) = 5.2, p < .05$ for Recency1) and for the slow stimuli ($F1(1, 57) = 27.5, p < .0005$ for Primacy; $F1(1, 57) = 27.3, p < .0005$ for Recency1; $F1(1, 57) = 24.4, p < .0005$ for Recency2; $MSE = 49.8$ for all comparisons). The results were also subjected to an item analysis as in Experiment 1. Primacy was significant for both the normal and slow nonwords ($F2(1, 472) = 9.9, p < .005$ and $F2(1, 472) = 8.7, p < .005$ respectively); recency was only significant for the slow nonwords ($F2(1, 472) = 8.7, p < .0005$ for Recency1; $F2(1, 472) = 8.0, p < .01$ for Recency2; $MSE = 464.3$ for all comparisons). The planned comparisons thus replicate Experiment 1's finding of syllable primacy and recency effects in nonword repetition for slow nonwords. They also provide evidence of the existence of primacy and recency for the normal nonwords (recency was significant in the subject analysis although not in the item analysis).

The present results indicate that overall repetition accuracy is lower for the slow nonwords, and that recency is stronger for the slow than for the normal nonwords. More importantly, the results also indicate that the primacy and recency effects in Experiment 1 were not simply because the nonword stimuli had been stretched, by providing evidence of primacy and recency even in repetition of the normal duration nonwords. Experiments 1 and 2 together suggest that serial position effects are indeed present in nonword repetition. However, the results of both Experiment 1 and Experiment 2 were obtained under (silent) concurrent articulation. Nonword repetition under concurrent articulation clearly introduces a load, which could conceivably have been the cause of the serial position effects obtained in Experiments 1 and 2. Furthermore, the nonwords used in these two experiments were unusual in having been composed from the concatenation of four monosyllabic words. It seemed possible that the observed serial position effects could have arisen simply from this compositional nature, that perhaps made these nonwords unusually list-like. Experiment 3 aimed to address these possibilities.

EXPERIMENT 3

Primacy and recency effects were examined in repetition of nonwords that were non-compositional (i.e., had not been created by concatenation of real words), and that were presented without the requirement for concurrent articulation. The elimination of silent concurrent articulation raised the possibility of ceiling effects in repetition of four-syllable nonwords; it was therefore decided to examine repetition of seven-syllable nonwords.

Method

Twenty undergraduate students at the University of Illinois participated in this experiment for course credit. Each participant performed a nonword repetition task.

Thirty seven-syllable nonwords were created (e.g., *bentisippelanjevill*, *fommigravelontipan*; in IPA, /ˌbɛntɪsɪpəˈlændʒəvɪl/ and /ˌfɑmɪgrævəˈlɑntɪpæn/ respectively), and were designed to have onsets roughly spanning the letters of the English alphabet. These nonwords had not been created by concatenation of real words . Each stimulus was recorded as digitized sound on a Macintosh computer by the same speaker as in Experiments 1 and 2, using the same software. Each stimulus was presented at its normal spoken duration as recorded. The procedure was identical to the procedure for nonword repetition in Experiments 1 and 2, except that there was no concurrent articulation task.

Results and discussion

Figure 3 plots the effect of serial position on repetition accuracy of the seven-syllable nonwords. The results were subjected to a 1-way ANOVA with serial position as the independent variable. Planned comparisons were made corresponding to the Primacy, Recency1, and Recency2 measures. Both primacy and recency were significant ($F1(1, 114) = 19.4, p < .0005$ for Primacy; $F1(1, 114) = 22.5, p < .0005$ for Recency2; $MSE = 87.7$). Primacy and recency were also significant in the item analysis ($F2(1, 203) = 6.3, p < .05$ for Primacy; $F2(1, 203) = 7.3, p < .01$ for Recency2; $MSE = 403.9$). Experiment 3 thus indicates the presence of syllable serial position primacy and recency effects in nonword repetition, even in the absence of concurrent articulation, and even for nonwords that are not created by concatenation of monosyllablic words but are more naturalistic.

The serial position curve is more U-shaped than is typical for immediate serial recall of lists of words, where the primacy portion is usually more extensive than the recency portion. This is likely due to the placement of stress. In the seven-syllable nonwords in Experiment 3, primary stress was always placed on the fifth or sixth syllable. When serial position curves are plotted separately for the fifth- versus sixth-syllable stress nonwords, there is a clear trend in each case for repetition accuracy to be greater for the stressed syllable than for the neighboring syllables. Thus for the set of seven-syllable nonwords overall, repetition accuracy at the fifth and sixth serial positions was boosted by primary stress. This is the likely reason why the recency portion is more extensive

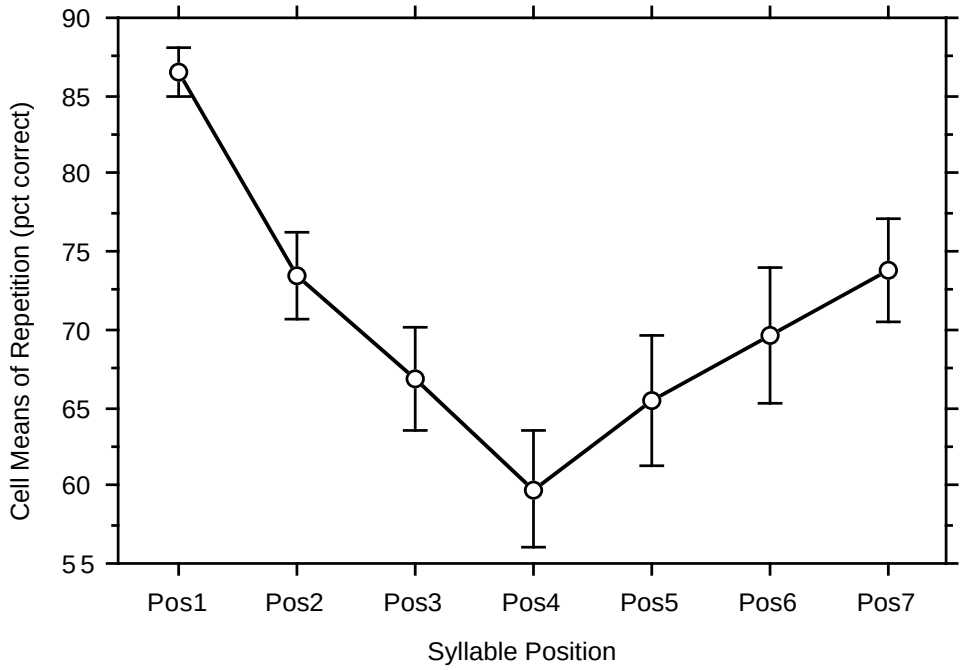

Figure 3: Results of Experiment 3

than typical of immediate serial list recall. A similar analysis for Experiments 1 and 2 reveals that repetition accuracy was also greater for the stressed (second or third) syllable in those experiments. However, this performance boost at serial positions two and three impacted both the primacy and recency portions of the serial position curve; this is the likely explanation for preservation of its typical shape in those experiments.

GENERAL DISCUSSION

The present experiments document the presence of syllable serial position primacy and recency effects in nonword repetition. These effects were obtained both with and without silent concurrent articulation, at both a normal and a slowed stimulus duration, for both compositional and non-compositional stimuli, and for both four-syllable and seven-syllable nonwords. In Experiment 1 especially, the serial position effects were very similar to those obtained in immediate serial recall of lists.

Although these results provide evidence of primacy and recency in nonword repetition, they do not in themselves establish that these serial position effects are necessarily generated by the same mechanisms as those underlying immediate serial recall of lists. Nevertheless, when taken together with the considerable body of evidence indicating an association between nonword repetition and list recall, these results are consistent with the idea that serial ordering mechanisms similar to those underlying immediate serial recall may be operative in the repetition of nonwords (see also Gupta, in press, for discussion of possible computational bases). The present results also indicate that serial position effects are a fruitful means of examining the important relationship between these

abilities, and that further investigation along these lines may be very informative.

Acknowledgements

The author thanks Mary Green for assistance with stimulus creation, Gary Dell, Nadine Martin, Randi Martin, Eleanor Saffran, Myrna Schwartz, and David Caplan for helpful discussion, and Karen Langsam, Rebecca Reese, Po-Han Lin, Tony Buhr, and Wendy Troob for assistance in transcription and coding of results.

References

Baddeley, A. D., Gathercole, S. E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review, 105*, 158–173.

Gathercole, S. E., & Baddeley, A. D. (1993). *Working memory and language*. Mahwah, NJ: Lawrence Erlbaum.

Gupta, P. (in press). Examining the relationship between word learning, nonword repetition, and immediate serial recall in adults. *Quarterly Journal of Experimental Psychology (A)*.

Gupta, P., & Cohen, N. J. (2002). Theoretical and computational analysis of skill learning, repetition priming, and procedural memory. *Psychological Review, 109*, 401–448.

Gupta, P., & Dell, G. S. (1999). The emergence of language from serial order and procedural memory. In B. MacWhinney (Ed.), *The emergence of language*, 28th Carnegie Mellon Symposium on Cognition. Mahwah, NJ: Lawrence Erlbaum.

SoundEdit 16 Users Guide [Computer software], Version 1.0. (1997). San Francisco: Macromedia, Inc.