INTERVENTION IN TWO RHYME PRIMING TASKS

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ABSTRACT

We report results from two experiments in which the effects of *rhyme prime* (RP) are investigated by manipulating the properties of the interveners between prime and target. Studies of visual priming report that interveners have differing effects depending on the types of processing they require; we extend this line of inquiry to the auditory domain. Results suggest that RP is affected by the types of processing required for interveners: intervening tones are less disruptive interveners than more complex nonwords. We relate this finding to the syllabic representations (or the process building them), and outline directions for further work.

Keywords: rhyme, priming, lexical processing

1. INTRODUCTION

Auditory phonological priming effects like those due to *rhyme prime* (RP) (e.g., *cat*→*mat*) diminish with increased distance between prime and target [5,14]. Decrease in phonological priming is reported both in studies that manipulate time (ISI/ITI/SOA) between prime and target, and in studies that add intervening items between them [2,9]. There are thus different reasons why RP facilitation might decrease. The decrease could be due to simply the raw time that has elapsed between prime and target; cf. [9]. At the same time, since words intervene between prime and target, other explanations are possible; e.g., that memory traces of intervening words push out older ones [2]. It is also possible that processing intervening items (not memory load *per se*) interrupts the storage of the prime, resulting in no facilitation of the rhyming target. Overall, intervention effects provide a window on the processes and representations that drive RP in the first place, and, ultimately, provide a window on the phonological organization of the mental lexicon.

2. BACKGROUND/GOALS/METHODS

Rhyme facilitates lexical access in auditory priming paradigms [14]. An important question about this effect is its locus/loci in the stages of processing and representations involved in lexical access. The finding of RP with nonwords suggests that the effect is driven by pre-lexical processing [5]. Studies investigating RP have revealed much about linguistic representations. For example, RP is driven by syllable rhyme overlap, and not just by overlapping segments: the priming produced by e.g., *cat*→*mat*, where the syllables rhyme, exceeds that found with *cat*→*tack*, even though the latter pair (unlike the former) consists of the same phonemes. RP has also been used to probe morphological processing [1,8].

Our goal in this work is to ask a set of questions about RP itself. Previous work has noted that it is short-lived: its effects disappear when even a single word intervenes between prime and target (*cat*→*bus*→*hat*). Using intervening items is a useful way for probing relatedness among words, as different types of relations show differences in persistence. For example, semantic and phonological inhibition effects have been reported to disappear after 1 intervener [11,16], whereas morphological and repetition priming effects persist after many intervening words [16]. Importantly, work in the visual domain by Forster [7,6] reports effects on priming modulated by amount of processing required for an intervener. Along these lines, this paper investigates the effects of interveners of differing acoustic and linguistic complexity. The intuition behind this manipulation is that it will allow us to see whether RP intervention is differentially modulated by the types of processing that are required for the intervener. In turn, observing such modulations will allow us to form hypotheses about the representations/processes implicated in RP.

We examine RP intervention in both lexical decision and stop-go paradigms. In continuous lexical decision, participants make judgments to all stimuli, whereas in stop-go, only words are responded to. By employing both tasks, it is possible in principle to probe the way in which intervention might be modulated by the need to make a judgment about interveners. Both experiments were implemented in Ibex [4]; subjects (recruited with Prolific; Expt. 1: 117; Expt. 2: 129) reported themselves as native speakers of American English. Both experiments use four intervener types between primes and targets, and between-subject designs so that across lists, identical targets were preceded by all four intervener types in both rhyme and non-rhyme prime conditions; this produced 8 lists per experiment. In both experiments, primes, targets, and fillers were matched as far as possible in SUBTLEX [3] contextual diversity measure. All word and nonword stimuli were recorded in a sound attenuated room by a male speaker of standard American English.

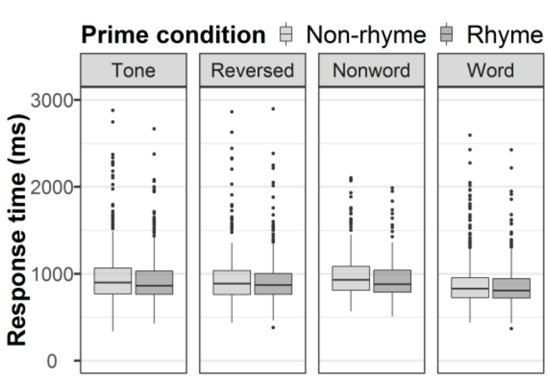
3. EXPERIMENT 1: LEXICAL DECISION

Experiment 1 used continuous lexical decision (subjects responded to all stimuli). Two prime conditions were matched with targets: R(hyming) and N(on)-R(hyming) (baseline). Primes and targets were separated by four intervener types: (1) Tones (400ms, steady state, varied between 700-1320Hz); (2) Reversed words (reversed word sound-files); (3) Nonwords (phonotactically licit); and (4) Words (monosyllabic). Example primes for a target *zinc* are *ink* (R) and *bliss* (NR); interveners are e.g., (1) 700Hz tone; (2) *skirt* (Reversed); (3) *jalk* (Nonword); and (4) *skirt* (Word). The stimuli differ along the following lines. Tones have acoustic properties but are not linguistic per se when divorced from words. Reversed words have the acoustic complexity of speech, but do not obey the phonotactics of the language, and are not intelligible in full-word reversal [15]. Nonwords are phonologically well-formed, but do not have lexical representations. Median RTs/boxplots for Experiment 1 are as follows:

Table 1: Median RT (ms) for Experiment 1.

IntType	R	NR
Tone	861	898
Reversed	869	885
Nonword	878	930
Word	807	828

Figure 1: Boxplot of RT (ms) for Experiment 1.



To probe differences produced by the intervener type, we used a Bayesian exGaussian Mixed-Effect model to directly predict the raw RT data. Bayesian modelling does not perform significance tests, but instead gives direct estimates of the probabilities of certain effect sizes. For use of the exGaussian on long-tailed RT data, see [13]. We chose to use Bayesian modelling because it provides an informative way of directly quantifying uncertainty about complex results, and thus presents a more nuanced picture than that provided by a binary significance decision [10]. We fit an intercept-free model, with a parameter for each intervener type (Tone, Reversed Word, Nonword, Word) and an interaction for each intervener type with prime type (baseline = non-rhyming prime). This model gives us estimates of the base RT after each intervener type as well as an estimate of the effect of introducing a rhyming prime. In addition to these critical variables, we also included participant variables of gender, handedness, and age (*z*-scored) along with prime and intervener RT (both *z*-scored). Random intercepts were included for participant, target word, prime word and intervening item. This formula was used to predict both the mean of the Gaussian and the beta of the exponential. The model produces a probability of a RP effect greater than 10ms (assuming a 50% prior; LB/UB = credible interval upper and lower bounds):

Table 2: Parameter estimates for Experiment 1.

Parameter	LB(ms)	UB(ms)	p. priming>10ms
Tone	730	795	
Reversed	732	798	
Nonword	740	808	
Word	696	760	
Tone	-32	8	60%
Reversed	-25	14	32%
Nonword	-25	14	25%
Word	-13	22	5%

The results are mixed. On the one hand, there is not unambiguous priming in any of the conditions; even with Tone interveners, for example, an inhibitory effect on rhyme is credible. We believe that the absence of overall priming might be due to an orthogonal factor (see below). On the other hand, the probability of priming associated with different intervener types appears to pattern in the predicted way: tones are the most likely to have been associated with RP, while other interveners decrease in RP likelihood as they increase in linguistic complexity.

Regarding the absence of priming, one problem with this experiment is that for all of the interveners that are not words, there is a large effect on RT, even for unprimed targets. One explanation for this effect is that there is always a switch in the button-press between these interveners and targets, since the former are always nonwords, the latter always words. Whether this was the case or not, the large effect of interveners in general is likely to have overwhelmed the (possibly quite subtle) differences between intervener types that the experiment was designed to probe. A further problem is that there was no condition without an intervener in this paradigm; thus, a baseline priming effect could not be determined.

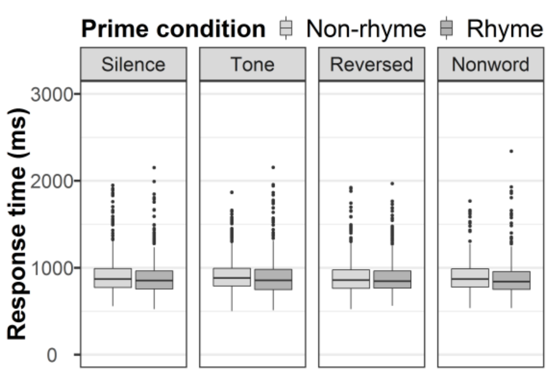
4. EXPERIMENT 2: STOP-GO

Experiment 2 employs three of the four intervener types from Experiment 1. The word interveners were replaced with a silence "intervener" (1200-1500ms); this allows us to see whether RP decay is a function of intervener, not just increased time between prime and target. It also provides us with an effective baseline for RP. The task was a stop-go word detection task, in which subjects responded only to words; i.e., to primes and targets, not interveners. Thus, we avoid the difficulties related to hand-switching with non-lexical interveners mentioned above with respect to Experiment 1.

Table 3: Median RT (ms) for Experiment 2.

IntType	R	NR
Silence	852	870
Tone	854	882
Reversed	845	856
Nonword	841	869

Figure 2: Boxplot of RT (ms) for Experiment 2.



A Bayesian Mixed-Effect Model was run on the RT data, as in Experiment 1. The results of this model are summarized in Table 4:

Table 4: Parameter estimates for Experiment 2.

Parameter	LB(ms)	UB(ms)	p. priming>10ms
Silence	753	802	
Tone	749	797	
Reversed	752	801	
Nonword	753	802	
Silence	-38	-7	95%
Tone	-39	-8	96%
Reversed	-31	-1	78%
Nonword	-30	4	62%

In this experiment, the model shows clear priming effects for all conditions except for Nonword interveners, where an inhibitory effect is still credible. A possible explanation for a difference in the strength of evidence for significant priming would be a difference in effect size. To compare the relative effects of different interveners, we calculated the pairwise probability of an effect size difference between each pair, as shown in Table 5, where "F_x" is "facilitation in condition x":

Table 5: Probability of effect size differences.

Condition A	Condition B	Prob. $F_A > F_B$
Silence	Tone	47%
	Reversed	76%
	Nonword	82%
Tone	Reversed	77%
	Nonword	84%
Reversed	Nonword	62%

In short, these comparisons indicate that the Tone and Silence conditions are very likely to have produced more priming than Reversed and Nonword interveners. Tone and Silence are not likely to differ between themselves in effect size, while there is a small amount of evidence in favor of the hypothesis that the Reversed condition has a larger priming effect than the Nonword condition.

There are two main observations to be made about these results. The first is that Tones—the least linguistically complex interveners that were used—pattern with Silence for the purposes of intervention: neither of these conditions appears to eliminate RP effects. The second point concerns the different tasks employed in Experiments 1 and 2. In Experiment 2, where subjects do not respond to interveners, the Nonword and Reversed word conditions are evidently less disruptive to RP than they are in Experiment 1. Evidently the task change (no response to interveners) is responsible for this difference.

5. DISCUSSION

Our goal was to investigate whether RP is affected differentially in a way that reflects properties of an intervener. Overall, the results of Experiments 1 and 2 provide evidence that there is an increasing probability of RP for non-linguistic interveners: RP is interrupted more by linguistically complex interveners. At a minimum, the findings suggest that something more than just temporal delay is at play. This observation leaves open various possibilities about how to understand RP and, in particular, what intervention reveals about the level(s) of representation/processing involved.

One point to consider is that Reversed/Nonword interveners both appear to inhibit RP relative to Silence/Tones. Care must be taken to interpret this finding given prior reports in the literature. The studies in [14] demonstrate that RP reflects metrical phonological representations (syllables), and not just segments. It has also been demonstrated that RP can be produced with nonwords, reinforcing the idea that the effect is pre-lexical. On the face of it, if RP is driven by syllabic representations, it is easy to understand why Nonword interveners like those used here would interrupt it, as they consist of licit syllables. Effectively, facilitation would result from a syllable nucleus being active in memory when the rhyming target is processed. The Reversed interveners, on the other hand, are not phonotactically well-formed in English. However, they are comprised of (reversed) speech sounds, and, as such, the speech processing system may attempt to parse them into syllabic representations; evidence for this idea can be found in the literature reviewed in [15], see also [12].

One possibility is that the operation of attempting to create syllables disrupts the RP effect even when the syllables in question do not exist in the language. The materials that were employed in the Reversed condition contain a mixture of licit and illicit syllables. The idea that the speech processing system is sensitive to this difference could be explored by comparing the intervention effects of nonword interveners that do and do not correspond to well-formed syllables in the language. As far as this reasoning goes, it is also important to consider the possibility that the Reversed and Nonword conditions might turn out, under further investigation, to be different from each other in their effects on RP, with Nonwords being more robust interveners (cf. Table 5).

In summary, continued exploration of intervention effects along these lines might provide insight into whether RP involves the activation of stored syllabic representations or the parsing of acoustic input into syllables, or both.

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