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Lexical Neighborhoods and Release from Proactive Interference: A First Report[1]

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Abstract. The effect of lexical competition on recall performance was studied using the release from proactive interference paradigm. Word triads were equated in terms of local neighborhood density but varied on global neighborhood density, neighborhood frequency, and word frequency to create sets of lexically "easy" and "hard" words. Proactive interference was built up across four trials of either "easy" or "hard" words and "released" on the fifth trial with words from the opposite lexical category. The results failed to support the prediction that greater release from proactive interference would be observed when switching from "hard" to "easy" words, although some evidence for a reversal of the release effect was found when switching from "easy" to "hard" words. Extensions to the current design and future studies using this experimental paradigm are discussed.

Introduction

In the Brown-Peterson paradigm (Brown, 1958; Peterson & Peterson, 1959), participants are presented with a short list of three items, followed by a retention interval in which they engage in some distracting activity – counting backwards by threes, backward naming, stroop color naming etc. – to prevent active rehearsal. Participants are then required to recall the list. Keppel and Underwood (1962) demonstrated that recall performance declined quickly over the first few trials. They attributed this effect to the build-up of proactive interference (PI). PI refers to the forgetting of current material because of interference from previously learned material. Items from earlier trials interfere with the recall of items from the current trial.

Recall performance can be raised again if some attribute of the items in the current trial is changed. Wickens, Born, and Allen (1963) demonstrated this "release" from PI effect by changing the semantic category of the items to be remembered in the critical trial; for example, switching from a consonant triad to a number triad or vice-versa. Participants are "released" from the effects of PI and recall performance is restored to the level of the first trial.

The typical procedure in this paradigm is as follows: in the first three trials, the experimental and control groups receive identical triads sharing a similar attribute, or drawn from a single category. These initial trials comprise the PI build-up phase. Recall performance declines as a function of increasing interference from earlier trials. On trial 4 – the critical or release phase – the experimental group receives a triad that differs from the earlier triads on some attribute, or the items are drawn from a different category. The control group continues to receive a triad that is similar to the trials in the PI build-up phase. Recall performance gets a dramatic boost in the experimental group, while it continues to decline in the control group.

This "release" from PI effect has been shown to be very robust using a wide variety of attribute changes. Wickens (1970) has argued that the paradigm is a powerful tool for exploring the extent to which various dimensions are encoded and stored in memory. The amount of "release" obtained with different dimensional changes is assumed to reflect the salience of that dimension in memory. Generally, semantic attributes such as category membership produce a greater amount of release from PI than physical attributes such as word length, phonological similarity, and visual configurations of the presentation (Wickens, 1970).

Although the Brown-Peterson technique is a short-term memory (STM) task, the nature of the release from PI effect is generally regarded as a secondary memory phenomenon (Craik & Birtwistle, 1971). The finding that semantic dimensions are more effective in producing release effects is consistent with the view that semantic dimensions are the domain of long-term memory (LTM). Phonological similarity and word length affect performance in STM span tasks (Baddeley, 1966; Baddeley, Thompson, & Buchanan, 1975), but both of these dimensions have little effect in producing release from PI (Wickens, 1970). This suggests that the locus of PI release is not in the STM processes involved in immediate memory span tasks but is in some other memory process that is dependent on long-term knowledge.

The Locus of the "Release"

Three different explanations have been proposed to account for the release from PI effect. First, the attentional or encoding hypothesis proposes that participants are perceptually alerted by the change in material, and consequently, the items are better registered in memory (Wickens, 1970).

Second, the storage hypothesis posits that PI reflects the spontaneous interaction during storage between traces of current items and those of similar items stored from preceding trials. "Release" items are less vulnerable to inter-trial interference (Posner, 1967). This view of PI release assumes the library metaphor of memory, in which items are "automatically" stored in their proper "shelves", with similar items being stored "closer" together. A change in material will therefore be less vulnerable to interference because the items will no longer be stored in the vicinity of the earlier items.

Third, the retrieval hypothesis proposes that the build-up of PI reflects the declining effectiveness of a participant-generated retrieval cue, which is common to the past few trials. A change in stimulus materials supplies a novel, and thus, more effective retrieval cue (Wickens, 1970).

The debate about PI release in the 1970s was largely between the encoding and retrieval hypotheses. Although one can imagine that some aspect of both explanations are operating in reality, these alternative hypotheses were often pitted against each other as mutually exclusive explanations. The resolution has largely been in favour of the retrieval cue hypothesis. I will describe one study that has often been cited in this regard.

Gardiner, Craik, and Birtwistle (1972) attempted to elucidate the locus of the PI release effect by making the category shift less obvious. Instead of shifting from one category to another on the critical trial, they made the change subtler by shifting from one subset of a larger category to another subset within that same category. For example, the items shifted from *wild* flowers to *garden* flowers.

Participants were randomly placed in one of three conditions. In the "cue at presentation" (CP) condition, a subset cue, "garden", was provided *before* the critical triad of words was presented. This manipulation should induce participants to use the subcategory cue during encoding of the triad, and presumably during recall as well. In the "cue at recall" (CR) condition, the subset cue was only provided at the *recall* phase. This should induce participants to use the subcategory cue during recall, but not at encoding. In the control condition, participants did not receive any subset cue at all. Table 1 summarizes the conditions in the study:

Gardiner et al. (1972) found that participants in *both* the CP and CR conditions showed a significant release from PI effect. No release was obtained in the control condition. At first glance, the results seem to support both the encoding and retrieval hypotheses. However, the authors argued for one alternative – the retrieval hypothesis. If the encoding hypothesis is correct, performance in the CR condition should be no better than the control condition. This is because there is no processing difference between the CR and control conditions until the recall phase. In both conditions, no attention was drawn to the fact that there was a subcategory shift in the last trial until the recall phase, so the participants in the CR condition should not have encoded the "release" trial any differently from the participants in the control condition. Since the cue was only provided during the recall phase in the CR condition, the facilitation in performance suggests that the cue was useful in the *retrieval* process and not the *encoding* process. In contrast, for the CP condition, attention to the cue was induced prior to encoding the "release" triad, so participants could encode the "release" triad differently. The encoding hypothesis can explain the release in the CP condition, but not the release in the CR condition. According to the encoding hypothesis, there should not have been any release in the CR condition, but the findings showed that there was a release effect.

Condition	PI Build-up Phase		Release Phase	Recall
Cue at presentation (CP)	wild flowers	cue	garden flowers	???
Cue at recall (CR)	wild flowers		garden flowers	cue ???
Control	wild flowers		garden flowers	???

Table 1. Conditions in the Gardiner et al. (1972) study.

This finding is also incompatible with the storage explanation because it rules out any "automatic" encoding of items in memory – otherwise any change in the material should lead to storage in a different location and thus better recall. The control group clearly showed that if the cue is not made salient, participants do not "automatically" use it. Because neither the encoding or storage hypotheses can fully explain the data, we are left, by elimination, with the retrieval hypothesis.

These results have been replicated in a more recent study (Wixted & Rohrer, 1993). Several investigations using other paradigms have also found support for a retrieval cue locus for the release from PI effect (e.g., Watkins & Watkins, 1975; Wickens, Moody, & Dow, 1981). The prevailing view is that subjects are unable to restrict their search space to just the current list, if the retrieval cue is also relevant to items from previous lists. Watkins and Watkins (1975) argued that the build-up of PI can be viewed as cue "overload", which describes the declining efficiency of a functional retrieval cue as the number of items it subsumes increases. This is consistent with other memory phenomena such as the list length effect (the decrement in performance as the length of the list increases) in free recall (see Raaijmakers & Shiffrin, 1992). If the context of the experiment or the presented list acts as a functional retrieval cue, then the cue's effectiveness for retrieval declines as list membership grows.

The use of a cue (completely new material, a subcategory, or other discriminating cue) that allows an effective restriction of the search space should result in the "release" from the interference of previous items.

Lexical Neighborhoods and Memory

Since the mid 1980s, there has only been a handful of research using the release from PI paradigm (e.g., Wixted & Rohrer, 1993). Given the robust nature of the effects that have been elicited by this paradigm, it remains a potentially useful task that can be utilized to explore the organization of lexical entries in LTM.

One aspect of lexical organization that has been intensively investigated in the spoken word recognition literature is the concept of lexical neighborhoods as defined by their phonological properties (Landauer & Streeter, 1973; Treisman, 1978; Luce, 1986; Luce & Pisoni, 1998). The neighborhood density of a word can be computationally derived by considering the number of words that can be obtained by a single phoneme substitution, addition, or deletion. The neighborhood frequency of a word can be derived from the average frequency of the word's neighbors.

Using these properties, words can be classified into those that would be theoretically "easier" or "harder" to recognize. "Easy" words are high frequency words with low neighborhood density and low neighborhood frequency. Thus, they have less competition from similar sounding words during the recognition process and so should be more easily recognized relative to "hard" words, which are low frequency words that come from high density and high frequency neighborhoods.

Previous studies have demonstrated that these lexical neighbourhood properties influence word recognition as shown in the accuracy of perceptual identification, latencies in naming and lexical decision tasks, and priming effects (Goldinger, Luce, & Pisoni, 1989; Luce & Pisoni, 1998; Luce, Pisoni, & Goldinger, 1990). Specifically, "easy" words are recognised more accurately and more quickly than "hard" words. These results have been incorporated in the Neighborhood Activation Model of word recognition (Luce & Pisoni, 1998), and the connectionist version, PARSYN (Luce, Goldinger, Auer, & Vitevitch, in press). The key assumption of both models is that words are recognised "relationally" through a process of lexical discrimination. The organization of the mental lexicon, specifically the phonological properties of these words' LTM traces, plays a critical role in the recognition process (see Luce & Pisoni, 1998).

While the effects of lexical neighborhoods on word recognition tasks have been well established, several recent studies have begun to explore the extent to which these properties affect other tasks such as serial recall. Goldinger, Pisoni, and Logan (1991) showed that serial recall of ten-word lists made up of lexically "easy" words was superior to lists made up of lexically "hard" words. Goh and Pisoni (1998) further showed that the difference between "easy" word-spans and "hard" word-spans were not related to participants' short-term memory capacity, as measured by digit-span performance, and that the serial recall differences between "easy" and "hard" words can be eliminated when a small set of words are repeatedly used over and over compared to using novel words for each new list. These results suggest that when considering the effects of lexical neighbourhoods on memory tasks such as serial recall, the locus of these effects is likely to be in the LTM component of the tasks, and not in the STM processes. STM capacity does not reliably predict the performance differences between "easy" and "hard" word lists (see Goh & Pisoni, 1998).

As previously described, the release from PI effect appears to be localized in LTM retrieval processes. The release from PI paradigm may thus provide another way to test the proposition that lexical neighbourhood effects stem from LTM processes. The use of different tasks to test hypotheses will provide valuable converging evidence or alternatively, disconfirmatory evidence for theoretical claims. The present pilot study was an attempt to explore the influence of lexical neighbourhoods on the release from PI effect.

The basic question of interest is whether the "release" effect will be of the same magnitude when the critical triad switches from "easy" words to "hard" words, compared to the reverse condition. Lexically "hard" words should result in a greater build up of PI because their dense neighbourhoods will result in interference from many similar sounding words in the lexicon. Any retrieval cues that participants may utilize to retrieve the target words will become increasingly less useful for discriminating between the context of the current trial and the interference from the neighbourhood activations of "hard" words and the context of previous trials. Hence, switching from "hard" to "easy" words may result in a significant "release" effect because the "easy" words will have to contend with fewer competing neighbours, and the retrieval cues may more easily discriminate the context of the current trial from the previous trials. In the reverse situation (switching from "easy" to "hard" words), the PI build up is likely to be less severe because the sparse neighborhoods may produce less interference. Switching from a context of less interference to one of more interference may not produce a "release" effect at all, and in fact, may even produce a greater decline in performance.

One important issue that needs to be discussed is the distinction between *local* and *global* neighborhoods. Global neighborhood properties refer to what has been traditionally computed in selecting the set of experimental stimuli – density and neighbourhood frequency indices derived from computations using the entire mental lexicon, or an estimate thereof. In contrast, local neighborhood properties refer to indices computed only from the set of experimental stimuli. For example, the local neighborhood density of a particular word will be derived from the number of other words in the experimental corpus that can be obtained using the phoneme substitution rule, not from the *total* number of words that can be obtained. Ideally, if one is investigating the influence of LTM structure and not STM, one should vary the global neighbourhood properties of the words and control for the local neighborhood properties. In other words, the "easy-hard" distinction should be based on *global* properties, while *local* properties are equated. Whatever effects are found can then be solely attributed to the global properties in LTM organization. This control is difficult to implement in studies that use a large number of words that are not repeated from trial to trial (e.g., Goh & Pisoni, 1998; Goldinger et al., 1991). However, in the release from PI paradigm, only a handful of words are required for the whole experiment, and hence it is easier to establish a local neighborhood control for the neighborhood density index. To establish local controls for the frequency and neighborhood frequency indices will require experimentally induced frequencies, which is not within the scope of the current paradigm.

The specific hypothesis of this investigation is that a greater release from PI will be observed when the critical triad switches from "hard" words to "easy" words than the reverse. There may not even be a reliable "release" effect in the "easy-hard" switch relative to performance on the first trial. In fact, the opposite effect may be observed, where performance declines even more sharply relative to the decline in performance in the trials during the PI build up phase.

Method

Participants

Forty-three Indiana University psychology undergraduates participated for course credit. All were native English speakers with no self-reported speech or hearing disorder at the time of testing.

Materials

Tokens of 30 spoken words (15 "easy" and 15 "hard") were drawn from a pre-recorded digital database (see Torretta, 1995, for a detailed description). All of the test items were monosyllabic consonant-vowel-consonant words that were rated as highly familiar (> 6.7) on the 7-point Hoosier Mental Lexicon scale (Nusbaum, Pisoni, & Davis, 1984). The tokens recorded by the most intelligible male talker (M9, who had a mean intelligibility score of > 95%) at a "medium" speech rate were used (see Torretta, 1995, for details). The mean statistical properties of the tokens are listed in the appendix.

Apparatus

Gateway 2000 Pentium 133 MHz IBM compatible computers equipped with SoundBlaster AWE32 sound cards were used to control the experiment. The stimuli were presented to participants via Beyer Dynamic DT100 headphones at approximately 75 dB SPL.

Design

The experiment employed a 2 x 5 mixed factorial design. The Release independent variable – "easy" words build-up, "hard" words release (EH) vs. "hard" words build-up, "easy" words release (HE) – was run as a between-subjects variable. The Trial independent variable (4 build-up trials and a single release on the 5^{th} trial) was run as a within-subjects variable.

Procedure

Participants were tested individually or in small groups of five or fewer. There were three phases in the experiment, which took approximately 15 minutes to complete. In the first phase, participants were given practice on the filler task, which was simply to mentally keep a running sum of a sequence of digits presented on the computer monitor. Each digit appeared at the center of the monitor for a duration of 1750 msecs, after which it was cleared from the screen and the next digit appeared at the same location. The digits were randomly picked from the numbers 5 through 9, with the proviso that the same digit did not appear consecutively. A total of ten digits appeared before participants were prompted to enter the sum of the digits. Feedback was given on the accuracy of the responses. After five filler trials, the computer determined if participants achieved a criterion of four correct trials. If not, another five trials were given to the participants and so on. After the third set of five filler trials, participants were allowed to move on to the next stage of the experiment, regardless of their performance on the practice filler trials. Performance accuracy was recorded by the computer.

In the second phase, participants heard a random sequence of three digits spoken by a male talker over the headphones at an inter-stimulus interval of 250 msecs. This male talker was not the same as the talker who produced the word tokens that were used in the final phase. After the presentation of the last digit, the same filler task that participants practiced in the first phase appeared. After a single trial of the filler task, participants were prompted to recall the three digits that they heard over the headphones. The total retention interval was 20 seconds. Participants had 15 seconds to type their responses using the keyboard before the next trial began. The computer recorded the responses for both the filler and recall tasks. Participants completed two more trials consisting of a digit triad presented auditorily followed by the filler task before moving on to the next stage of the experiment. The purpose of this second phase was to give participants some practice on doing the recall and filler tasks together.

In the final phase of the experiment, the procedure was exactly the same as the second phase, except that a triad of spoken word tokens was randomly selected and presented auditorily instead of three digit tokens. Words selected for the current trial were not used again in any subsequent trials. The first four trials constituted the PI build-up trials in which the triads were comprised of only "easy" words in the EH condition, or only "hard" words in the HE condition. The fifth trial was the release trial, where "hard" words were presented in the EH condition, and "easy" words were presented in the HE condition.

Results

Analyses by Subjects

I had initially intended to analyse only the data from participants who were able to meet the criterion of four out of five correct trials in the filler task practice phase. This was deemed necessary to ensure that participants were actually doing the filler task and not rehearsing the auditory triad during the retention interval. However, the filler task proved to be rather difficult and only six participants met this strict criterion. Therefore, I will report two sets of analyses – one using all participants, regardless of filler task performance, and one using a more relaxed criterion, in which those participants who gave an accurate response to three out of the five filler trials in the final phase of the experiment were included in the analyses. The latter criterion yielded 20 admissible participants.

Following Kincaid and Wickens (1970), a point was given for each word of the triad that was correctly recalled, regardless of sequence position. An extra point was given if all three words were recalled in the correct order. So the maximum score for any single trial is four – three points for each word, and one extra point if the triad was recalled in the correct order.

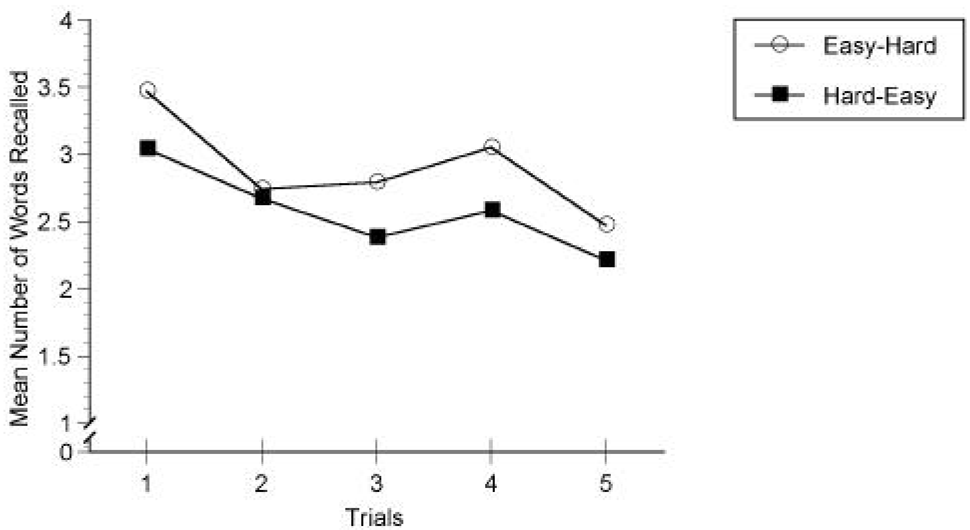

Figure 1. Mean recall for all participants.

Figure 1 shows the pattern of results when the data from all participants were included, regardless of whether they met the performance criterion in the filler task. A 2 x 5 mixed factorial analysis of variance (ANOVA) revealed a reliable main effect of Trials, $F(4, 164) = 3.27$, $MSe = 1.49$, $p < .05$, indicating that performance decreased as the number of trials increased. Figure 1 shows the presence of an increasing build-up of PI from the first to the fifth trial. All other effects were not significant, which indicates that when the performance of all participants was considered, the hypothesised interaction between the type of word (“easy” vs. “hard”) and the effect on the release from PI (EH vs. HE at trial 5) was not supported. The mean performance on each trial is given in Table 2.

Release Condition	Trial				
	PI Build-up Phase				Release
	1	2	3	4	5
Easy-Hard					
M	3.47	2.74	2.79	3.05	2.47
SD	0.90	1.33	1.08	1.18	1.39
Hard-Easy					
M	3.04	2.67	2.38	2.58	2.21
SD	1.08	1.31	1.41	1.53	1.28

Table 2. Mean recall performance across trials (all participants).

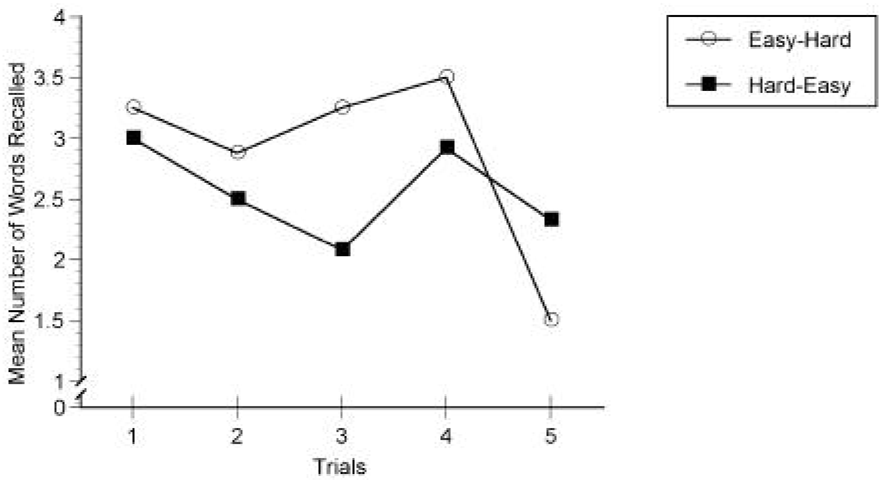

Figure 2. Mean recall for participants who were accurate on at least 3 filler trials.

Figure 2 shows the pattern of results when only the data from the participants who met the relaxed criterion of 3 out of 5 filler trials correct were examined. A 2 x 5 mixed factorial ANOVA again showed a reliable main effect of Trials, $F(4, 72) = 4.51$, $MSe = 1.12$, $p < .01$, indicating a general build-up of PI as performance decreased across trials. This time, however, there was a marginal Trials x Release interaction, $F(4, 72) = 2.55$, $MSe = 1.12$, $p < .07$. Tests of simple effects showed that the source of the interaction was the significant simple effect of Trials in the EH condition, $F(4, 72) = 4.57$, $MSe = 1.12$, $p < .01$; all other simple effects were not significant. Post-hoc pairwise comparisons of the recall performance at each trial in the EH condition showed that the "release" trial (trial 5) was significantly lower than all the trials in the PI build-up phase (trials 1 to 4). This result suggests that there was a reversal of the release effect in the EH condition – switching to "hard" words caused even more interference for recall than switching to "easy" words. This supports one of the earlier predictions. However, the data do not support the prediction that switching from "hard" to "easy" words should result in a reliable release effect in the HE condition. The mean performance at each trial is shown in Table 3.

Release Condition	Trial				
	PI Build-up Phase				Release
	1	2	3	4	5
Easy-Hard					
M	3.25	2.88	3.25	3.50	1.50
SD	1.04	1.25	1.04	0.93	1.20
Hard-Easy					
M	3.00	2.50	2.08	2.92	2.33
SD	1.04	1.17	1.31	1.38	1.37

Table 3. Mean recall performance across trials (at least 3 fillers correct).

Analyses by Trials

The data were also subjected to a trials analysis. In this analysis, for each of the five trials across every participant, only those trials where a correct answer was given for filler task were admitted. Although this meant that there would probably be unequal numbers of participants for each trial (to be conservative, Trials would be considered a between-subjects factor), this method of analysis may provide additional converging evidence for the pattern of results obtained in the analyses by subjects.

Figure 3 shows the pattern of results observed after using the above criterion. A 2 x 5 between-subjects ANOVA showed a reliable main effect of Trials, $F(4, 84) = 3.11$, $MSe = 1.54$, $p < .05$, again indicating a general build-up of PI across trials. All other effects were not significant. Although there was no significant interaction between Trials and Release, the observed pattern is similar to the pattern displayed in Figure 2. Post-hoc analyses using Tukey's HSD procedure for each level of the Release independent variable showed that, in the EH condition, recall at Trial 5 was significantly lower than recall at Trials 1 and 4. None of the other pairwise comparisons were significant. In the HE condition, all pairwise comparisons were not significant. Again, the results of this analysis suggest that there was some indication of a reversal of the release effect in the EH condition, but there was no evidence of any release effect in the HE condition.

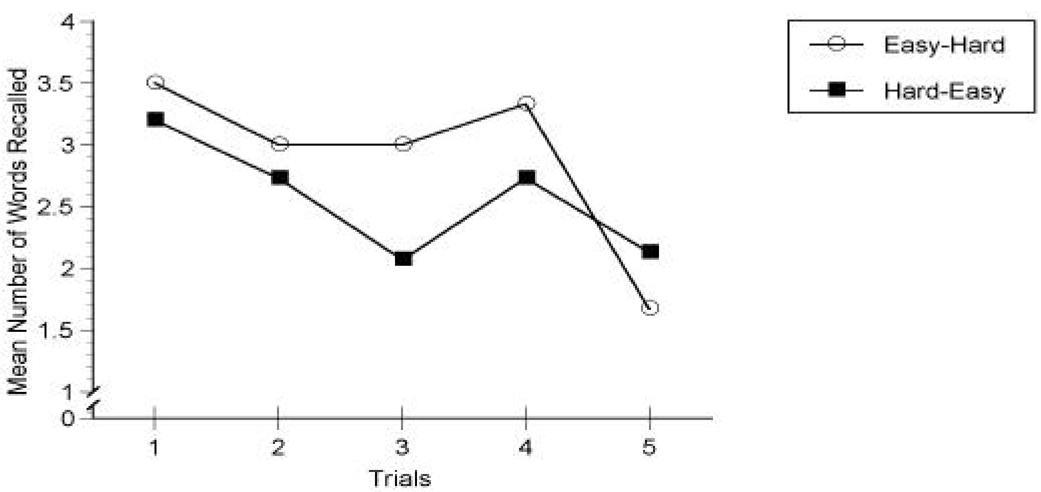

Figure 3. Mean recall for trials with accurate filler answers.

Figure 4 shows the pattern of results obtained when a less stringent criteria was used to do the trials analyses. This time, trials in which the participants' filler task response did not deviate by more than 5 from the correct sum were included. The 2 x 5 between-subjects ANOVA revealed a reliable main effect of Trials, $F(4, 173) = 3.62$, $MSe = 1.54$, $p < .01$, replicating previous analyses, and a reliable main effect of Release, $F(1, 173) = 6.13$, $MSe = 1.54$, $p < .05$, indicating that there was generally better recall in the EH condition relative to the HE condition. There was no significant interaction between Trials and Release. Again, however, Tukey's HSD analyses showed that there was a significant difference between recall at Trials 1 and 5, but only in the EH condition. As before, the "release" with the "hard" words was actually more detrimental to performance, but again, there was no evidence of any release in the predicted direction in the HE condition.

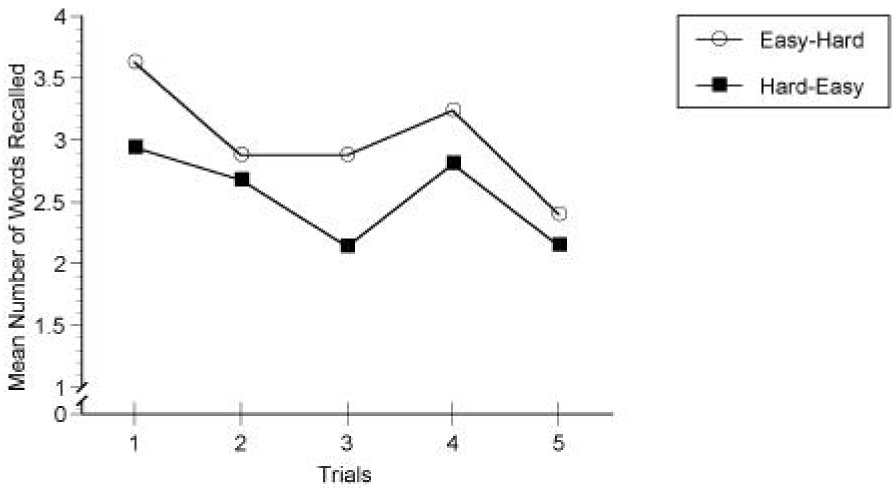

Figure 4. Mean recall for trials with filler answers that did not deviate by more than 5 from the correct answer.

Discussion

The observed results did not support the main hypothesis that there would be a greater release from PI effect when participants were switched from "easy" word triads to "hard" word triads than the reverse. Some evidence was obtained that supported the predicted detrimental effect on performance in the release trial of the "hard-easy" switch.

It should be pointed out that several important control conditions were not run in the present pilot study, namely, the conditions where all five trials remained "easy" or "hard" word triads. The extent of a "release" effect would normally be determined by comparing the recall performance on the "release" trial with the recall performance on the fifth trial on these control conditions. However, since the critical prediction of the original hypothesis was a *relative difference* between recall on the first and fifth trials across the two different release conditions, the lack of the "no switch" controls does not detract from the interpretation of the major results.

The overall lack of a release from PI effect in this study suggests that the lexical neighborhood properties of the word triads are not affecting the retrieval processes used in recalling the words in this paradigm. However, there are a number of issues that warrant further investigation. First, there does seem to be some detrimental effect when switching from "easy" to "hard" triads, so the greater lexical competition in "hard" neighborhoods may in fact be affecting the efficacy of retrieval cues. Second, it is possible that a longer retention interval may be required to reveal a release effect in the “hard-easy” condition – the activation levels of the “hard” neighborhoods in the PI build-up phase may still be at a level that is high enough to cause interference in the “easy” release trial. Increasing the retention interval may serve to reduce the activation levels of the “hard” neighborhoods sufficiently for the “easy” release trial to show the predicted effect. Neighborhood activity becomes attenuated when the inter-stimulus-interval between trials is increased in a priming paradigm (Goldinger et al., 1989). Finally, Wickens (1970) noted that the release from PI phenomenon is most robust when the dimension that is switched is semantic in nature. Surface level features such as orthography and phonology show much weaker release from PI effects. It may thus be inherently more difficult to elicit an effect with phonological neighborhood properties, especially when it is the global and not local properties that were manipulated – phonological neighborhoods may constitute a dimension that is not “salient” enough to produce a robust effect in this procedure.

In summary, while the present results did not provide conclusive evidence that phonological neighborhood properties affect the efficacy of retrieval cues that prior studies have shown to be the locus of the release from PI phenomenon, some evidence was observed for an asymmetry across the two conditions tested. There seemed to a reversal of the release from PI effect in the EH condition, but the typical release from PI effect was not obtained in the HE condition. Extensions of the current design using some of the control conditions that were not implemented in the present study, or increasing the retention interval, may provide more reliable results.

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Appendix

"Easy" Words

curve	dirt	dog	fig	join
judge	league	leg	lose	noise
page	roof	soil	theme	wash

"Hard" Words

cheer	chore	comb	hid	hoot
hurl	lad	mall	pawn	pup
sill	soak	tan	wail	white

Note. Except for cheer/chore, league/leg and sill/soil, which are neighbors of each other, the local neighborhood density for the other 24 words is 0 – none of these words are neighbors of each other. The mean global neighborhood density, mean log neighborhood frequency, and log frequency for the "easy" words are 11.87 (4.63), 1.93 (0.25), and 2.75 (0.10) respectively; and for the "hard words, they are 25.53 (5.94), 2.22 (0.25), and 1.80 (0.54) respectively. Numbers in parentheses are the standard deviations. Frequency counts are based on the Kucera and Francis (1967) counts.