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Lexicality and Phonological Similarity:

A Challenge for the Retrieval-Based Account of Serial Recall?

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Abstract

The retrieval-based account of serial recall (Saint-Aubin & Poirier, 2000) attributes lexicality, phonological similarity, and articulatory suppression effects to a process where long-term representations are used to reconstruct degraded phonological traces. Two experiments tested this assumption by manipulating these factors in the recall of four- and five-item lists. Lexicality enhanced item recall (IR), but only affected position accuracy (PA) for five-item lists under suppression. Phonological similarity influenced both words and non-words, and produced impaired PA in silent and suppressed conditions. Consistent with the retrieval-based account, words and non-words of high-word likeness appear subject to redintegration. However, some findings, like suppression not reducing the phonological similarity impairment in suppressed conditions, present challenges for the retrieval-based account and other models of serial recall.

Lexicality and Phonological Similarity: A Challenge for the Retrieval-Based Model of Serial Recall?

A number of recent short-term memory theories have proposed that, at retrieval, degraded phonological representations must undergo a redintegration process supported by long-term knowledge (Farrell & Lewandowsky, 2002; Nairne, 2002). Effects of long-term factors such as word frequency (Poirier & Saint-Aubin, 1996) and lexicality (Hulme, Maughan, & Brown, 1991) on serial recall attest to this. Saint-Aubin and Poirier (2000) provided a retrieval-based account of how long-term knowledge is utilised to redintegrate phonological traces in serial recall. It provides an account of how long-term factors and phonological factors affect item and order memory. However, certain predictions derived from the model remain, as yet, untested. The aim here was to test some of these predictions, by manipulating lexicality and phonological similarity in short-term serial recall experiments.

Correct-in-position (CIP) recall is typically utilized to assess serial recall performance. With this measure, an item is considered correct when correctly recalled (item recall (IR)) in correct serial position (position accuracy (PA)). Separate methods of estimating IR and PA have been developed in response findings that variables affect CIP recall in different ways. Long-term factors like word frequency and semantic similarity improve IR but do not affect PA (Saint-Aubin & Poirier, 1999). Lexicality enhances IR and impairs PA (Saint-Aubin & Poirier, 2000). Phonological similarity can influence IR (Fallon, Groves, & Tehan, 1999), but impairs PA (Poirier & Saint-Aubin, 1996). Articulatory suppression impairs both IR and PA (Fallon et al., 1999). IR is generally taken as the proportion of items correctly recalled, regardless of order. Measuring PA independent of IR involves taking a proportion of order errors made given correct IR.

Saint-Aubin and Poirier's (2000) retrieval-based model attempted to provide accounts for these differential effects. It assumed that phonological traces are output in order of presentation. These traces serve as retrieval cues to access appropriate long-term representations during redintegration. Variables that increase accessibility of long-term representations enhance IR, and variables that increase degradation of phonological traces impair PA. Manipulations that increase similarity among phonological traces make it more difficult to match them to long-term representations during redintegration, also producing impaired PA.

The retrieval-based model provided successful accounts of many empirical findings. Phonological similarity produces impaired PA because of increased similarity of phonological traces, which produces discrimination problems during redintegration. The enhancement of IR by rhyming (e.g. Fallon et al., 1999) is produced because rhyme categories act as retrieval cues, reducing the pool of long-term candidates for redintegration. Articulatory suppression impairs IR by increasing degradation of phonological traces, and impairs PA through loss of features in phonological traces. The account also makes novel predictions regarding effects of lexicality on IR and PA. Specifically, lexicality was predicted to enhance IR but impair PA, assuming that words, possessing long-term representations, would undergo redintegration, while non-words would not be subjected to this process because they have no long-term representations. Words can be redintegrated, but confusions are also possible. With non-words, no redintegration occurs, so no confusions are possible. These predictions were confirmed by their data (Saint-Aubin & Poirier, 2000).

The retrieval-based account also suggested that suppression would result in increased resemblance between phonologically dissimilar and similar traces, resulting

in reduced effects of similarity on PA under suppression. Saint-Aubin and Poirier (2000) also introduced the caveat that non-words of high word-likeness might undergo redintegration using long-term phonological information. They cited Besner and Davelaar (1982), who compared CIP performance for phonologically similar and dissimilar non-words of high word-likeness (e.g. thawl) and pseudohomophones (e.g. phawl) under silent and suppressed conditions. Phonological similarity was detrimental to performance for both materials in silent but not suppressed conditions, while lexicality improved performance in both conditions. Performance for non-words was higher than observed by Saint-Aubin and Poirier (2000).

Taking this caveat into account, the Besner and Davelaar (1982) results fit nicely with the retrieval-based account. Both pseudohomophones and non-words would have undergone redintegration, though redintegration for non-words was less effective than for pseudohomophones, producing a lexicality effect of smaller magnitude than observed by Saint-Aubin and Poirier (2000). Additionally, phonological similarity effects would have been expected for both materials in the silent, but not the suppressed, condition of the experiment. However, data was not broken down to the level of IR and PA. Given that the retrieval-based account derives its predictions at these levels of sensitivity, Besner and Davelaar's findings do not represent the strongest test of this account's assumptions. A stronger test would involve using a similar design to theirs, but examining IR and PA measures.

Two experiments, both involving a repeated-measures factorial combination of lexicality (words vs non-words high of word-likeness), phonological similarity (rhyming vs dissimilar), and suppression (silent vs suppressed) were conducted. Both involved serial recall of visually presented lists selected from open word pools. Four- and five-item lists were used in Experiments 1 and 2, respectively. CIP recall was the

proportion of items presented that were recalled in correct serial position. IR involved taking the proportion of presented items correctly recalled, regardless of serial position. PA was derived by taking the proportion of order errors made, conditional upon correct IR.

For CIP recall, we expected to replicate Besner and Davelaar's (1982) findings. The retrieval-based account predicted the typical IR/PA dissociations for lexicality and phonological similarity (e.g. Fallon et al., 1999; Saint-Aubin & Poirier, 2000). Phonological similarity was expected to enhance IR and impair PA for both words and non-words. Articulatory suppression was expected to reduce the phonological similarity impairment on PA.

Experiment 1

Method

Participants. Nineteen undergraduate students from Southern Cross University participated for course credit.

Materials. For each participant, 40 four-item lists were constructed. Two item pools were used, one containing words and the other non-words. The word pool contained five single-syllable words from each of 17 ending categories (e.g. peek meek creek beak leak) chosen from the South Florida Rhyme Category Norms (Walling, McEvoy, Oth, & Nelson, 1984). The non-word pool also contained 17 groups of five rhyming single-syllable non-words from the same endings used in creating the word pool (e.g. deek treek jeek yeak neak). Pronunciation duration across pools was not measured. Since the same word pool was used to create rhyming and dissimilar lists, and rhyme categories and dissimilar list items were chosen randomly for each participant, frequency and imageability were not considered during item selection.

Of the 40 lists, 10 contained rhyming words, 10 contained phonologically dissimilar words, 10 contained rhyming non-words, and 10 contained phonologically dissimilar non-words. Rhyming lists were created by randomly selecting 10 ending categories from the relevant pool, randomly selecting four items from each category, and randomly allocating selected items to serial position. An identical process was used to create dissimilar lists, except four items were randomly selected without replacement from the relevant pool, conditional upon only one list item coming from any ending category. For each list type, half the lists were randomly allocated to silent conditions; the remainder were allocated to suppressed conditions. For "silent" lists, the precue "SILENT" preceded list presentation; the precue "SUPPRESS" preceded presentation of "suppressed" lists. Finally, order of list presentation was randomized.

Procedure. Items were presented on a monitor at a rate of one item per s. After the final list item, a set of question marks was presented for 1 s, followed by a 15-s recall period. The questions marks cued participants to recall the list items in order on a response sheet. If an item could not be recalled, a blank was left corresponding to the serial position of the forgotten item. If the precue "SILENT" was presented, participants silently rehearsed list words. If "SUPPRESS" was presented, they repeated aloud the word "the", at a fast rate, from when the precue appeared until the question marks appeared.

Results and Discussion

Figure 1 shows CIP recall for rhyming and dissimilar lists in Experiments 1 and 2, as a function of lexicality, suppression, and serial position. Data from the IR and PA analyses are presented in Table 1. In both experiments, a 2*2*2*6 repeated-measures analysis of variance (ANOVA) was utilized for CIP data. For IR and PA, 2*2*2 repeated-measures ANOVAs were conducted, with lexicality, suppression, and

phonological similarity as independent variables. For all analyses of simple effects, the probability of making a Type I error was controlled by using sequential Bonferroni adjustments. Interactions not reaching significance were not reported.

CIP recall. The ANOVA revealed main effects of suppression, F (1, 18) = 45.35, $P < .01$, lexicality, F (1, 18) = 161.86, $P < .01$, similarity, F (1, 18) = 7.26, $P < .05$, and serial position, F (3, 54) = 11.80, $P < .01$. Interactions were observed between lexicality and suppression, F (1, 18) = 12.36, $P < .01$, and similarity, F (1, 18) = 6.07, $P < .05$. A three-way interaction between these variables was observed, F (1, 18) = 4.56, $P < .05$. Subsequent analysis revealed an interaction between lexicality and similarity in silent conditions, F (1, 18) = 9.32, $P < .025$, that was not significant in suppressed conditions, F (1, 18) < 1, $P > .025$. In silent conditions, similarity did not affect CIP words recall , F (1, 18) < 1, $P > .025$, but enhanced non-words recall, F (1, 18) = 7.16, $P < .025$. In suppressed conditions, similarity enhanced recall of both materials.

Serial position interacted with suppression, F (3, 54) = 8.09, $P < .01$, lexicality, F (3, 54) = 3.27, $P < .05$, and similarity, F (3, 54) = 6.84, $P < .01$, indicating more bowed serial position curves in suppressed conditions, smaller lexicality effects with increasing serial position, and more bowed serial position curves for dissimilar lists. Finally, there was a small four-way interaction that was difficult to interpret, F (3, 54) = 3.14, $P < .05$.

IR. Results were similar to those observed for CIP recall. Main effects of suppression, lexicality, and similarity were observed, F (1, 18) = 79.45, $P < .01$, F (1, 18) = 233.33, $P < .01$, and F (1, 18) = 59.08, $P < .01$, respectively. Lexicality interacted with suppression, F (1, 18) = 5.42, $P < .05$, and similarity, F (1, 18) = 5.41, $P < .05$, and there was a three-way interaction, F (1, 18) = 8.24, $P < .05$. Subsequent

analysis revealed that lexicality interacted with similarity in silent conditions, F (1, 18) = 12.42, P < .025, but not in suppressed conditions, F (1, 18) < 1, P > .025. Similarity enhanced IR of both materials in suppressed conditions. In silent conditions, similarity did not influence IR of words, F (1, 18) = 3.45, P > .025, but enhanced IR of non-words, F (1, 18) = 21.66, P < .025.

PA. In this analysis, suppression impaired performance, F (1, 18) = 6.57, P < .05, as did similarity, F (1, 18) = 46.81, P < .01. PA of words and non-words did not differ, F (1, 18) < 1, P > .05.

The predicted IR/PA dissociation for phonological similarity for word lists and enhanced IR produced by lexicality are replicated. Additionally, suppression impairs IR and PA, and phonological effects are present in non-word lists. However, impaired CIP recall for phonologically dissimilar lists and the predicted reduction in the phonological similarity impairment for PA in suppressed conditions were not evident.

Experiment 1 suggests that patterns related to phonological similarity for words and non-words are similar. A problem, however, was the close-to-ceiling performance in silent conditions, particularly for IR. Experiment 2 replicated Experiment 1, utilising five-item lists.

Experiment 2

Method

The method used was identical to Experiment 1, except that for similar lists, all five items from a rhyme category were randomly allocated without replacement to serial position. Similarly, five items were randomly selected for each dissimilar list. Twenty-two undergraduate students from the University of Southern Queensland participated for course credit.

Results and Discussion

CIP recall. The ANOVA revealed main effects of suppression, F (1, 21) = 49.40, P < .01, lexicality, F (1, 21) = 69.08, P < .01, similarity, F (1, 21) = 32.47, P < .01, and serial position, F (4, 84) = 23.22, P < .01. Significant interactions were observed between lexicality and suppression, F (1, 21) = 23.17, P < .01, and similarity, F (1, 21) = 10.85, P < .01. Additionally, a three-way interaction was observed between these variables, F (1, 21) = 7.41, P < .05. Subsequent analysis revealed an interaction between lexicality and similarity in silent conditions, F (1, 21) = 14.22, P < .025, not evident in suppressed conditions, F (1, 21) < 1, P > .025. Similarity enhanced CIP recall for both materials in suppressed conditions. In silent conditions, similarity did not affect word recall, F (1, 21) = 2.49, P > .025, but enhanced non-word recall, F (1, 21) = 55.98, P < .025.

Serial position interacted with suppression, F (4, 84) = 15.36, P < .01, lexicality, F (4, 84) = 17.50, P < .01, and similarity, F (4, 84) = 8.27, P < .05, indicating less recency and greater primacy in suppressed conditions, reduced lexicality effects with increasing serial position, and greater primacy in similar lists. Finally, there was a small four-way interaction that was difficult to interpret, F (4, 84) = 2.79, P < .05.

IR. Results were similar to those in the CIP analysis. Main effects were observed for suppression, F (1, 21) = 32.38, P < .01, lexicality, F (1, 21) = 145.33, P < .01, and similarity, F (1, 21) = 82.06, P < .01. Interactions were observed between lexicality and suppression, F (1, 21) = 21.32, P < .01, and similarity, F (1, 21) = 6.27, P < .05. The three-way interaction was also significant, F (1, 21) = 11.25, P < .01. Subsequent analysis revealed an interaction between lexicality and similarity in silent conditions, F (1, 21) = 15.30, P < .01. Similarity enhanced IR for words less than non-

words, F (1, 21) = 6.26, P < .025, and F (1, 21) = 60.94, P < .025, respectively. In suppressed conditions, similarity enhanced IR of both words and non-words, F (1, 21) < 1, P > .025.

PA. PA was better for dissimilar than similar lists, F (1, 21) = 38.75, P < .01. Main effects were also observed for lexicality, F (1, 21) = 7.82, P < .05, and suppression, F (1, 21) = 8.47, P < .01, and the interaction between these variables was significant, F (1, 21) = 5.14, P < .05. Subsequent analysis revealed equivalent PA for both materials in silent conditions, F (1, 21) < 1, P > .025, but better PA for non-words than words in suppressed conditions, F (1, 21) = 14.09, P < .025.

Patterns related to phonological similarity, articulatory suppression, and the effect of lexicality on IR, in essence, replicate those observed in Experiment 1. The PA impairment for words predicted by the retrieval-based account is evident, but only in suppressed conditions. Experiment 2 shows that effects observed in Experiment 1 are replicable, and that some are inconsistent with previous research and predictions derived from this account.

General Discussion

The two experiments reported here sought to test assumptions of the retrieval-based account of serial recall (Saint-Aubin & Poirier, 2000), by presenting lists of phonologically similar and dissimilar words and non-words in silent and suppressed conditions. The data present a consistent picture, with the majority of findings conforming to predictions derived from previous research and the retrieval-based account. The IR/PA dissociation for phonological similarity is present for both words (Fallon et al., 1999) and non-words of high-word likeness, suggesting that both materials undergo redintegration. Lexicality enhances IR in silent and suppressed conditions (Besner & Davelaar, 1982), suggesting better use of long-term information

in redintegration of words than non-words. While pronunciation duration of words and non-words has not been equated in these experiments, and non-words take longer to pronounce than words when equated on number of letters or phonemes (Multhaup, Balota, & Cowan, 1996), the lexicality effects observed are stronger than if pronunciation duration alone is responsible for differences. Additionally, lexicality effects are present in suppressed conditions, where pronunciation duration should be irrelevant.

However, some findings are inconsistent with expectations. Lexicality does not consistently impair PA. Phonological similarity does not affect CIP performance in silent conditions. Additionally, reduction of the phonological similarity impariment on PA in suppressed conditions is not observed.

In these experiments, PA for words and non-words does not differ, except for 5-item lists presented under suppression. At first glance, this appears consistent with the retrieval-based account. Both words and non-words of high word-likeness undergo redintegration, leading to PA errors in both materials. However, redintegration is less effective for non-words of high-word likeness than for words, which leads to lexicality effects in IR when these materials are compared. Why, then, are proportions of PA errors for words and non-words the same in all but one experimental condition? Further clarification of this is required by the retrieval-based account.

The standard phonological similarity effect in silent CIP recall (e.g. Besner & Davelaar, 1982) is not observed in these experiments. We are uncertain why this occurred, though we are certain that enhancements in IR, and not PA, are responsible. When this enhancement occurs varies, but it seems related to phonological similarity being operationalised as rhyming items. We believe that, when list items rhyme, the rhyme category acts as a retrieval cue, facilitating IR for those lists compared to

dissimilar lists. Increasing task difficulty (e.g. increasing list length, undertaking articulatory suppression, or delaying recall) and item sampling from open pools increases the likelihood of this effect occurring (Fallon et al., 1999; Tehan et al., 2001). Open sampling was used in experiments reported here, which may explain the lack of phonological effects in CIP recall. However, other researchers using similar sampling techniques have failed to replicate this (Lian, Karlsen, & Eriksen, in press). Additionally, alternative explanations cannot be ruled out. For example, rhyming items could help participants utilize alternative strategies, like remembering only the first letter of each word. Future research should investigate this possibility, perhaps by a performance comparison between lists containing rhyming words with phonologically similar start consonants and lists containing rhyming words with phonologically dissimilar start consonants.

In contrast to predictions made by the retrieval-based account, phonological similarity influences memory for order in all conditions once item influences have been controlled. This is observed consistently in past research where PA has been measured (Fallon et al., 1999; Lian et al., in press). The retrieval-based account would at least predict that suppression would reduce this effect. In these experiments, this does not occur. The findings imply that the phonological similarity impairment on PA is universal, at least in conditions tested to now.

Having said that, most short-term memory models would suffer from similar failings. For example, the feature model (Nairne, 2002) assumes, like the retrieval-based account, that item features are lost under suppression. Baddeley's (1986) *working memory* assumes visually presented items are prevented from entering the phonological loop by suppression. The *network model* (Burgess & Hitch, 1999) utilizes a similar assumption, with activation of input phoneme nodes by the item

layer prevented by suppression of visually presented items. These mechanisms all predict at least a reduction in PA under suppression. The *primacy model* (Page & Norris, 1998) and *start-end model* (Henson, 1998) both include a non-phonological first stage to explain serial position effects, and an output stage where phonological effects occur. In both models, access of visually presented items to this second stage is prevented by suppression. Interestingly, if suppression influenced the first-stage of these models, and left the output stage available, both the primacy and start-end models might be capable of explaining phonological effects evident in the current data. Similarly, models proposing separate input and output phonologies (e.g. Martin, Lesch, & Bartha, 1999) might account for the observed phonological effects by assuming that suppression affects only input phonology, with phonological similarity continuing to hinder output phonology.

In conclusion, the reported experiments have provided a test of the retrieval-based account (Saint-Aubin & Poirier, 2000). While most data is consistent with derived predictions, it and other models fall short of providing a clear and succinct explanation of the data. It suggests that: (a) words and non-words of high word-likeness undergo redintegration, producing lexicality effects and episodic cuing effects for both materials; and (b) short-term memory representations for visually presented words and non-words of high word-likeness contain phonological characteristics unaffected by suppression. Current models of short-term memory need to consider incorporating mechanisms that parsimoniously explain how these different mechanisms contribute to serial recall.

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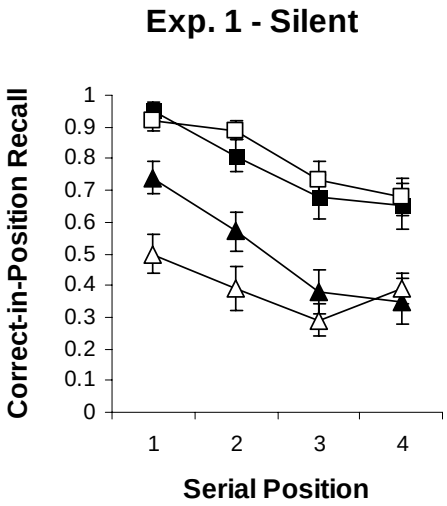
Table 1

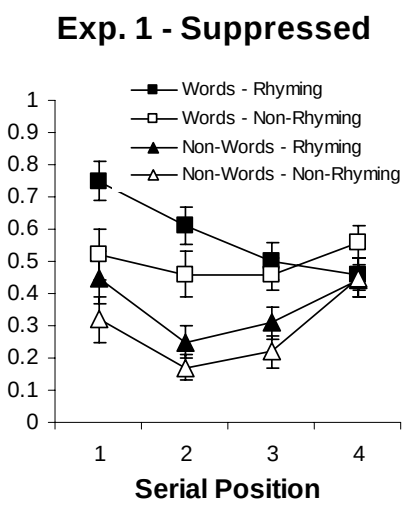
Means and Standard Errors of Means (in Parentheses) for Rhyming and Dissimilar Lists of Words and Non-Words in Silent and Suppressed Conditions in Experiments 1 and 2

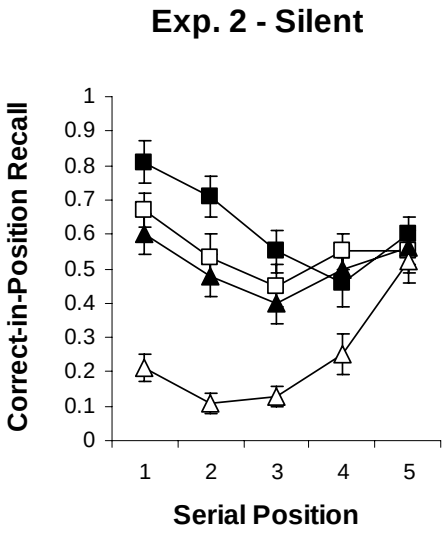
	Silent		Suppressed	
	Words	Non-Words	Words	Non-Words
	Experiment 1 (N = 19) – 4-Item Lists			
Item Recall				
Rhyming	0.87 (.03)	0.61 (.05)	0.73 (.04)	0.46 (.03)
Dissimilar	0.83 (.03)	0.40 (.03)	0.54 (.04)	0.30 (.03)
Position Accuracy				
Rhyming	0.13 (.03)	0.15 (.03)	0.21 (.04)	0.20 (.03)
Dissimilar	0.03 (.01)	0.00 (.00)	0.08 (.02)	0.04 (.02)
	Experiment 2 (N = 22) – 5-Item Lists			
Item Recall				
Rhyming	0.70 (.04)	0.55 (.04)	0.57 (.02)	0.44 (.03)
Dissimilar	0.61 (.04)	0.26 (.02)	0.40 (.03)	0.29 (.03)
Position Accuracy				
Rhyming	0.14 (.03)	0.12 (.03)	0.26 (.03)	0.16 (.03)
Dissimilar	0.07 (.02)	0.06 (.02)	0.13 (.03)	0.03 (.02)

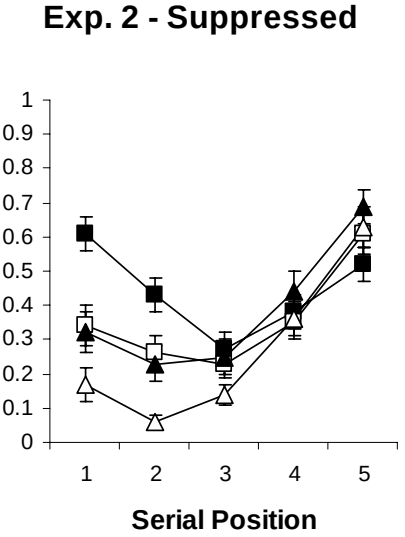
Figure Captions

Figure 1. CIP recall for rhyming and dissimilar lists in Experiments 1 and 2, as a function of lexicality, suppression, and serial position. Error bars represent standard errors of each mean.


Exp. 1 - Silent
Correct-in-Position Recall
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
Serial Position


Exp. 1 - Suppressed
Words - Rhyming
Words - Non-Rhyming
Non-Words - Rhyming
Non-Words - Non-Rhyming
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
Serial Position


Exp. 2 - Silent
Correct-in-Position Recall
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Serial Position


Exp. 2 - Suppressed
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Serial Position