Title
A Sublexical Locus for Repetition Blindness: Evidence from Illusory Words

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 19(0)

Authors
Morris, Alison L.
Harris, Catheringe L.

Publication Date
1997

Peer reviewed

A Sublexical Locus for Repetition Blindness: Evidence from Illusory Words

Alison L. Morris and Catherine L. Harris
Boston University, Department of Psychology
64 Cummington St., Boston, MA 02215
alisonm@bu.edu, charris@bu.edu

Abstract

When words containing an orthographically similar segment (*rock, shock*) are rapidly displayed in word lists and immediately reported by subjects, the second critical word (W2) is frequently omitted, a deficit known as repetition blindness (Kanwisher, 1987). Three experiments used an illusory words paradigm to demonstrate a sublexical locus for repetition blindness in orthographically overlapping words. In Experiment 1, we constructed RSVP streams of words and word fragments which would allow the W2's unique letter clusters to combine with a word fragment to create a word, as in *rock shock ell*. The illusory word *shell* was produced 36% of the time in the RB condition, compared to 16% of the time for letter migration control trials (*rock shoeu ell*) and 16% of trials containing sequential presentation of the illusory word's fragments (*rock sh ell*). Experiment 2 demonstrated the same superiority for the RB condition over a letter migration control using nonword stimuli (*riwu shiwu ell*). Experiment 3 showed that the unique letters left-over after RB are marked for position. Implications for models of repetition blindness are discussed.

Introduction

Repetition Blindness (RB) is the failure to detect a repetition of a visual event, when the two events are rapidly and briefly displayed (usually for durations of less than 150 msec; Kanwisher, 1987). The most common technique for eliciting RB is via rapid serial visual presentation (RSVP). RB occurs for diverse visual stimuli including words in lists and in sentences, phonologically similar items (Bavelier & Potter, 1992), pictures, and even between words and pictures (such as a picture of the sun and the word *sun*; Bavelier, 1994). Demonstrations of RB in sentences are striking; for a sentence such as *When she spilled the ink there was ink all over*, readers report, *When she spilled the ink there was all over* (Kanwisher, 1987). The subjective experience of viewers is not that they forgot the second event or were confused about what appeared, but that they saw one occurrence of the event rather than two.

Kanwisher's explanation for RB is that the visual system fails to individuate the two stimuli as distinct events (Kanwisher, 1987; Kanwisher & Potter, 1990). She refers to this as "type activation without token individuation". The current paper focuses on RB in words, and so it is helpful to translate Kanwisher's general theoretical statement into one specific for words. A word's *type* is what word recognition researchers have called its logogen (Morton, 1969), node, or word-level representation (McClelland & Rumelhart, 1981). Kanwisher's "token individuation hypothesis" therefore implies that a word's recognition node is activated twice, but only one of these activations can be bound to an episodic visual *token*, or event representation (Park & Kanwisher, 1994).

Many questions in cognitive science revolve around the nature of the representational units which mediate perceptual processing and recognition. Studies of RB using words in lists and sentences would appear on the surface to suggest that the locus of RB is at the word level. But the picture becomes more complicated when the repeating events are non-identical words. Kanwisher and Potter (1990) found RB for orthographically similar words, such as cap and cape. Misreading cap as cape could potentially result in word-level RB; however, a letter-level locus for RB could also account for these results. Kanwisher and Potter failed to find RB for words such as *fault* and *heart*, where removal of the shared letter from *heart* would create another word, *hear*. They therefore argue that RB is not the sum of independent letter-level effects. Kanwisher and Potter were unable to differentiate whether RB occurs at the whole word or letter cluster level; however, they did suggest that the locus of RB is partly determined by which visual unit is "most relevant" to the task. Thus, when subjects are viewing and reporting single letters, RB occurs at the letter level; when subjects are viewing and reporting words, RB operates at the word level.

Bavelier, Prasada, and Segui (1994), on the other hand, in their investigations of RB between orthographic neighbors, (e.g. *made* and *fade*) suggest that RB effects are located at the level of abstract letter clusters. Specifying letter clusters as the orthographic representation that is activated, but not individuated, in RB would appear to account for a wide range of observed RB phenomena. However, these authors did not explicitly test this hypothesis.

Experiments in our laboratory using orthographically overlapping words (*models...modest*; *income...comet*; *sister...blister*) in RSVP sentence displays have provided some additional clues to the locus of RB (Harris & Morris, 1996). A typical result in our experiments was that subjects reported the first critical word (W1) and omitted the second (W2). However, we also observed that subjects occasionally reported the non-shared letters in the W2, in the form of a guess at a real word containing these letters.

This sometimes resulted in amusing reconstructions of the RSVP stream. The following are examples of stimulus sentences (S) and instances of their serial reports (R):

S: *I'll take a chance the chancellor will do us good.*
R: *I'll take a chance the counsellor will do us good.*

S: *My sister was unhappy because her blister was hurting*
R: *My sister was unhappy because of the blinding??*

S: *I can't face my fate back home.*
R: *I can't face my -- [pause] plate back home??*

Subjects frequently indicated with uncertain tone (marked above by ??) that they were unsure of their reading of the sentence. In the above examples, the letters preserved in the misreading are the W2's unique letters. In the *sister...blister* example, it is if the shared *ister* segment has disappeared from *blister*, leaving a *_bl* cluster behind. Word recognition theories (Carr, 1986; Grainger and Jacobs, 1994) specify that letter clusters activated by visual features send activation to words containing them (*ate* activates *plate*, *rate*, *activate*, and so on). Our analysis of subjects' misreading errors suggests that the non-shared letters in a word affected by RB are detected and available for activating words, but normally fail to do so, and decay without being consciously perceived by subjects. If the non-shared letters in a W2 are not affected by RB, then RB must be operating at a sub-lexical (abstract letter cluster) level. One way of testing the hypothesis that the W2's unique letters are activated would be to observe whether placing a word fragment in the RSVP stream would result in subjects' combining the left-over letters with the fragment to produce an "illusory" word. This idea was explored in Experiment 1.

Experiment 1

Subjects were shown RSVP lists of words of the form in (1) (items marked *filler* were unrelated words serving to make the perceptual task more difficult). If the letters *gr* are "left-over" from RB affecting *grain*, readers may perceive and report *gravy*.

(1) filler *pain grain avy* filler

In a pilot experiment, subjects did produce illusory words under these conditions. However, experiments on reading rapidly presented word pairs have shown that a common type of error is letter migration. Mozer (1983) found that subjects produced *line* and *lace* when presented with *lane* and *lice*. To support our theory that the W2's nonshared letters are activated in RB, we needed to show that more illusory words are reported in an **RB** condition than would be expected from letter migration.[1] We also needed to control for the possibility that *avy* alone may sometimes activate *gravy*. To create conditions which would promote letter migration, we replaced the W2's with nonwords containing low frequency, difficult-to pronounce trigrams, such as *uiw* and *uen*, creating a **Letter migration** condition, as in (2).

(2) filler *pain grusu avy* filler

1. We thank Daphne Bavelier for pointing out the problem of letter migrations.

A second control condition, the **Split** condition, displayed the two components of the target illusory word separated in time (3). This condition controls for activation of an illusory word based on cohort activation from either or both of its two components.

(3) filler *pain gr avy* filler

Our prediction was that more illusory words would be reported for the RB condition than would be expected if letter clusters were simply present in the RSVP stream (the Split condition: *gr avy*) or from letter migration (the Letter migration condition: *grusu avy*).

Materials and Procedure

Subjects were 12 Boston University students who participated in exchange for course credit. All subjects acquired English in the home before age 5 (four subjects acquired English simultaneously with another language).

Three versions of each stimulus item were created: an RB condition, a Split condition, and a Letter migration condition. For the **RB** condition, the critical items were two orthographically similar words (W1 and W2) which differed only in their initial consonant cluster (*kill, chill*), plus a word fragment. Fragments were selected such that an illusory word would result if the fragment combined with the initial consonant cluster from the W2 (*sleep creep azy ---> crazy*; *fair chair ild ---> child*). In the **Split** condition, the W1 was followed by two successive fragments which formed the illusory word (*sleep cr azy*). In the **Letter migration** condition, the W2 was similar in length to the target illusory word, and contained the same initial 1-2 letters, but its body consisted of low frequency trigrams (usually beginning with *u*, creating nonwords such as *grusu, chuas, shoeu*). Sequences of 5 items for all conditions were then created by adding filler words as the beginning and ending item (the same filler words were used in all three versions of each word list.) The three versions of each word list were counterbalanced across subjects.

Each trial began with a row of asterisks appearing in the center of the computer monitor. When the subject pressed the space bar, the word list appeared one word at a time in the same location as the asterisks. Each word was centered on the display. Subjects were warned that RSVP is a difficult perceptual task in which they would not be able to see every word, but that they should report what words they saw without trying to fix up or fill in words they thought they might have missed. Subjects were additionally instructed to report word fragments they may have noted. Experimenters recorded via keypresses whether subjects reported the target illusory word; keypresses also recorded whether subjects reported both critical items, the W1 only, the W2 only, or none of the critical items. Exposure duration for the 42 experimental trials was set individually for each subject based on 3 sets of 5 practice word lists. The average duration per word for the experimental trials across the 12 subjects was 120 msec. The stimuli were presented on a Macintosh IIci, controlled by PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993). The font was 48 pt. Chicago. Subjects sat 20 inches from the screen.

Results and Discussion

Table 1 shows frequency of report of W1 and W2 for the RB, Letter migration, and Split conditions. The low W2 report in the Letter migration condition likely reflects the difficulty in reporting nonwords with low frequency trigrams such as *grusu* and *shoeu*.

Table 1: Frequency of Report for Critical Words (Exp. 1)

Stimulus Condition	Example	W1	W2
RB	beer sneer ake	92	38
Letter migration	beer snooa ake	95	11
Split	beer sn ake	95	31

Table 2 shows frequency of report of illusory words in all conditions. Analysis of variance revealed a highly significant effect of condition, $F(2, 22) = 12.5$, $p < .001$, with more illusory words being reported in the RB condition. The Letter migration and Split conditions were not significantly different from each other. Illusory words were generally reported in lieu of the W2 in all conditions; in other words, it was quite rare for a subject to report both the W2 *and* the illusory word.

Table 2: Frequency of Report for Illusory Words (Exp.1)

Stimulus Condition	mean	stand.err.
RB	.36	.05
Letter Migration	.16	.03
Split	.16	.05

Experiment 1 tested the prediction that illusory words could be produced by combining the letters left-over from orthographic RB with a subsequent fragment in the RSVP stream. To attribute the illusory word production to the effects of RB, we needed to find more illusory words in the RB condition compared to control conditions designed to evoke illusory words via activation from the word's components (Split condition) or letter migration (Letter migration condition). This is exactly what we found. Even though all items in the RB condition were pooled for analysis, (including those where both the W1 and W2 were reported, thus no RB actually could have occurred) subjects still produced over twice as many illusory words in the RB condition compared to the control conditions. The effect also had a compelling phenomenology; when an illusory word was "perceived" during an RB trial, the trial appeared to be a normal four word list. When illusory words were perceived during the Split and Letter migration conditions, subjects more frequently remarked that the visual input looked odd (usually because they saw some of the odd letters in the Letter migration condition, or the gap in the Split condition).

It is important to note that our illusory words were not simply the result of letter "copies" as in most previous letter migration experiments (Mozer, 1983). Usually, if the W2 was reported, the illusory word was not. We recoded the RB condition trials to determine the percentage of illusory words reported when the W2 was omitted (as in RB) vs. when it was reported (no RB). Illusory words were reported on 52% of RB condition trials when the W2 was omitted; when the W2 was reported (no RB) illusory words were only reported 7% of the time.

Experiment 1 provides strong evidence for a sublexical locus for RB. Only the shared letters of the W2 are lost, leaving the non-shared letters attempting to activate words. But generally, parts of words are not enough by themselves to activate a word, so the fragment decays and is not consciously perceived. Why do the "left-over" letters of the W2 combine with the subsequent fragment so much more effectively than the same letters in the Letter migration and Split conditions? We could speculate that the left-over letters in the W2 are marked for word position. The *sh* fragment in the Split condition, because it is ambiguous for word position, is therefore at a disadvantage for activating words. In the Letter migration condition, there is some competition from the nonword (*shoeu* competes with *shell*). We will address the issue of position marking of the left-over letters in Experiment 3.

If, as we claim, RB occurs at the level of shared orthographic segments rather than words, we should be able to produce illusory words via RB using orthographically overlapping nonword stimuli as well as word stimuli.[2] This question is investigated in Experiment 2.

Experiment 2

Experiment 2 tested the effectiveness of overlapping nonwords (*muvu, chuvu*) in producing illusory words. Nonwords are not often used in RB experiments because of the difficulties in perceiving nonwords given the brief exposures required to obtain RB. We used nonwords that had no orthographic neighbors, but that were pronounceable, in order to make the task somewhat easier for subjects. Subjects were excluded from analysis if they were unable to report either critical word on more than 50% of trials (four subjects were excluded under these criteria).

Methods and Procedure

Subjects were 16 Boston University students who participated in exchange for course credit. All subjects acquired English in the home before age 5 (three subjects acquired English simultaneously with another language).

Stimuli were derived from 24 of the items used in Experiment 1. For each stimulus item, a low frequency letter cluster was substituted for the shared letters from the W1 and W2 of the RB condition, as in (4)

(4) filler *peki greki avy* filler

The letter migration condition from Experiment 1 was used as a control condition, with the W1 modified to match the W1 from the RB condition:

(5) filler *peki grusu avy* filler

2. We thank Wayne Podrouzek for suggesting the nonwords experiment.

Each subject viewed 12 stimuli, half from the RB condition and half from the Letter migration condition, plus 12 filler trials designed to test another hypothesis. All stimuli were counterbalanced across subjects.

Procedure was identical to that of Experiment 1, except subjects were informed that they would be viewing both words and pronounceable nonwords. Mean exposure duration was also longer, at 150 msec, to accommodate the difficulties of reading nonwords in RSVP.

Results and Discussion

Table 3 shows frequency of report of W1 and W2 for the RB and Letter migration conditions. The lower report for both critical words in the RB condition in Experiment 2 compared to Experiment 1 reflects the difficulties in perceiving nonwords, even at increased exposure times.

Table 3: Frequency of Report for Critical Words (Exp. 2)

Stimulus Condition	Example	W1	W2
RB	buha snuha ake	.48	.19
Letter migration	buha snooa ake	.57	.08

Table 4 shows frequency of report of illusory words for the RB and Letter migration conditions. As in the previous experiment, report of illusory words was significantly greater in the RB condition compared to the Letter migration condition, $t(15) = 2.9$, $p < .05$.

Table 4: Frequency of Report for Illusory Words (Exp. 2)

Stimulus Condition	mean	stand.err.
RB	.21	.05
Letter migration	.09	.03

The RB condition again produced twice as many illusory words as the control condition. Our finding that illusory words can be produced by orthographic RB with nonword stimuli provides further evidence that the locus of RB is at the level of contiguous letter clusters.

An alternative explanation for our results must be considered. We have argued that RB prevents processing of the shared letters of the W2, leaving the non-shared letters left-over, usually to decay without being perceived. It is remotely possible, however, that the formation of the illusory word is the process which disrupts processing of the W2 in our stimuli, by co-opting the *nonshared* letters. We examined this question, as well as the question of whether the left-over letters are marked for position, in experiments 3a and 3b. These experiments were run as one experiment, but are presented separately here for ease of explanation.

Experiment 3a

In our discussion of letter clusters, we have assumed that they are marked for position; that is, *_sh* is a different letter cluster than *sh_*. We have also speculated that the "left-over", non-shared letters in orthographic RB are position-specific. Experiment 3a was designed to investigate this question, by determining whether illusory word production is constrained by a letter cluster's position in the W2. Studies of letter migration have shown that migrating letters maintain their positions (McClelland & Mozer, 1986). If letter clusters in a W2 affected by RB are marked for position, then we should not be able to create an illusory word by moving a cluster at the *end* of a W2 to the *beginning* of an illusory word.

Materials and Procedure

Our stimuli used letter clusters which are orthographically legal at both beginnings and ends of words (*ch, st*). The main manipulation was whether or not letter cluster position was consistent from the W2 to the illusory word. For the **Match** stimuli, the cluster at the *end* of the W2 formed the *end* of the illusory word. For the **MisMatch** stimuli, the cluster at the *end* of the W2 formed the *beginning* of the illusory word. Our control condition, the **Split** condition, is ambiguous with regard to position of the "migrating" letter cluster. Examples of stimuli are provided in Table 5.

Table 5: Examples of Stimuli (Exp. 3)

Match type	
RB	filler *road roast bla* filler ---> filler *road blast* filler
Split	filler *road st bla* filler ---> filler *road blast* filler

MisMatch type	
RB	filler *leave leash ell* filler ---> filler *leave shell* filler
Split	filler *leave sh ell* filler ---> filler *leave shell* filler

Note that, in the **Match** stimuli, the fragments creating the illusory word are presented in a different temporal order than those for the **MisMatch** stimuli (*st bla* vs. *sh ell*). To control for any potential differences in illusory word production arising from this temporal order difference, we actually presented all **Split** condition stimuli in both orders, counterbalanced across subjects. So, some subjects would view *road st bla*, while others viewed *road bla st*. Subjects viewed a total of 30 items from experiments 3a and 3b combined.

A total of 28 subjects participated in experiments 3a and 3b. Subjects were drawn from the same pool as for the previous experiments. Procedures and exposure times were similar to those described in Experiment 1.

Results and Discussion

Table 6 shows frequency of report of W1 and W2 for the RB and Split conditions. There were no significant differences in report of either W1 or W2 between conditions or stimulus types. Since in the Split condition, there can be no RB, the low report for W2 in this condition is attributed to the difficulties in perceiving small word fragments.

Table 6: Frequency of Report for Critical Words (Exp. 3a)

Stimulus Condition		W1	W2
RB	Match	.89	.30
RB	MisMatch	.95	.25
Split	Match	.94	.22
Split	MisMatch	.95	.18

Percent of illusory words for each condition is shown in Table 7. Since we found no effects of presentation order (*bla st* vs. *st bla*) on illusory word production in the Split condition, all Split items were pooled within type for further analysis. There were no significant main effects of condition (RB vs. Split) or stimulus type (Match vs. MisMatch), however, the condition x type interaction was significant, $F(1, 18) = 18.1$, $p < 0.001$. Note that, although we show that illusory words can be created by attaching the left-over letters from the *end* of a W2 to the *end* of a subsequent fragment, (Match type) *no* illusory words were created in the RB condition by changing the position of the letter cluster from the *end* of the W2 to the *beginning* of the illusory word (MisMatch type). For the Match stimuli, the percent of illusory words was significantly greater for the RB condition compared to the Split condition, $t(9) = 3.49$, $p < .01$.

Table 7: Frequency of Report for Illusory Words (Exp. 3a)

Stimulus Condition	Stimulus type: Match		MisMatch	
	mean	stand.err.	mean	stand.err.
RB	0.20	0.05	0.00	0.00
Split	0.06	0.03	0.10	0.04

Experiment 3a demonstrates that the left-over letters of a word affected by RB do not change positions in creating illusory words. This provides support for our assertion that these letters are marked for position.

Experiment 3b

Experiment 3b, run concurrently with experiment 3a, was designed to investigate whether the apparent "loss" of the W2 in the RB condition could be due not to RB, but to letter "stealing" by the illusory word. If this were true, then the amount of RB affecting the W2 (as indexed by report of W2) should be greater when the combination of the leftover letters with the subsequent fragment produces a word, rather than a nonword.

Materials and Procedure

We created two versions of each RB stimulus: a "word" version, (*road roast bla ---> blast*) where the left-over letters combining with the subsequent fragment formed a word; and a "nonword" version, (*road roast pri ---> prist*) where a pronounceable nonword would result from such a combination. The two versions of the stimuli were counterbalanced across subjects.

Results and Discussion

Since no illusory words were created in the MisMatch RB condition, We examined only the Match type items for this analysis. Table 8 shows frequency of report of W2 for word vs. nonword stimulus types:

Table 8: Frequency of Report of W2 (Exp. 3b)

Illusory Type	report of W2
word	.30
nonword	.36

W2 report for word vs nonword illusories was not significantly different, $t(27) = 1.48$, $p = .15$. Since subjects never once reported a nonword illusory (even though all would be easily pronounceable) yet the impact on W2 was similar, the explanation for the frequent failure to report the W2, compared to good report of W1, cannot be explained by simple letter "stealing" by the illusory word.

General Discussion

Repetition Blindness has been the focus of considerable investigation since Kanwisher's initial description of the phenomenon (Kanwisher, 1987). RB is surprising, and interesting, because it presents such a strong conflict between stimulus and perception.

The present study used an RSVP-illusory words paradigm to investigate the locus of orthographic repetition blindness effects. Kanwisher and Potter (1990) suggested the locus for RB depends on the level of unit being attended to. Thus, although RB can occur for single letters in single-letter displays, when the displays are words, RB will not show independent letter-level effects. But Kanwisher and Potter's reasoning and conclusions were premature. We show that the phenomenon is robustly sublexical. In orthographic RB between *rock* and *shock*, if *rock* is perceived, only the shared *ock* segment will be lost from *shock*. The *_sh* will be "left-over" and available for activating words. In Experiment 1, subjects created illusory words by combining such left-over letters with a subsequent word fragment. It is tempting to regard the report of illusory words in the RB condition as just simple letter migration; however, our subjects created illusory words in the RB condition (*rock shock ell*) more than twice as frequently as in a Letter migration control condition (*rock shoeu ell*). Could it be that the advantage of the RB condition over the letter migration condition was simply that the migrating letters in the RB condition were copied from a word, as opposed to a nonword in the control condition? But the illusory words in the RB condition were not the result of copying the letters from the W2. In fact, when the illusory word was reported, the W2 was rarely reported. Why would *shock* so readily give up its *_sh* cluster to the illusory word *shell*, unless processing of *shock* had already been disrupted?

Our finding in Experiment 2 that we could also create the illusory word *shell* out of the nonword sequence *riwu shiwu ell* provides further evidence for a letter cluster locus for RB. This finding with nonword stimuli also nullifies the possible argument that, in Experiment 1, illusory words were more prevalent in the RB condition because the W2 in the RB condition was a word, and the W2 in the control condition was a nonword (because in Experiment 2, both W2's were nonwords).

The superiority of the RB condition over the control conditions in Experiment 1 is even more striking when considering only those trials where a W2 was not reported (as would occur in RB). Illusory words were reported on 52% of those trials. In addition, subjects' subjective reports indicated that these illusory words looked normal, where the illusory words created from Split (*sh ell*) or Letter migration conditions did not. Experiment 3a demonstrated that the letters left-over after RB are marked for position. We can therefore speculate that what is encoded in an RB trial of *rock shock* is something like *rock _sh---* , and when *ell* immediately follows, a fully integrated word *shell* is easily perceived. Whether subjects encode information about the length of the W2 is an open question for future research.

Our finding that the processing of only part of a word can be disrupted in RB makes it difficult to defend claims by various investigators that the effects of RB can be attributed to postperceptual processes (Armstrong & Mewhort, 1995; Fagot & Pashler, 1995; Whittlesea, Dorken, & Podrouzek, 1995). The results of our experiments cannot be explained by response biases. These results provide additional evidence that RB is a true perceptual effect.

In the ten years since RB was "discovered", it has been well studied within experimental psychology, but hasn't become a topic of interest to mainstream cognitive science. This neglect is puzzling, since RB is nearly as "interdisciplinary" as a cognitive phenomenon can be. RB involves perception, attention, and the transfer from visual memory to working memory. It is found for almost any type of visual materials, creating a common problem for those studying word recognition and picture perception. RB is relevant for the study of awareness and phenomenology, and seems to be most compatible with a multiple drafts model of consciousness. Finally, because RB appears to operate at a lower level than the tokens recorded into STM, RB is relevant to subsymbolic approaches to cognition, and could thus illuminate distributed models of visual information processing.

References

Armstrong, I., & Mewhort, D. J. K. (1995). Repetition deficit in rapid-serial-visual-presentation displays: Encoding failure or retrieval failure? *Journal of Experimental Psychology: Human Perception and Performance, 21,* 1044-1052.

Bavelier, D. (1994). Repetition Blindness between visually different items: The case of pictures and words. *Cognition, 51,* 199-236.

Bavelier, D., and Potter, M. (1992). Visual and phonological codes in repetition blindness. *Journal of Experimental Psychology: Human Perception and Performance, 18,* 134-147.

Bavelier, D., Prasada, S., & Segui, J. (1994). Repetition blindness between words: Nature of the orthographic and phonological representations involved. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 1437-1455.

Carr, T. H. (1986). Perceiving visual language. In K .R. Boff, L. Kaufman, & J. P. Thomas (Eds.), *Handbook of perception and human performance.* New York: Wiley.

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments & computers, 25,* 257-271

Fagot, C., & Pashler, H. (1995). Repetition blindness: Perception or memory failure? *Journal of Experimental Psychology: Human perception and Performance, 21,* 275-292.

Grainger, J., and Jacobs, A. M. (1994). A dual read-out model of word context effects in letter perception: Further investigations of the Word Superiority Effect. *Journal of Experimental Psychology: Human perception and Performance, 20,* 1158-1176.

Harris, C. L., & Morris, A. L. (1996). Letter clusters unite: Illusory words created by repetition blindness. *Poster presented at the Thirty-seventh Annual Meeting of the Psychonomic Society,* Chicago, Illinois.

Kanwisher, N. (1987). Repetition blindness: Type recognition without token individuation. *Cognition, 27,* 117-143.

Kanwisher, N., and Potter, M. (1990). Repetition blindness: Levels of processing. *Journal of Experimental Psychology: Human Perception and Performance, 16,* 30-47.

McClelland, J. L., and Mozer, M. C. (1986). Perceptual interactions in two-word displays: Familiarity and similarity effects. *Journal of Experimental Psychology: Human Perception and Performance, 12,* 18-35.

McClelland, J. L., and Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review, 88,* 375-407.

Morton, J. (1969). Interaction of information in word recognition. *Psychological Review, 76,* 165-178.

Mozer, M. C. (1983). Letter migration in word perception. *Journal of Experimental Psychology: Human Perception and Performance, 9,* 531-546.

Park, J., and Kanwisher, N. (1994). Determinants of repetition blindness. *Journal of Experimental Psychology: Human Perception and Performance, 20,* 500-519.

Whittlesea, B. W. A., Dorken, M. D., & Podrouzek, K. W. (1995). Repeated events in rapid lists: Part 1. Encoding and representation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 1670-1688.