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Illusory words created by repetition blindness: A technique for probing sublexical representations

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When two orthographically similar words are displayed using rapid serial visual presentation (RSVP), the repeated letters in the second critical word (W2) are not detected, leading to a deficit in reporting this word, a phenomenon known as repetition blindness (RB). The unrepeated letters in W2 do appear to be detected and available to feed activation to words compatible with them (Morris & Harris, 1999). When a fragment was strategically placed in the RSVP stream, as in GROW *throw ank*, observers reported seeing *thank* more often than in the control condition BEAT *throw ank*. Illusory words were facilitated by repetition blindness only when the recombining letters maintained their position in the words. Illusory word report was insensitive to the phonological similarity of the recombining letters; equal quantities of illusory words were created by sequences like *china* CHEAT THR (→ *threat*) and *swung* SWEAT THR (→ *threat*). In addition to being an interesting phenomenon in its own right, the illusory words paradigm may have considerable use as a tool for probing the perceptual units underlying visual word recognition.

We introduce a new methodology for probing sublexical representations. Words and word fragments presented via rapid serial visual presentation (RSVP; Forster, 1970) will combine with each other to create "illusory words" (Morris & Harris, 1999). That is, observers will report seeing words that have not been presented. For example, when shown the sequence *lake* BRAKE USH, with each word or word fragment displayed for approximately 100 msec with a 15–30 msec interstimulus interval (ISI), observers frequently report seeing *lake brush*. The phenomenology of seeing the illusory word *brush* is strong, and observers report surprise that it has not actually been displayed.

It is well known that RVSP leads to misreadings of words, including migrations of letters and letter clusters from one word to another (Van der Velde, 1992). Our technique differs from simple letter migration in that we take advantage of the repetition blindness phenomenon. When two identical or orthographically similar words are briefly displayed with stimulus onset asynchronies of approximately 100–300 msec, conscious recognition of the first critical word appears to interfere with the ability to report the second, relative to the ability to report two nonsimilar words. Even when case is changed across the two words, observers are at risk for failure to report the second critical word (W2). This is called *repetition blindness* (RB; Kanwisher, 1987). It contrasts with masked priming paradigms, because in the RB paradigm, words have exposures that are long enough (80–150 msec) to ensure good report of both critical words when they are not visually or phonologically similar. Indeed, there is some evidence to suggest that when W1 is not perceived, repetition priming rather than repetition blindness can occur, at least in the case of identical words (Kanwisher, 1987; Whittlesea, Dorken, & Podrouzek, 1995, Experiment 3d).

Repetition blindness between nonidentical words has frequently been thought to stem from a process operating at the level of a whole lexical item (Chialant & Caramazza, 1997; Kanwisher & Potter, 1990). Some authors have noted that RB for nonidentical words may implicate a sublexical level, such as the unit of contiguous letter clusters (Bavelier, Prasada, & Segui, 1994; Kanwisher & Potter, 1990). In Harris and Morris (2000), we provided evidence supporting the sublexical perspective by showing that amount of RB increases as a function of the proportion of repeated letters, and that small but measureable RB can be obtained even for a single letter.

The illusory words paradigm (Morris & Harris, 1999) also provides evidence that repetition blindness in orthographically similar words has a sublexical locus, affecting only the words' shared letters. In the *lake* BRAKE USH sequence, report of *brush* appears to occur because recognition of the AKE in BRAKE is disrupted by its prior occurrence in *lake*. The BR letters are, however, detected and available to participate in cohort activation of words containing them, as suggested by word recognition models (Grainger, 1990; McClelland & Rumelhart, 1981). Because the word fragment USH is also activating a cohort of words, the word *brush* has some probability of being activated and passing its recognition threshold. In a series of experiments, Morris and Harris (1999) ruled out letter migration, contour summation, and differences in

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Table 1
Recombining Letters: *sh*

Match Condition	Mismatch Condition
creep	blade
sheep	shade
ift	har

processing load as explanations for the illusory words effect. The role of repetition blindness in producing report of illusory words over and above that expected from letter migration was clear, since report of the illusory word *brush* was two to four times more frequent in *lake BRAKE USH* than in the letter migration control condition, *pond BRAKE USH*. In contrast, when sequences of words and word fragments were set up so that the shared rather than the unique letters in W2 could combine with a fragment to produce an illusory word, as in *more CHORE ST*, there were actually fewer reports of illusory words in repeated than in unrepeated conditions.

In the present paper, we illustrate how the illusory words paradigm can be used to pursue questions related to sublexical representations. In Experiment 1, we investigated whether sequences of letters are marked for their position at the beginnings and ends of words. Empirical data for this already exists in studies of letter migration (Mozer, 1983), orthographic priming (Humphreys, Evett, & Quinlan, 1990), and in the exterior letters effects (Jordan, 1990; McCusker, Gough, & Bias, 1981). Our question is whether the illusory words paradigm can be an additional method for verifying that sequences of letters are marked for their position in words prior to word recognition.

EXPERIMENT 1

The stimuli consisted of two critical words (W1 and W2) that shared an orthographic string at either their beginning (*MONEY moth*) or their end (*PHONE stone*), and a fragment. In the unrepeated control condition, a replacement word was selected for W1 such that it shared no letters with W2.[1] The letters not shared with W1 (the *st* in *stone* in this example) were the letters that had some probability of combining with the word fragment to create an illusory word, and thus we will refer to them as the *recombining letters.*

For each trial, the dependent measure was whether or not research participants reported seeing the illusory word. For example, in the sequence *MONEY moth bir*, we recorded whether participants reported *birth* (as well as recording what other words were reported, whether correctly or incorrectly). Our question was whether more illusory words would be reported if the position of the recombining letters in W2 matched the position that they assumed in the illusory words.

Method

Design and Materials. Forty RSVP sequences implemented a 2 × 2 design. The repeatedness factor was whether or not letters in W1 were repeated in W2. The match/mismatch factor referred to whether the recombining letters of W2 shared the same or a different position in the illusory word. We also varied whether the repeated orthographic string was at the beginning or end of the critical words. The two similar words were embedded in positions 2 and 4 of an RSVP sequence of length six, with the first critical word in uppercase, as in *nook CREEP bun sheep ift &&&&&*.

Orthographically similar words were identified such that the unique (unrepeated) letters in W2 were a two-letter consonant cluster that was legal in English as a word-initial and a word-final cluster. The following eight consonant clusters were used, with the number indicating how many stimuli used this cluster: ch 7, ph 2, sh 7, sk 4, sm 2, sp 3, st 7, th 8.

Critical words had similar print frequencies across the conditions defined by the match/mismatch variable and also similar lengths. To create the repeated/unrepeated versions, an alternate W1 was selected that was matched in length and approximate frequency to W1 in the repeated condition. Log frequencies of the words ranged from 0 to 7.7 (Francis & Kučera, 1982, log of number of occurrences per sample of 1 million words). Although most words were of length 5, words from length 4 to 7 were included. Length did not vary significantly across conditions.

Procedure. A potential confound was that screen position could favor production of illusory words in the match condition, if items were simply centered on the screen. This was especially problematic when repeated letters were at the ends of words, as is shown in Table 1 for sequences that could produce the illusory words *shift* and *harsh*.

To avoid this confound, we left-aligned the fragment and moved W2 one space to the right. This roughly equated the benefit of screen position across the match/mismatch conditions, as can be seen in Example 1.

The participants were first run on two practice blocks of five trials each. The practice trials contained sequences with and without orthographically similar words. Exposure duration of each item in the RSVP stream was set to 120 msec, and was increased if subjects could not report both critical words when they were orthographically dissimilar and decreased if subjects reported both critical words when they were orthographically similar. The mean exposure across participants was 100 msec (range, 75–155). Each element in the RSVP sequence was separated by an ISI of 15–30 msec. The final ampersand string was displayed for 250 msec. The participants immediately reported what they had seen to the experimenter.

Participants . The participants were 48 Boston University undergraduates who participated to receive course credit. Seven participants had acquired another language along with English from birth, and 1 participant had acquired English as a second language before 5 years of age.

Apparatus. For this and Experiment 2, participants sat 20–22 in. from the screen. The font was fixed-width Courier, point size 28. Stimulus presentation and data recording were controlled by

Example 1

Recombining letters in the same position, letters repeated at ends of words:

filler	nook	
W1	CREEP	
filler	bun	
W2	sheep	[W2 moved one space rightward]
fragment	ift	[possible illusory word *shift*]
final mask	&&&&&&&	

Recombining letters in a different position, letters repeated at ends of words:

filler	pay	
W1	BLADE	
filler	noon	
W2	shade	[W2 moved one space rightward]
fragment	har	[possible illusory word *harsh*]
final mask	&&&&&&&	

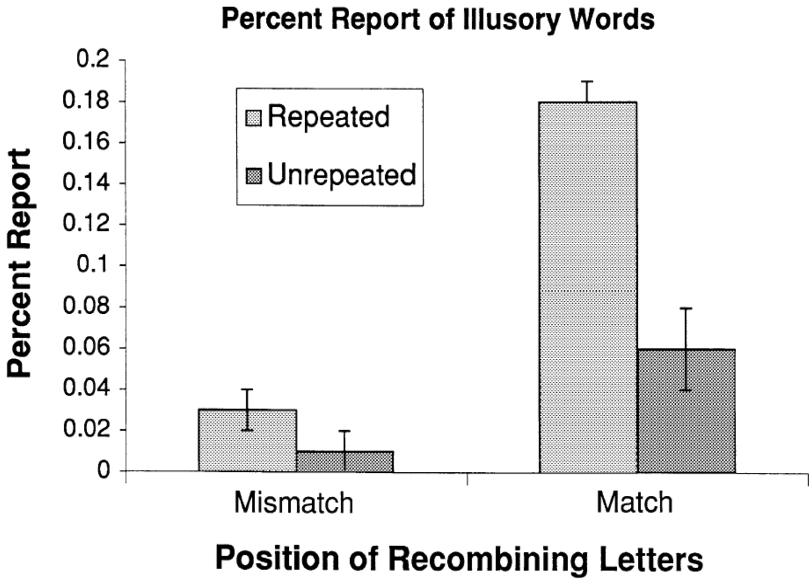

Figure 1. Results of Experiment 1. Percent of trials in which participants reported an illusory word, as a function of repeatedness and whether the combining letters had the same or different position in the illusory word as in W2.

PsyScope Experimental Control software (Cohen, MacWhinney, Flatt, & Provost, 1993).

Results and Discussion

We will first report amount of RB as a function of stimulus conditions, and then present illusory word report. We use the repetition blindness index (RBI; Park & Kanwisher, 1994), because differences in amount of RB between two conditions can be measured as the presence of a main effect in an analysis of variance (ANOVA), rather than as an interaction between stimulus type and repeatedness.

RBI is an index that extends between 0 and 1, with 0 indicating *maximal RB*, 0.5 indicating *absence of RB*, and 1 indicating *priming*. The formula for RBI is as follows:

$$\mathrm{RBI} = \frac{\mathrm{BothRepeated}}{(\mathrm{BothRepeated+BothUnrepeated})},$$

where BothRepeated = report of both critical words in the repeated condition, and BothUnrepeated = report of both critical words in the unrepeated condition.

RB was strong when repeated letters appeared both at the beginnings of words and at the ends of words, as is indicated by RBIs of .28 and .32, respectively. Standard error of the mean in both conditions was .02; and RBIs were significantly less than .5 by *t* tests, with $t(47) = 9.5$ for repeated letters at the beginning and $t(47) = 10$ for repeated letters at the ends of words.

Figure 1 shows that more illusory words were reported when the position of the recombining letters in the illusory word matched the position in W2, in comparison with the mismatch condition. This was verified by a significant main effect in an ANOVA performed on percent report of illusory words [$F_1(1,47) = 70$; $F_2(1.38) = 5$; both p values $< .01$]. The interaction between position of recombining letters and repeatedness was also significant [$F_1(1,47) = 34$; $F_2(1,38) = 10$; both p values $< .005$]. As is shown in Figure 1, illusory word report was low in the mismatch condition, and it did not vary as a function of repeatedness. This indicates that the mechanism that causes repetition blindness increased the probability of reporting illusory words, relative to the baseline unrepeated condition.

We conducted separate ANOVAs on stimuli that shared their first letters (and thus had recombining letters at the end of W2) versus letters that shared their last letters (and thus had recombining letters at the beginning of W2). When items were classified according to whether the recombining letters moved to the beginning of the fragment (*rock* ***sh****ock ell* → ***sh****ell*) or the end of the fragment (*crumb cru****sh*** *tra* → *tra****sh***), it was revealed that most of the illusory word report was from the latter category. However, the former category did show the basic interaction of repeatedness and position of recombining letters, although values were too small relative to standard errors to obtain significance. That is, in the match condition, illusory word report for the repeated condition was 7% versus 2% for the unrepeated condition. In the mismatch condition, illusory word report for the repeated condition was 4% versus 2% for the unrepeated condition. In prior work (Morris & Harris, 1999), we obtained high illusory word report for stimuli in which the recombining letters moved from the beginning of W2, as in *pain* ***gr****ain avy* → ***gr****avy*. This suggests that factors specific to the present materials and procedure resulted in low illusory word report, not a general difficulty in creating illusory words from letters that migrate from the beginning of W2 to the beginning of the fragment.

Table 2

lag 0, same pronunciation	lag1, different pronunciation
cross/windy	spot/tape
CROOK	BRO
BRO [possible illusory word *brook*]	SPOOK [possible illusory word *brook*]
&&&&&&&	&&&&&&&

We conclude that illusory words are more easily created when a letter cluster can be moved from the end of one word to the end of another, and that orthographic RB increases this process. This supports the proposal that orthographic units, detected in the early stages of visual word recognition, are encoded with respect to whether they are at the beginning or end of a word.

EXPERIMENT 2

Is there an early stage of visual word recognition during which orthographic units are detected but before phonological codes are activated? In a number of studies, it has been found that phonological information is available as early as it can be tested for (Lukatela & Turvey, 1991; Perfetti & Bell, 1991; Van Orden, 1987). Furthermore, RB can result from phonological similarity with no visual similarity (Bavelier, 1994; Bavelier & Potter, 1992), although there is some evidence that phonological RB is weaker than orthographic RB (Bavelier et al., 1994; Harris & Morris, 2000). In Experiment 2, we asked a new question about the letters that are "left over"—that is, the letters that are not repeated and thus are detected and available to activate words compatible with them. Is illusory word report sensitive to the pronunciation of the leftover letters? For example, in the sequence *china* CHEAT THR, the EAT may be left over and available to combine with the THR fragment to create the illusory word *threat*. The EAT sequence in CHEAT has a different pronunciation from the *eat* sequence in the illusory word *threat*. Are illusory words equally frequent when the pronunciation of the leftover letters is different from that of the potential illusory word?

Method

Design and Materials. The locus of orthographic similarity between the two critical words was at the word beginning for all sequences. Whether the second critical word (W2) and the illusory word shared the same pronunciation, as in *study* STAID AFR → *afraid*, or had different pronunciations, as in *plush* PLAID AFR → *afraid*, was manipulated within items. A second within-items variable was whether the fragment followed W1 and W2, or occurred between them, as in *study* AFR STAID. Placing the fragment between the two similar words increases the time between processing them, thus functioning as a lag. It is believed that lags decrease the amount of RB since they provide additional time to tokenize W2 (Kanwisher, 1987). We will refer to this as the *lag manipulation* (lag 0 vs. lag 1).

The words selected to replace W1 in producing the unrepeated condition were matched to W1 for length and print frequency (Francis & Kučera, 1982). The mean log frequency (occurrences per million words) was 3.6 in both the repeated and the unrepeated conditions. Because in the same/different pronunciation condition the illusory word had the same or different pronunciation as the leftover letters in W2, this means that the identity of W1 and W2 differed for the same and different conditions. However, the two pairs of critical words were exactly matched for length and degree of orthographic similarity. Although frequency was not precisely matched for every same/ different pair, across the set of stimuli the frequency did not vary as a function of stimulus condition for either W1 or W2.

A between-items variable was whether the illusory word had regular or irregular spelling-to-sound correspondence. Spelling-to-sound correspondence can be based on word bodies or graphemes (see discussion in Coltheart, Curtis, Atkins, & Haller, 1993). We used the body-based categorization scheme of Plaut, McClelland, Seidenberg, and Patterson (1996), because the word bodies were frequently the part of W2, which could potentially recombine with the fragment. Of the 48 RSVP sequences seen by each participant, 30 had regular spelling-to-sound correspondence and 18 had irregular. The eight versions of each RSVP sequence were counterbalanced across participants.

Participants and Procedure. Forty-one Boston University undergraduates participated for course credit. All participants had learned English from birth, although 8 had acquired English simultaneously with a second language.

The procedure was the same as in Experiment 1, except that a single 250-msec mask appeared after the final item and no filler words were used. The mean exposure per RSVP item was 95 msec (range, 60–120). All stimuli were left aligned. This meant that the fragment, when interposed between the critical words in the lag 1 condition, served to mask the first letters of W1, which were always the locus of orthographic similarity with W2. The sequences designed to produce the illusory word *brook* are given in Table 2 (the first line of which lists repeated/unrepeated W1).

Results and Discussion

Neither amount of RB nor percent of illusory words varied as a function of spelling-to-sound regularity; nor did this factor interact with any other factors, which is consistent with Bavelier et al. (1994). We thus omitted this between-stimulus factor, meaning that ANOVA was conducted on the three-factor design of repeatedness × pronunciation × lag.

RB occurred across all conditions, as is indicated by RBI scores that were all substantially less than .5. Means for RBI were 0.20 and 0.27 for the lag 0 and lag 1 cells of the same pronunciation condition and 0.14 and 0.18 for the lag 0 and lag 1 cells of the different pronunciation condition. Standard errors of the mean ranged from .04 to .05, and t values for tests for a significant difference from .5 were all greater than 3.5, with p values $< .002$. An ANOVA performed on RBI yielded no significant differences between conditions, with p values $> .10$.

Figure 2 shows that percent report of illusory words was higher in the repeated condition [$F_1(1,40) = 40$, $p < .0001$; $F_2(1,46) = 40$, $p < .0001$], replicating the finding of Experiment 1 that orthographic RB facilitates illusory

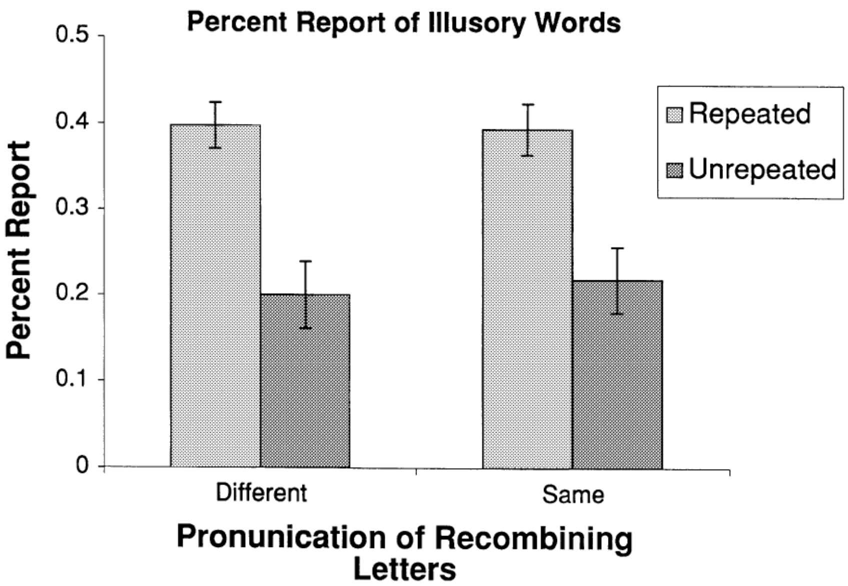

Figure 2. Results of Experiment 2. Percent of trials in which participants reported an illusory word, as a function of repeatedness and whether the combining letters had the same or different pronunciation in the illusory word as in W2.

words. The striking finding of this experiment is the robust report of illusory words even when the recombining letters of W2 had different phonology from that of the illusory word. Indeed, the frequency of illusory words in the different pronunciation condition was as great as in the same pronunciation condition.

Illusory words appear to arise from a stage of word recognition when orthographic sequences are not yet marked for phonology. Alternatively, orthographic sequences may be marked for phonology, but activation of a cohort of word detectors is little influenced by phonology. So, illusory words produced by simple letter migration (*scarf wha* → *wharf*) should also be uninfluenced by phonology. The present experiment demonstrated this effect of letter migration, since illusory words were reported in the unrepeated condition without regard to match of phonology between W2 and the illusory word.

In some of our stimulus sequences, the repeated letters corresponded to the initial consonant clusters as in ***sw**ung* SWEAT; ***ch**ina* CHEAT, whereas others did not (***pa**nic* PATCH, ***wa**ltz* WATCH). In a post hoc analysis, we divided stimuli according to whether or not the distinction between the repeated and recombining letters corresponded to the onset/rime distinction (Treiman, 1994). RBI and report of illusory words was comparable for trials in which the repeated versus recombining letters did instantiate the onset/rime distinction, and the trials in which they did not. This suggested that the onset/rime distinction did not influence probability of reporting illusory words.

GENERAL DISCUSSION

The illusory words paradigm (Morris & Harris, 1999) was first developed to test the hypothesis that when two orthographically similar words (W1 and W2) are rapidly and sequentially displayed, the deficit in reporting the second word can be localized to a deficit in detecting the repeated letters, leaving the unrepeated letters capable of participating in cohort activation. The two experiments here replicated the basic illusory words effect. In comparison with performance on trials containing no repeated letter sequences, observers were twice as likely to recombine letters from W2 and a fragment when those letters were "left over" from suppression involved in the phenomenon of repetition blindness (RB).

Our goal in the present paper was to investigate this paradigm further, particularly to determine whether it could be useful for investigating aspects of sublexical processing and the nature of orthographic units. In Experiment 1, we investigated a hypothesis about which there is already considerable agreement: Clusters of letters are marked for their positions at the beginnings and ends of words (Humphreys et al., 1990; Mozer, 1983). Report of illusory words was consistent with this. Orthographic similarity between the critical words facilitated illusory word report only when the leftover letters maintained their position in the word in W2 and the illusory word. For example, the leftover *th* from the critical words GROWING *grow**th*** combined with the *leng* fragment to produce *leng**th***. In contrast, the leftover *th* from PLUMP ***th**ump* did not combine with the *wor* fragment to produce *wor**th***.

In Experiment 2, we investigated whether illusory word production was sensitive to the match between phonology of the illusory word and W2, the word from which recombining letters migrated. Frequency of report of illusory words was similar across the same/different pronunciation conditions, indicating that a phonological match is not required for illusory word production. Indeed, phonology appeared to make no difference in observers' report of illusory words.

The present results are most consistent with the view that RB represents a perceptual effect (see, e.g., Harris & Morris, 2000; Hochhaus & Johnston, 1996; Kanwisher, 1987; Kanwisher, Kim, & Wickens, 1996; Morris & Harris, 1999; Park & Kanwisher, 1994) rather than a failure of retrieval processes (Armstrong & Mewhort, 1995; Fagot & Pashler, 1995) or an artifact of reconstructive memory (Whittlesea et al., 1995; Whittlesea & Podrouzek, 1995; Whittlesea & Wai, 1997). It is difficult to envision how reports of illusory words could result from retrieval failure. Similarly, proponents of the reconstructive view have yet to detail how this view explains repetition blindness in nonidentical words. On the reconstructive memory account, the difficulty in reporting repeated words stems from separate but nondistinctive encoding of the two occurrences of the word, leading to less effective recall of the separate instances. The results of our Experiment 2 would appear to pose a particular challenge for this account. If both W1 and W2 are adequately encoded, as is claimed by the reconstructive memory account, the phonology of W2 should influence report of illusory words. The finding that phonology of W2 did not influence illusory words is most consistent with the proposal that RB arises during the on-line process of constructing a conscious perception of the word list.

We have presented the illusory words paradigm as one that is relevant to visual word recognition. An objection to this is that when observers see the final fragment, they may be guessing a word that is compatible with that fragment, with this guess being influenced by the letters in the preceding word. To explain the "repeatedness" effect, one would need to propose that the unique letters figure more prominently in the guess. The view we favor is that the illusory word is actually activated and passes its recognition threshold, meaning that observers have a perceptual experience (as may happen when a low-frequency word is misread as its higher frequency neighbor; Grainger, 1990).

Evidence against the guessing explanation comes from Experiment 1. If participants are guessing on the basis of the nonrepeated letters from W2, then it is unclear why the position of the letters within a word are relevant to this guess. A "perception" versus "guessing" account could also be explored by following the serial report of the RSVP list with a probe word and asking observers to rate their confidence of seeing this word. We predict higher confidence when the illusory words are reported with the help of orthographic similarity, in comparison with when they are the result of letter migration. Repetition priming paradigms could also shed light on this question. Priming on a subsequent perceptual identification task for words actually displayed in RSVP could be compared with priming for "illusory" words. If the illusory word was "perceived" in a manner similar to other words shown in RSVP, we should find priming equivalent to that seen for words actually displayed. If the illusory word was generated via guessing, such priming might not be evident, or we might find a weaker effect such as that seen with cross-modality priming. We might even find priming for word fragment completion but not on perceptual identification, since these tasks are sensitive to different processes. In any case, we agree that this question does merit further investigation.

As with any new paradigm, many questions remain, both methodological and theoretical. Questions that have occurred to us, and which have almost certainly occurred to many readers, include the following:

Repetition blindness is known to decrease with lag (i.e., intervening words between the critical words; Kanwisher, 1987). How resistant is production of illusory words to lag (or to an unfilled delay) intervening between W2 and the fragment?

How much does illusory word production depend on lexical characteristics? One such characteristic is the degree to which the fragment entails the illusory word. For example, *afr* as a candidate word-onset segment is consistent only with *afraid* and *africa*; *dwa* is consistent only with *dwarf*. Sequences that produce a high number of illusory words included *study staid afr* → *afraid* and *scale scarf dwa* → *dwarf*.

Can the illusory words paradigm be used to investigate theories of the units mediating visual word recognition? Particularly appealing is the prospect that illusory words are most frequently reported when the recombining letters correspond to the primary units of visual word recognition. These could correspond to the letter clusters or spelling patterns described by Gibson (1965, 1971), or the multiletter reading units described by Prinzmetal and colleagues (Prinzmetal, Hoffman, & Vest, 1991; Prinzmetal, Treiman, & Rho, 1986). Other proposed units are basic orthographic syllable structures (Taft, 1979), vocalic center groups (Spoehr & Smith, 1973), and onset/rime units (Treiman, 1994). It is our hope that other researchers will use the illusory words paradigm, adding it to the arsenal of techniques for studying visual word recognition.

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NOTE

1. We allow the convention of referring to the manipulation of repeated letters as the "repeatedness" manipulation, even though letters within words are what is repeated rather than entire words.

APPENDIX A
Stimuli for Experiment 1

Filler 1	W1 (repeated/unrepeated)	Filler 2	W2	Fragment	Illusory Word
Positions of recombining letters do not match; first letters of critical words are repeated:					
plug	DINNER/BOTTOM	full	dish	ave	shave
ray	CHAIR/BOUND	took	chasm	ell	smell
mud	TWINE/LUMPY	roof	twist	ack	stack
tar	HUNG/MOON	bled	husk	irt	skirt
beef	CLAIM/MOUTH	grew	clasp	oon	spoon
but	PATROL/REFUND	swig	patch	oke	choke
ken	CARD/TEEN	bomb	cask	ill	skill
kid	MODEL/CHINA	bang	most	ore	store
pot	DEAF/LICK	town	death	umb	thumb
arc	RANGE/VOODOO	jeep	ranch	ief	chief
Positions of recombining letters do not match; last letters of critical words are repeated:					
tone	DRUNK/ACTOR	dump	skunk	bri	brisk
bone	THICK/CALL	jury	stick	coa	coast
pay	BLADE/CIVIC	noon	shade	har	harsh
sire	BRAIN/GUEST	flop	chain	wat	watch
era	BRING/STOCK	lump	thing	fai	faith
brim	ALONE/STUDY	wet	phone	gra	graph
lady	PROVE/THIGH	junk	stove	tru	trust
den	CLOSE/VIRUS	gaze	those	wor	worth
crew	AGREE/VIVID	quit	three	sou	south
pill	MEANT/WORSE	quiz	chant	rea	reach
Positions of recombining letters match; first letters of critical words are repeated:					
joy	RICH/CAMP	even	risk	di	disk
large	WIND/DUTY	jazz	wisp	cri	crisp
bid	CATTLE/ENERGY	miss	catch	por	porch
gasp	MONEY/FIELD	lend	moth	bir	birth
lake	CRUMB/FLICK	pony	crush	tra	trash
inn	ROAD/KEEP	chum	roast	bla	blast
book	PEANUT/KITTEN	swag	peach	lun	lunch
quad	GROWING/SCIENCE	baby	growth	leng	length
king	FLAT/WARM	been	flash	cra	crash
copy	FRENCH/WINDOW	kitty	fresh	bru	brush
Positions of recombining letters match; last letters of critical words are repeated:					
curb	GONE/BILL	hum	stone	aff	staff
jar	ROCK/WIRE	know	shock	ell	shell
huff	BROKE/PAINT	chug	smoke	ile	smile
press	AMONG/EARLY	mill	thong	ird	third
rum	DRINK/JUDGE	lacy	think	orn	thorn
jazz	QUITE/KNOWN	food	spite	eed	speed
teeth	CHASE/LOGIC	buzz	phase	ony	phony
nook	CREEP/TIDAL	bun	sheep	ift	shift
bolt	YEARS/WHILE	hood	stars	eam	steam
bat	MORE/WILL	stun	chore	ild	child

APPENDIX B
Stimuli for Experiment 2

Pronunciation Same				Pronunciation Different			
W1 (repeated/unrepeated)	W2	Fragment	Illusory Word	W1 (repeated/unrepeated)	W2	Fragment	Illusory Word
swung/funny	sweat	thr	threat	china/plain	cheat	thr	threat
wealth/terror	weight	fr	freight	sleeve/powder	sleight	fre	freight
mock/bang	moth	clo	cloth	bone/knee	both	clo	cloth
class/music	clamp	tra	tramp	swan/dung	swamp	tra	tramp
cross/wagon	crook	bro	brook	spot/tape	spook	bro	brook
panic/lucky	patch	mat	match	waltz/venom	watch	mat	match
door/help	dove	lo	love	worn/bird	wove	lo	love
study/going	staid	afr	afraid	plush/booth	plaid	afr	afraid
four/need	fork	sto	stork	wood/calm	work	sto	stork
list/step	live	dri	drive	find/knew	five	dri	drive
ball/deep	band	sta	stand	warm/gray	wand	sta	stand
forgery/bookish	forgive	nat	native	derange/calming	derive	nat	native
place/every	plant	cha	chant	meal/rock	meant	cha	chant
whack/youth	wharf	dwa	dwarf	scale/quick	scarf	dwa	dwarf
defend/stupid	defeat	tre	treat	green/fresh	great	tre	treat
roles/trail	rough	eno	enough	thorn/zombie	though	eno	enough
paint/fever	paste	wa	waste	camel/icing	caste	wa	waste
noel/sail	none	do	done	torn/ward	tone	do	done
error/smell	erase	cha	chase	phone/dozen	phase	cha	chase
boat/camp	bowl	sco	scowl	hour/meet	howl	sco	scowl
they/been	that	fla	flat	when/such	what	fla	flat
stems/turns	steak	bre	break	spent/write	speak	bre	break
shame/tooth	sheaf	le	leaf	deck/sink	deaf	le	leaf
gain/hill	gave	bra	brave	hand/took	have	bra	brave

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