Research Report

SEMANTIC BLINDNESS:
Repeated Concepts Are Difficult to Encode and Recall Under Time Pressure

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Abstract—*This study demonstrates a recently predicted cognitive phenomenon known as semantic blindness, an inhibitory effect attributable to concept repetition in the serial recall of rapidly presented sentences. Proficient bilinguals read mixed, Spanish-English sentences, each including a target and a pretarget word. Targets and pretargets were related in three ways: They were identical (e.g., like-like), semantically identical across languages (e.g., gusta-like), and nonidentical within or across languages (e.g., read-like). Equivalent repetition blindness was found for targets with identical and semantically identical pretargets, indicating that repetition deficits were occurring solely at the semantic level, rather than at orthographic or phonological levels.*

Repetition blindness (RB) refers to the inability to detect or recall a repeated word in rapid serial visual presentation (RSVP; see, e.g., Bavelier & Potter, 1992). The present article asks two questions about the level at which RB occurs: Is orthographic or phonological identity always necessary for occurrence of RB? Or is semantic identity sometimes sufficient to cause RB, which in this hypothetical case could be called semantic blindness (SB)? Both questions are relevant to a recently developed theory of repetition deafness and blindness (Miller & MacKay, 1991; this issue, pp. 47–51) that predicts the existence of SB and semantic deafness. Demonstrating these phenomena is important not just to test this theory, but also to determine whether words can be registered in short-term memory via semantic as well as visual, orthographic, and phonological codes (see Bavelier & Potter, 1992).

Bavelier and Potter (1992) argued that visual characteristics such as spatial location, visual form, and visual format are irrelevant to RB. Identical spatial location is irrelevant because RB is equivalent whether subjects read sentences word by word and left to right or by RSVP (Kanwisher, 1987). Identical visual form and format are likewise irrelevant because RB is unaffected when pretarget and target differ in case, as in "They wanted more than *NINE* but *nine* was all they got" (pretarget and target italicized; Bavelier & Potter, 1992; Kanwisher, 1987), or in visual format, as in "They wanted more than *9,* but *nine* was all they got." Because *9* and *nine* share no visual features, not even abstract ones, Bavelier and Potter suggested that phonological identity suffices to induce RB, and that words are initially registered only phonologically in short-term memory. Despite the conceptual identity of *9* and *nine,* Bavelier and Potter rejected semantics as an initial code because Kanwisher and Potter (1990) had found that "noun synonyms" as in Sentences 1 and 2 did not induce SB:

1. The company's new *toxin* might *poison* people accidentally.
2. The new *students* worked with *pupils* who might help them.

From this failure to find SB, Kanwisher and Potter concluded that "repetition blindness occurs at a level of processing prior to the attainment of conceptual representations" (pp. 42–43; see also Potter, 1993).

We had several reasons for reopening the search for SB: One is that two words in the same language are never completely identical in meaning (Lyons, 1968; MacKay, 1973). To illustrate, note that *poison* and *toxin* differ in both lexical and connotative meaning in Sentence 1: Subjects undoubtedly comprehended *to poison* as an action harmful to health, but could have comprehended *toxin* as

beneficial to health, as in medical use of toxins to induce antibodies. Some of Kanwisher and Potter's (1990) synonyms also differed in reference as well as lexical and connotative meaning. For example, subjects reading Sentence 2 may have comprehended *students* and *pupils* as referring to different sets of people (referents). In short, if occurrence of SB requires complete conceptual identity, Kanwisher and Potter may have failed to find SB because their synonyms differed in lexical concept, connotation, and (sometimes) reference.

Another reason for reopening the search for SB is that identical lexical nodes play a central role in RB in the node structure theory (NST; Miller & MacKay, 1991, this issue). And whereas within-language synonyms involve different lexical nodes, only one lexical node underlies words that refer to familiar objects or concepts in the two languages of proficient bilinguals (MacKay, 1982). In the following sentence, for example, *horses* and its Spanish translation equivalent, *caballos,* share a single lexical node and are identical in connotation and reference: Both words refer with similar connotative import to the same object class.

3. They saw *horses,* but *caballos* were prohibitir to enter. (SB repeated-target condition)

The NST therefore predicts that proficient bilinguals will exhibit SB: For example, they will encode and recall *caballos* less often when the reference and meaning of its pretarget are identical (as in Sentence 3) than when they are different (as in Sentence 4).

4. They saw *sheep,* but *caballos* were prohibitir to enter. (SB unrepeated-target condition)

Because *horses* and *caballos* differ in orthography and phonology, such an outcome can be explained only in terms of

shared lexical or referential units (the SB hypothesis).

Under the RB hypothesis, the word itself (its phonology or orthography) must be identical for RB to occur. The RB hypothesis predicts that encoding and recall of a target such as *caballos* will be much less likely in Sentence 5, where its pretarget (*caballos*) is identical, than in Sentences 3, 4, and 6, where pretargets differ from *caballos* in phonology and orthography.

5. They saw *caballos*, but *caballos* were prohibitir to enter. (RB repeated-target condition)
6. They saw *oveja*, but *caballos* were prohibitir to enter. (RB unrepeated-target condition)

METHOD

To test these hypotheses, we asked 48 highly fluent Spanish-English bilinguals (see Appendix 1) to read and immediately recall 32 RSVP strings: 16 fillers randomly interspersed among 16 experimental sentences (e.g., Sentences 3–6; see Appendix 1 for rules of construction). Eight fillers were ungrammatical (e.g., Sentence 7), and 8 were normal Spanish or English sentences without code switches (e.g., Sentence 8). Fillers ensured that subjects would not come to focus on code switching or target repetition, and could sometimes expect ungrammaticality, as might result from SB or RB.

7. When we went a la it was very crowded. (ungrammatical filler)
8. When we went to the store it was very crowded. (normal filler)

Experimental materials were presented at either 70 or 90 ms/word, with one or two short words separating repeated words (see Appendix 1 for details and rationale). Subjects were informed that words would appear one at a time at the center of the screen, speeded up to varying degrees, and that they were to immediately recall the words aloud and in correct order. Subjects were told that many strings would contain a mixture of Spanish and English words, and that if they could not remember a word or its language, they should guess. Subjects were warned that some strings might

seem strange or ungrammatical, but that they should try to repeat strings verbatim without paraphrasing.

RESULTS

Percentages of correct target report (see Appendix 2) are 43 and 34 for unrepeated and repeated targets, respectively, in the SB (across-language) condition and 42 and 32 in the RB (within-language) condition, signifying equivalent magnitudes of blindness. An analysis of variance (ANOVA) showed a main effect of repetition on number of correct target reports ($F[1, 42] = 6.87, p < .01$), but no interaction between the two types of target repetition ($F[1, 42] = 0.93, p = .93$).

DISCUSSION

Our results support the SB hypothesis and indicate that meaning is registered early in short-term memory: Because SB translation equivalents differed in phonology and orthography, the superior recall of unrepeated relative to repeated SB targets cannot be explained at orthographic or phonological levels. This SB effect suggests an alternate explanation for several earlier findings that have been attributed to phonological identity (e.g., Bavelier & Potter's, 1992, 9-vs.-*nine* effect) or to visual-orthographic identity (e.g., Kanwisher & Potter's, 1990, suffix-identity effect). These effects are now explainable in terms of shared reference or semantics rather than shared visual, orthographic, or phonological features. Superior recall of unrepeated relative to repeated targets can no longer be automatically attributed to nonsemantic factors.

Moreover, the equivalence of SB and RB under the present experimental conditions rules out effects of phonology or orthography in our data: To support a role for orthographic or phonological identity, the difference in recall of repeated versus unrepeated targets should have been larger for RB conditions than for SB conditions, contrary to the present results. This equivalence of SB and RB effects strongly supports the NST (Miller & MacKay, 1991, this issue), according to which RB and SB share the same underlying basis: A single node or set of nodes represents a lexical

concept in long-term memory, and sentence comprehension proceeds in part by forming connections from already existing lexical nodes to phrase-level nodes. For example, consider how a proficient German-English bilingual comprehends the sentence "They saw Pferde, but horses were verboten there" (see the nodes in Fig. 1). The single lexical node for the repeated concept (*Pferde/horses*) must quickly connect with two nodes, for the verb phrase "saw horses" and for the proposition "horses were forbidden." Lexical nodes for unrepeated concepts (e.g., *they, saw, were,* and *verboten* in Fig. 1) likewise become connected with phrase nodes. The difference is that connections from unrepeated concepts are one-to-one and can be formed in parallel, whereas connections from repeated concepts are one-to-many and must be formed in sequence, requiring added time (see Miller & MacKay, this issue). Given time pressure, as in RSVP experiments, the first connection from a repeated concept may be formed successfully but the second may not, so that the second concept is
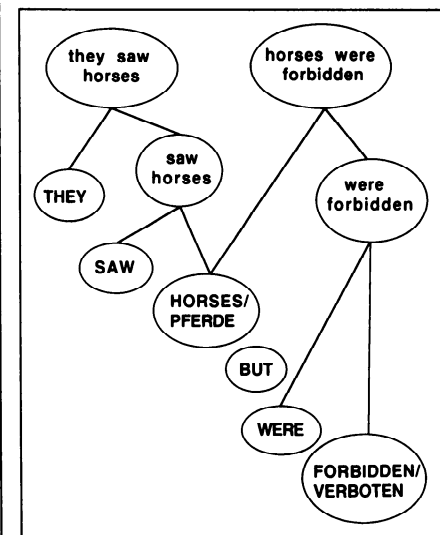

Fig. 1. Phrase nodes (lower case) and lexical nodes (capitals) for a proficient German-English bilingual comprehending aspects of the sentence "They saw Pferde, but horses were verboten there." Note that a single lexical node codes the repeated concept *Pferde/ horses,* the hypothetical basis for SB. Orthographic and phonological nodes are omitted from the figure.

unencoded and its phonology or orthography is unretrievable.

Principles whereby NST explains the equivalence of SB and RB in the present experiment also apply at other levels to explain demonstrations of RB without involvement of lexical nodes. An interesting example is the demonstration (MacKay, 1969) of RB for misspelled words in sentences. Repeated-letter misspellings (e.g., *elderdly*) were harder to detect than unrepeated-letter misspellings (e.g., *elderkly*). Like RB for RSVP words (Kanwisher, 1987), this repeated-letter effect reflects an encoding problem that diminishes with lag or degree of separation of the repeated letters. Interestingly, analogous effects occur in memory: Given perception of a misspelling, repeated-letter misspellings were more poorly recalled than unrepeated-letter misspellings (MacKay, 1969). Neither misspelling effect depended on cross-sentence or cross-item interference (unlike Ranschburg inhibition; see Jahnke, 1972), but both effects involved relatively long processing times: The subjects read sentences at 96 ms/letter or 116 ms/phoneme on average, considerably slower than rates at which RSVP RB has been demonstrated (about 25 to 60 ms/phoneme). Parametric studies of rate therefore seem warranted to determine whether rate limits of RB (see Kanwisher, 1987) are item- or task-specific.

Three other clear instances of RB without involvement of lexical nodes are RB for homonym pairs (e.g., *like* [verb] and *like* [preposition]), for homograph pairs (e.g., *bass* [fish] and *bass* [male voice]), and for homophone pairs (e.g., *won* and *one;* Bavelier & Potter, 1992; Kanwisher & Potter, 1990). Because differing lexical nodes underlie same-spelling or same-sounding words that differ in meaning, these results argue for the existence of two types of blindness (semantic and orthographic-phonological).

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APPENDIX 1: METHODOLOGICAL DETAILS

Subjects

Subjects were 19 males and 29 females (46 right-handed, 2 left-handed; mean age = 24.8 years; SD = 8.33) with normal (corrected) vision. Most were recruited for pay ($7) from ads in the University of California, Los Angeles (UCLA), student newspaper; some were graduate students in Spanish at UCLA; and some volunteered for partial course credit in UCLA psychology classes. Subjects reported speaking Spanish longer than English (M = 21 years vs. 19 years), but using a 5-point scale, they rated their fluency slightly higher for English than Spanish (M = 3.9 vs. 3.3). Thirty-five (73%) listed their first-learned language as Spanish, 11 (23%) listed it as English, and 1 each listed it as Chinese and Polish.

Experimental Sentences

There were 128 experimental sentences (mean length = 10 words, 5 in Spanish, 5 in English) formed by code switching within 16 English prototype sentences (adapted from MacKay & Miller, 1992a). A typical prototype sentence is shown in Sentence 9 (unrepeated pretarget in parentheses), together with its eight code-switching translations in Sentences 10 through 17. Targets and pretargets are italicized and labeled as to language and repetition condition. For example, Sentence 13 is an SB sentence with a Spanish pretarget that is completely different from the English target and is labeled "SB unrepeated-target condition: Spanish–English." Similarly, Sentence 17 is an RB sentence with a repeated English target and is labeled "RB repeated-target condition: English–English."

9. Example prototype sentence
Her *son* (*kids*), my *son*, and his daughter go to school together.
10. SB repeated-target condition: English–Spanish
Her *son*, mi *hijo*, y his hija van a la escuela together.
11. SB repeated-target condition: Spanish–English
Su *hijo*, my *son*, and su daughter go to school juntos.

Donald G. MacKay and Michelle D. Miller

12. SB unrepeated-target condition: English–Spanish

Her *kids,* mi *hijo,* y his hija van a la escuela together.

13. SB unrepeated-target condition: Spanish–English

Sus *niños,* my *son,* and su daughter go to school juntos.

14. RB unrepeated-target condition: Spanish–Spanish

Her *niños,* mi *hijo,* y his hija van a la escuela together.

15. RB unrepeated-target condition: English–English

Sus *kids,* my *son,* and su daughter go to school juntos.

16. RB repeated-target condition: Spanish–Spanish

Her *hijo,* mi *hijo,* y his hija van a la escuela together.

17. RB repeated-target condition: English–English

Su *son,* my *son,* and su daughter go to school juntos.

As in Sentences 10 through 17, targets in repeated- and unrepeated-target versions of SB and RB sentences were identical: Only the pretarget differed. Also, as in Sentences 12 through 15, pretargets in unrepeated-target versions of SB and RB sentences were translation equivalents. Targets and pretargets never occurred first or last in a sentence, were always high in frequency, and, when unrepeated, differed in phonology, orthography, and visual shape in both Spanish and English. The eight versions of a prototype were all grammatically acceptable and virtually identical in syntax, and were counterbalanced across subjects.

On average, words in a sentence occurred in 10 RSVP frames or simultaneous displays. In the few cases where translation demanded more than one word per frame, corresponding concepts were identically framed. For example, two conceptually equivalent frames represented the translation equivalents "to play ball" and "jugar a la pelota," namely, /to play/ball/ and /jugar/a la pelota/. The number of code switches per sentence and same-language words per switch varied within and across the 16 sets of 8 sentences. Any given content word never occurred in more than 1 of the 16 prototype sentences.

Procedure and Design

A general-purpose program (GenPrime; Banks, Burke, Krajicek, & Whetstone, 1990) controlled stimulus presentation to the monitor of a Macintosh Plus computer, beginning with a 200-ms warning, "Get ready for the next sentence." A string of question marks (??????) followed each stimulus, calling for verbal recall. Subject output was recorded using a cassette recorder, but was also transcribed "on line" by the experimenter. After generating a response, the subject pressed the space bar to begin the next trial.

Each subject saw four SB sentences (target repetition across languages), four RB sentences (target repetition within languages), plus corresponding unrepeated-target versions for the remaining eight sentences, with SB and RB versions and language of the target and pretarget counterbalanced across subjects. Stimulus order varied at random across subjects except that average serial position for repeated and unrepeated targets was held constant. Presentation rate varied orthogonally with type of experimental stimulus, with four repeated-target sentences and four unrepeated-target sentences presented at each rate (i.e., 70 ms/word and 90 ms/word) for each subject. The 16 filler sentences were presented at fixed rates, either 50, 70, 90, or 130 ms/word, with 4 at each rate. Each session began with four representative practice sentences presented in different orders and rates, counterbalanced across subjects. We chose 70 and 90 ms/word as rates on the basis of pilot data indicating correct target recall in the 50% range, thereby avoiding floor or ceiling effects that could distort the relative degree of SB versus RB.

APPENDIX 2: ANALYTIC DETAILS

Each trial was scored for correct inclusion of the pretarget and target in the subject's response. We then determined the *conditional measure* of recall, which we believe most accurately represents the magnitude of repetition deficits (MacKay & Miller, 1992b). For conditional measures, repeated and unrepeated targets count as correct only if their pretargets are also recalled. Without recall of the pretarget, data for that trial are discarded.

Subjects recalled the target concept correctly, but in the wrong language, on 14 trials, 7 with repeated targets and 7 with unrepeated targets, as in Sentence 18, where the target, *two,* was misrecalled as its conceptual equivalent, *dos.* Identical *p* values and degrees of repetition deficit resulted when these 14 trials (1.8% of the conditional data) were excluded in a separate analysis. Similar semantic errors also occur in single-language RB experiments, but likewise too rarely to discount RB as a phenomenon. An example (from MacKay & Miller, 1992a) is Sentence 19, in which a pronoun was substituted for the repeated target (see also Sentence 20).

18. I vivo at five ocho two Iglesia Calle
Misrecalled as "I vivo at five ocho dos Iglesia Calle" (cross-language semantic error)
19. We buy fruit when fruit is in season
Misrecalled as "We buy fruit when it is in season" (within-language semantic error)
20. We buy juice when fruit is in season
Misrecalled as "We buy fruit when juice is in season" (within-language semantic error)