

Bilingual deep dysphasia

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We report B.R.B., a bilingual Turkish–English speaker with deep dysphasia. B.R.B. shows the typical pattern of semantic errors in repetition with effects of lexicality and imageability on performance in both languages. The question we asked is whether language type (Turkish or English) or language status—that is, first acquired (L1) or second acquired (L2)—has a greater impact on performance. Results showed that repetition in L1 (Turkish) was better than that in L2 (English). We also observed effects of language status on oral reading, writing to dictation, and naming (spoken and written) with greater impairment to repetition than other tasks in both languages. An additional finding was that spoken-word translation in both directions was worse than written-word translation, and word class had an effect on translation from L1 to L2. We argue that interactive activation models of deep dysphasia could explain deep dysphasia in bilingual speakers and interactions between task and language, if the weighted connections that support language processing in L2 are assumed to be weaker, thus causing rapid phonological decay to have more impact on task performance in L2. Implications of the results for models of bilingual language processing are also considered.

Keywords: Aphasia; Turkish; Short-term memory.

Deep dysphasia is a disorder of repetition defined by semantic and phonological errors in word repetition: better repetition of words than non-words (i.e., a lexicality effect); better repetition of high-imageability/concrete words than of low-imageability/abstract words (i.e., an imageability effect); and impaired auditory short-term memory (Butterworth & Warrington, 1995; Coslett, 1991; Franklin, Howard, & Patterson, 1994; Katz & Goodglass, 1990; Martin, Dell, Saffran, & Schwartz, 1994; Martin & Saffran, 1992; Martin, Saffran, & Dell, 1996; Tree,

Perfect, Hirsh, & Copstick, 2001). Patients often present with additional problems on a range of tasks including naming to confrontation (anomia), writing to dictation (dysgraphia), and oral reading (dyslexia).

Deep dysphasia has been reported in French and Italian (Cardebat, Puel, Démonet, & Nespoulous, 1991; de Partz, 1995; Duhamel & Poncet, 1986; Majerus, Lekeu, Van der Linden, & Salmon, 2001; Metz-Lutz & Dahl, 1984; Michel, 1979; Michel & Andreewsky, 1983; Trojano, Stanzione, & Grossi, 1992;

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We dedicate this work to B.R.B., who passed away recently.

Valdois, Carbonnel, David, Rousset, & Pellat, 1995) and in a Turkish speaker B.R.B. (Raman & Weekes, 2003). Here we report further on the performance of B.R.B., who is a bilingual speaker of English and Turkish. Patient B.R.B. shows a pattern of semantic errors in repetition with effects of lexicality and imageability on performance across tasks in both languages. The question we asked is whether language status—that is, first acquired (L1) or second acquired (L2)—has an impact on B.R.B.’s performance. We asked this question because in our view studies of patients with bilingual aphasia can inform the development of cognitive neuropsychological models of language disorders (see also Beaton & Davies, 2007; De Diego Balaguer, Costa, Sebastián-Galles, Juncadella, & Caramazza, 2004; Ferrand & Humphreys, 1996; Gollan & Kroll, 2001; Hernández, Costa, Sebastián-Gallés, Juncadella, & Reñé, 2007; Kambanaros & van Steenbrugge, 2005).

Martin and colleagues (Martin et al., 1994, 1996; Martin & Saffran, 1992) have developed a computational account of deep dysphasia (see Figure 1). Martin et al. (1994) first showed that the characteristics of deep dysphasia could be simulated in an interactive

semantic–lexical–phonological network initially developed by Dell (1986), using pathologically rapid decay to the representations (nodes). They proposed the *phonological decay (PD) hypothesis* to explain deep dysphasia, which assumes that impaired repetition results from an abnormally rapid increase in decay of phonological representations—that is, the speed with which activation of any unit in the lexical network returns to its resting level of activation after performance. Martin et al. (1994) argued that during normal repetition, phonological units increase their activation and subsequently feed activation forward to lexical and semantic units. At the same time words sharing those phonological units become active, resulting in activation of semantic and lexical units corresponding to those similar words. Martin et al. (1994) further assumed that feedback from semantic and lexical features to target representations supports activation of previously active phonological units. Given the assumption that activation feeds forward and backward, the target receives most activation and is selected for output. However if decay is abnormally rapid, then semantically related repetition errors occur. This is most likely for low-imageability

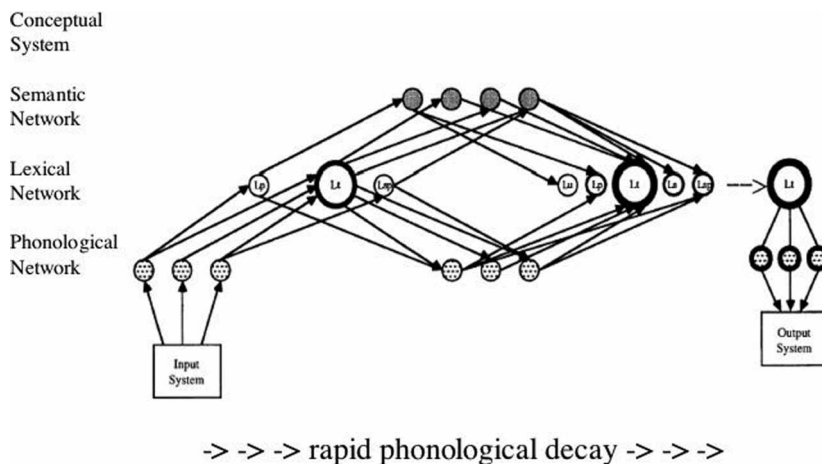


Figure 1. Martin et al. (1996) model of deep dysphasia. From “A Spreading-Activation Theory of Retrieval in Sentence Production”, by G. S. Dell, 1986, *Psychological Review*, 93, p. 00. Copyright 1986 by the Name of Copyright Holder. Adapted with permission.

words and nonwords because weaker connections allow underactivation to generate a word substitution (lexicalization) or no response at all. The PD hypothesis therefore assumes that effects of imageability and lexicality arise due to low-imageability words and nonwords receiving less feedback from semantic units. It also assumes that reduced digit span and length effects on repetition—that is, shorter words repeated better than longer words—result from phonological underactivation (Majerus et al., 2001).

It is not clear how the model in Figure 1 would explain deep dysphasia in bilingual speakers. However, the model does not exclude the possibility that more than one language is represented in the semantic–lexical–phonological network. Indeed interactive models such as the bilingual interactive activation model (BIA; Dijkstra & Van Heuven, 2002) assume that two (or more) languages can be instantiated with weighted connections between units that code the specific features of each language at a common level of representation. The strength of the weightings within that model is adjusted to reflect the tendency for language processing to be less efficient in L2 than L1 even for proficient speakers (Kroll & Dijkstra, 2002). Given that the model of Martin and colleagues (1994, 1996) is interactive and assumes weighted connections in the network, it is straightforward to allow phonological underactivation to have an impact on repetition in both languages of a bilingual speaker using the framework that is shown in Figure 1. Specifically, rapid phonological decay could have more impact on repetition of words in L2 if it is assumed that the strength of connections representing L2 items is weaker than L1, and the speed that units in the lexical network return to their resting level is more rapid for units with weaker connections. This would simulate an effect of *language status*. An additional possibility, however, is that the linguistic properties of the languages spoken by a bilingual also impact on phonological decay—that is, there is an effect of *language type* on performance. If language type did have an effect on performance, then it would not be sufficient to assume that language status

alone constrains the performance of patients with bilingual deep dysphasia. All computational models of deep dysphasia would then need to accommodate effects of language type as well as language status in order to explain the performance of these speakers. Our primary aim was to examine these different possibilities with B.R.B. who has deep dysphasia in English (L2) as well as Turkish (L1).

The PD hypothesis also explains effects of task on performance in deep dysphasia whereby performance in oral reading and confrontation naming is better than repetition and writing to dictation with the same items. This is because underactivation of phonological–lexical–semantic representations and their feedback connections will have graded effects on tasks depending on the direction of activation from presented stimuli (Tree et al., 2001). For example, tasks that depend on bidirectional activation are more difficult than tasks that are performed via feedforward connections alone, because greater phonological activation is required. Tasks including repetition, digit span, writing to dictation, picture naming (spoken and written), and oral reading all require feedforward phonological activation from input to the lexical network. Therefore rapid phonological decay will impact on performance in each of these tasks. However, repetition, digit span, and writing to dictation also require feedback from phonological units (from the lexical network to output) whereas oral reading requires no feedback according to most models (though see Van Orden, Pennington, & Stone, 1990). Performance on oral reading will therefore be better than repetition or writing to dictation. Although this is the pattern that is typically observed in French (Majerus et al., 2001) and English (Tree et al., 2001), no study has compared the effects of task on performance across languages. In our view, interactions between language type and task would be informative to the PD hypothesis. For example, repetition problems might be exaggerated relative to reading and writing difficulties in agglutinative languages such as Turkish when compared to English and French. This is

because highly inflected words in Turkish tend to be longer and thus phonologically more complex. By contrast, printed Turkish words are easier to read than printed English and French words because Turkish contains transparent mappings only between orthography and phonology (Raman & Weekes, 2005a, 2005b).

Turkish belongs to the Turkic language cluster and is a submember of the Altaic family. It is the westernmost of the Turkic languages that are spoken across Central Asia and is classified as a member of the Oğuz group. Modern Turkish is based on the Istanbul dialect of Anatolian (Campbell, 1991). Turkish is an agglutinative language—that is, words are composed in a linear sequence of morphemes with each component of meaning represented by its own morpheme (e.g., *gülmek*, *to laugh*, and *gülme*, *laughing*). Turkish words are highly inflected.¹ Old Turkish was written in the Ottoman script. Modern written Turkish uses a Roman-based system that was adopted in the writing reform of 1928 (Comrie, 1990) and contains 29 letters with 8 vowels and 21 consonants. The script symbolizes sounds that are specific to Turkish by adapting phonetic symbols. Turkish orthography was designed to retain the sounds of the spoken language in a maximally transparent way so that grapheme to phoneme and phoneme to grapheme mappings are completely regular and consistent. Written Turkish is thus a pure example of a transparent orthography (Katz & Frost, 1992).

We know that the linguistic properties of Turkish have an impact on the symptoms of aphasia (Gürel, 1999). For example, unlike

nonfluent cases in English, Turkish speakers preserve grammatical morphemes, especially noun and pronoun inflections that are acquired early in development (Aksu-Koç & Slobin, 1985; Slobin & Bever, 1982). Slobin (1991) argued that preservation of grammatical morphemes in Turkish nonfluent speakers reflects a high informational value for these features in Turkish. Therefore, differences in symptom patterns are informative for understanding aphasia across languages (Nilipour & Paradis, 1995; Yiu & Worrall, 1996). In our view this cross-linguistic approach to understanding aphasia has the potential to inform cognitive models (see Coltheart, 1984; Weekes, 2005), including models of oral reading in deep dysphasia (e.g., see Valdois et al., 1995).

Our primary motivation for studying B.R.B. was to test predictions derived from the PD hypothesis as in previous case reports of patients who have deep dysphasia (Majerus et al., 2001; Tree et al., 2001). However, studies of bilingual speakers with aphasia show that brain damage often leads to selective language problems—that is, dissociations in processing one language and not the other (Fabbro, 1999; Kambanaros & van Steenbrugge, 2005; Paradis & Goldblum, 1989). In these patients, L1 is typically better preserved than L2 although the reverse pattern is reported (Agliotti & Fabbro, 1993; Beaton & Davies, 2007). We therefore hypothesized that language status (L1 versus L2) would impact on B.R.B.'s performance across a range of tasks, including translation, a repetition task familiar to bilingual speakers.

According to the PD hypothesis, rapid phonological decay in the lexical network will cause a

¹ Turkish is cited as an example of an agglutinating language that approximates to the ideal type (Cromer, 1991). Grammatical function in Turkish is given by adding suffixes to a stem. Separate suffixes on nouns indicate both gender and number, but there is no grammatical gender in Turkish. Nouns are declined in three declensions with six case endings: nominative, genitive, dative, accusative, locative, and ablative; number is marked by a plural suffix. Verbs agree with their subjects in case and number, and, as in nouns, separate identifiable suffixes perform these functions. The order of elements in a verb form is: verb stem + tense aspect marker + subject affix. There is no definite article, although the number “one” may be used as an indefinite article. Subject–object–verb word order in Turkish is typical, but other orders are possible under certain discourse situations. As a subject–object–verb language where objects precede the verb, Turkish has postpositions rather than prepositions and relative clauses that precede the verb. Modern Turkish also has Turkic vowel harmony in which the vowels of suffixes must harmonize with the vowels of noun and verb stems. Thus, for example, if the stem has a round vowel then the vowel of the suffix must be round. Stress assignment on words pronounced in isolation is on the final syllable but stress assignment in discourse can be complicated in the verb (Campbell, 1991; Comrie, 1990).

patient with deep dysphasia to have problems repeating words and, because more phonological activation is required, will have a greater impact on tasks that depend on bidirectional activation from presented stimuli. Two predictions that can be derived from the PD hypothesis are that (a) phonological underactivation will result in poor repetition in Turkish and English, and (b) repetition will be worse than oral reading of the same lexical items in Turkish and English. In addition, because we hypothesize that language status will impact on B.R.B.'s performance, we expect performance across tasks to be worse in English (L2) than Turkish (L1). If we do observe effects of language status on B.R.B.'s performance, this will have implications for the PD hypothesis as well as cognitive neuropsychological theories of deep dysphasia including computational models. Specifically, an effect of language status—although not incompatible with the Martin et al. (1994) model—would suggest that modifications to that model are necessary in order to explain deep dysphasia in bilingual speakers.

CASE DESCRIPTION

B.R.B. is a right-handed male, and he was 67 years of age at the time of testing. B.R.B.'s native language is Turkish (L1); however, he was educated in English (L2) from an early age to tertiary level (14 years) in Cyprus, where he worked as a senior civil servant using both languages. Turkish is a co-official language in Cyprus and is spoken as a first language by approximately 19% of the population. Prior to brain injury B.R.B. resided in London for 20 years where he used English and Turkish daily for speaking, reading, and writing. B.R.B. was hospitalized following an acute cerebrovascular accident (CVA) in 2001. Computed tomography (CT; see Figure 2) revealed a medium-sized infarct in the left parietal-occipital region. B.R.B.'s premorbid IQ was

assessed in English using the National Adult Reading Test (NART; Nelson, 1982) and was estimated to be in the high-average range. As the NART is a measure of the ability to read irregularly spelled words in English, his performance also reflects an above-average ability to use English proficiently. We had no reference group to compare performance in English and Turkish. However, reports from family members, all of whom are bilingual in English and Turkish, as well as extracts taken from a diary (written in English pre-morbidly) suggested to us that pre-morbid language skills in both Turkish and English were proficient.

B.R.B.'s speech was severely reduced following his stroke. He presented with fluent but semantically empty speech in Turkish and English, and he tended to produce semantic errors in spontaneous speech and circumlocutory errors on informal tests of confrontation naming in both languages. Case notes suggested that his volitional speech and writing were better preserved than his naming and writing to command, and anecdotal reports of cross-linguistic errors suggested an alternating recovery pattern—that is, L2 substitutes were produced when speaking in L1 (and L1 for L2). However, these effects were not formally assessed.

Language assessments in Turkish

B.R.B. displays all features of deep dysphasia in Turkish. Raman and Weekes (2003) reported (a) semantic paraphasias in repetition (e.g., ayak/foot → parmak/finger); (b) better repetition of words (57%) than nonwords (0%); (c) better repetition of high-imageability words (e.g., yatak/bed, 55%) than low-imageability words (e.g., yorum/interpretation, 2%); and (d) an effect of word class on repetition with nouns (e.g., ağaç/tree, 61%) repeated better than verbs (e.g., açmak/to open, 23%) and verbal nouns (e.g., gülme/laughing, 0%).² Digit span forward and digit span backward were 1 each. These effects

² A verbal noun is a noun formed directly as an inflexion of a verb or a verb stem.

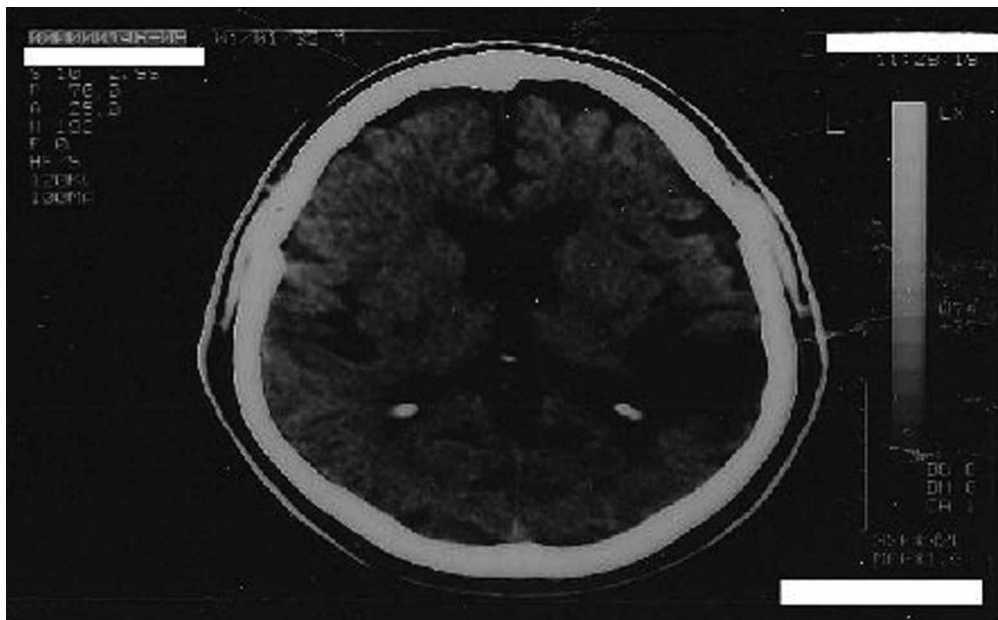


Figure 2. Computed tomography (CT) scan showing damage to the left hemisphere.

are assumed to arise from rapid phonological decay with word class effects arising from the relatively longer word length of verbs and verbal nouns (Raman & Weekes, 2003).

Raman and Weekes (2003) compared B.R.B.'s performance across tasks in Turkish using the same lexical items and found that repetition performance and spelling to dictation were significantly worse than oral reading—a pattern compatible with the PD hypothesis and similar to reports of English and French speakers (Majerus et al., 2001; Tree et al., 2001). However, they also found spelling to dictation was worse than repetition—a pattern that to date appears to be unique to deep dysphasia in Turkish (Raman & Weekes, 2003).

Raman and Weekes (2005a) reported that B.R.B.'s oral reading in Turkish was better for high-imageability nouns (95%) than for low-imageability nouns (70%) with intact reading of non-words (100%), concrete nouns (100%), abstract verbs (95%), and abstract verbal nouns (100%). Raman and Weekes (2005b) reported that B.R.B. was deep dysgraphic in Turkish, producing

semantic writing errors (e.g., ağaç/tree, written as bahçe/garden; and güneş/sun, as gündüz/day), poor spelling of nonwords (0% correct), and effects of word class on writing to dictation (i.e., nouns, 64%, better than verbs, 0%, and verbal nouns, 0%).

Language assessment in English

For the purposes of the present study we examined B.R.B.'s language skills in English using the Psycholinguistic Assessment of Language Processing and Aphasia (PALPA) Battery (Kay, Lesser, & Coltheart, 1992). Our rationale for choosing this battery was to use established procedures and norms (following Tree et al., 2001) assuming that B.R.B. had at least average premorbid ability in English. Results are in Table 1.

B.R.B. produced frequent semantic paraphasias in repetition (e.g., battle → “conquer”; spider → “fly”), although phonological errors were noted (e.g., iron → “irony”; plea → “we”). We observed effects of lexicality and imageability (PALPA 8 and 9): better repetition of words 52/80 (65%)

Table 1. Summary of tests and findings used in the assessment of B.R.B.'s English language

<i>Test</i>	<i>Date</i>	<i>Summary findings</i>
PALPA 5	6.8.01	Intact auditory lexical decision: Words (97%) and nonwords (97%) equally preserved
PALPA 8	10.8.01	Lexicality effect on repetition: Better repetition of words (65%) than nonwords (0%)
PALPA 9	2.8.02	Imageability effect on repetition: Better repetition of high-imageability words (65%) than low-imageability words (0%)
PALPA 10	9.7.02	Word class effect on repetition: Better repetition of nouns (55%) than verbs (0%) and function words (0%).
PALPA 36	8.8.01	Intact visual lexical decision: Words (99%) and nonwords (99%) equally well preserved
PALPA 38	17.7.01	Poor homophone definition (33%)
PALPA 40/41	18.7.01	Impaired irregular-word reading: Accuracy for irregular-word reading poor (45%) compared to regular-word (100%) and nonword reading (100%)
PALPA 46	27.7.02	Impaired spelling of homophones to dictation in a sentence (55%)
PALPA 47/48	23.7.01/30.7.01	Preserved comprehension of high-imageability nouns on word–picture matching tests in spoken (100%) and written modalities (95%)
PALPA 49/50	7.8.01	Imageability effect on synonym judgement: In spoken modality high-imageability words (100%) more accurate than low-imageability words (77%); in written modality a similar pattern with high-imageability (100%) versus low-imageability (87%) words
PALPA 51	9.8.01	Imageability effect in spoken-word semantic association with high-imageability words (100%) correct versus low-imageability words (46%)
PALPA 52	9.8.01	Imageability effect in spoken-word–written-word matching with high-imageability words (100%) correct versus low-imageability words (73%)
Words from diary (oral reading, repetition, spelling)	30.8.01	Discrepancy between pre- and post-CVA: Reading (82% correct) followed by repetition (12%) and writing to dictation (10%)
Digit Span	1.5.02	Impaired forward and backward digit span (1 each)

Note: PALPA = Psycholinguistic Assessment of Language Processing and Aphasia Battery. CVA = cerebrovascular accident.

than nonwords 0/80 (0%) with lexicalization errors (e.g., spool → “school”); better repetition of high-imageability (e.g., window, 65%) than of low-imageability words (e.g., concept, 0%); and a word class effect on repetition (PALPA 10; i.e., nouns repeated better, 55%, than verbs, 0%, and function words, 0%). Digit span forward and backward was 1.

Testing revealed no impairment to comprehension of high-imageability nouns on word–picture matching tests (PALPA 47/48) using spoken words (40/40 correct) and written words (38/40 correct; controls = 38/40). However, there were problems with comprehension of low-imageability words (nouns, verbs, prepositions, and adjectives). For example, there were effects of imageability on the following: synonym judgement with spoken words

(PALPA 49; high imageability = 30/30 correct; low imageability = 23/30 correct; controls = 29/30) and written words (PALPA 50; high imageability = 30/30 correct; low imageability = 26/30 correct; controls = 29/30); spoken-word semantic association (PALPA 51; high imageability = 15/15 correct; low imageability = 7/15 correct; controls = 15/15); and spoken-word–written-word matching (PALPA 52; high imageability = 15/15 correct; low imageability = 11/15 correct; controls = 15/15). Word recognition in English was mostly intact, reflecting our contention that B.R.B. was proficient pre-morbidly. Auditory lexical decision was preserved (PALPA 5; words = 78/80 correct; nonwords = 78/80 correct; controls = 79/80), as was his visual lexical decision (PALPA 36; words = 29/30 correct, controls = 30/30; nonwords = 29/30

correct, controls = 29/30). On tests of oral reading (PALPA 40/41), B.R.B. displayed characteristics of surface dyslexia. He was impaired with irregular-word (exception-word) reading (18/40 correct; controls = 39/40) but not regular-word reading (40/40 correct) or nonword reading (40/40 correct). He was unable to define homophones (PALPA 38), scoring near to chance (7/20 correct; controls = 19/20). B.R.B. produced frequent regularization errors when reading irregular words and homophone substitutions (e.g., *pail* → “*yellow*”), although he was able to produce cross-linguistic definitions in Turkish ($n = 13$) that were judged to be acceptable by a native speaker. This suggests that he understood the meaning of written words in L2 and that this task generated response competition between L1 and L2 for spoken-word output. Although cross-linguistic semantic reading errors are a feature of impaired oral reading in bilingual speakers (Beaton & Davies, 2007; Byng, Coltheart, Masterson, Prior, & Riddoch, 1984; Eng & Obler, 2002; Karanth, 2002; Masterson, Coltheart, & Meara, 1985), it is notable that B.R.B. did not produce cross-linguistic semantic errors in single-word reading at all. B.R.B. could read function words (40/40). However, imageability had an effect on his oral reading (PALPA 9): high-imageability nouns = 80/80 correct; low-imageability nouns = 60/80 correct (controls = 79/80). On tests of writing to dictation including homophones that were defined in a sentence context (PALPA 46), B.R.B. was impaired (11/20 correct; controls = 19/20). He was deep dysgraphic producing frequent semantic errors (e.g., “*pain*” → *wound*), and he was completely unable to write nonwords (0/20).

To ensure that B.R.B.’s language problems in L2 were acquired and not due to lack of familiarity with English, we selected 40 words from his diary (written pre-morbidly in English). Words were mostly abstract in meaning and included function words, adjectives, verbs, and nouns. He performed below criterion on tasks containing these words including: repetition = 5/40 correct; writing to dictation = 4/40 correct; and oral reading = 34/40

correct. Therefore, we can conclude that B.R.B. sustained acquired language impairments in English.

Summary

B.R.B. meets the criteria for deep dysphasia in both Turkish and English including the following: semantic and phonological errors in repetition; better repetition of words than nonwords; better repetition of high-imageability than low-imageability words; reduced digit span; an effect of word class on repetition; deep dysgraphia; and surface dyslexia in English. These impairments were observed in the context of largely preserved written- and spoken-word recognition in both languages. However, comprehension of low-imageability English nouns was poor. In this respect B.R.B. resembles other patients with deep dysphasia in English (e.g., D.R.B. reported by Franklin et al., 1994; Franklin, Howard, & Patterson, 1995). Rapid phonological decay might explain poor performance with low-imageability nouns on PALPA comprehension tasks. This is because spoken-word input requires the retention of auditory verbal information while selecting a target from related foils. However, for B.R.B., poor performance with low-imageability nouns may reflect lack of familiarity with the specific English words in this task. This is a known problem in the assessment of aphasia in bilingual speakers (Paradis, 1977). If that is correct, then the theoretical significance of B.R.B.’s performance in L2 for the PD hypothesis would be severely limited. We therefore explore this question in further detail below.

EXPERIMENTAL INVESTIGATIONS

The data from the case description suggest that B.R.B.’s performance may be more impaired in L2 than in L1. However, as assessments were performed using different tasks it is not yet clear whether language status has an effect on B.R.B.’s performance. The following experiments were therefore designed to compare his performance in Turkish and English on tasks that are expected to be impaired in both languages according to the PD hypothesis.

EXPERIMENT 1: EFFECTS OF LANGUAGE ON REPETITION

Our aim here was to test the following predictions: According to the PD hypothesis, low-imageability and low-frequency words should be more difficult for B.R.B. to repeat in both L1 and L2. However, if language status also has an impact on performance in bilingual deep dysphasia, then B.R.B.'s repetition of words in L1 should be better than repetition in L2.

Method

Materials

To examine effects of word imageability and frequency on B.R.B.'s repetition, we used items taken from standardized tests (PALPA 9) and Turkish equivalents. A total of 80 monomorphemic words were presented orally to B.R.B. in two different testing sessions: once in English and, 8 weeks later, in Turkish. Stimuli were divided into equal-sized groups: (a) high-imageability and high-frequency words (e.g., letter/mektup); (b) high-imageability and low-frequency words (e.g., axe/balta); (c) low-imageability and high-frequency words (e.g., idea/fikir); and (d) low-imageability and low-frequency words (e.g., woe/hüzün).

Procedure

The following procedure was used: The examiner presented a stimulus word once, and B.R.B. was asked to repeat it. The response was transcribed, and the next stimulus was then presented. Stimuli were presented in random order. In both sessions precautions were taken to prevent lip-reading by having the examiner mask the lips during the pronunciation of stimuli. The examiner was a native Turkish speaker who was also fluent in English.

Results

Analysis of variance (ANOVA) was used to analyse accuracy data. Three factors were analysed: language (Turkish and English), imageability

Table 2. Effects of word imageability and frequency on B.R.B.'s repetition performance

Imageability	Frequency	% correct	
		Turkish	English
High	High	70	25
High	Low	40	15
Low	High	5	0
Low	Low	0	0

(high and low), and frequency (high and low). Results are summarized in Table 2.

ANOVA found significant effects of language, $F(1, 19) = 33.78, p < .01$, as well as imageability, $F(1, 19) = 44.33, p < .01$, but no significant effect of word frequency, $F < 1$. There was a significant interaction between language and imageability, $F(3, 19) = 30.0, p < .01$, and an interaction between language and frequency that approached significance, $F(3, 19) = 4.13, p = .06$. Additional higher order interactions between language, imageability, and frequency were not significant, $F_s < 1$. Analyses of simple main effects found that performance was better in Turkish than in English, and imageability had a smaller effect on repetition in English (all $p_s < .05$). Word frequency had an effect on repetition in Turkish for high-imageability words only. These interactions may be due to floor effects as shown by values in Table 2.

Comment

The results support our predictions because repetition of words in L1 was better than repetition of words in L2, and low-imageability nouns were more difficult for B.R.B. to repeat in both L1 and L2. The pattern of better performance with high-imageability nouns than with low-imageability nouns on lexical-processing tasks has been reported in other cases of bilingual aphasia (Beaton & Davies, 2007; Kiran & Tuchtenhagen, 2005; Roberts, 1998). However, ours is the first report of an imageability effect on repetition in bilingual aphasia. Imageability

had more impact on repetition in L1 than in L2. However, these results are complicated as B.R.B. was unable to repeat all low-imageability English nouns, suggesting that he may be unfamiliar with these words. There was no evidence of a language type effect—that is, repetition was not more impaired in the phonologically more complex language (Turkish).

EXPERIMENT 2: EFFECTS OF LANGUAGE ACROSS TASKS

Our aim here was to examine B.R.B.'s performance using the same concepts across language and the same lexical items across tasks. High-imageability concrete nouns were used in all tasks given the imageability effects on performance reported above. We assumed that B.R.B. would be familiar with these items in both Turkish and English. According to the PD hypothesis, repetition and writing to dictation should be more difficult than oral reading in Turkish and English because underactivation of representations in the lexical network has a greater impact on tasks that require bidirectional activation than tasks performed via feed-forward connections alone. However, if language status has an impact on performance in bilingual deep dysphasia, then performance across tasks should be better in L1 than in L2.

Method

Materials

B.R.B. was presented with 40 high-imageability English nouns (e.g., shoe) and Turkish equivalents (e.g., ayakkabı; note that all nouns were unambiguous for translation) in the following tasks: repetition, writing from dictation, oral reading, spoken picture naming, and written picture naming. All stimuli were from PALPA Test 47.

Procedure

B.R.B. was first asked to perform the tasks in English and then, 8 weeks later, to perform these same tasks in Turkish. The following procedures were used: For repetition the examiner presented

a stimulus word once, and B.R.B. was asked to repeat it; for writing to dictation the examiner presented a stimulus word once, and B.R.B. was asked to write it on a blank sheet of paper; for oral reading the printed word was presented on a card, and B.R.B. was asked to read it aloud; for spoken picture naming a pictorial stimulus was presented, and B.R.B. was asked to name it; for written picture naming a pictorial stimulus was presented, and B.R.B. was asked to write the name on a sheet of paper. Each response was transcribed, and then the following stimulus was presented. Stimuli were presented in random order. In both sessions precautions were taken to prevent lip-reading by having the examiner mask their lips during the pronunciation of stimuli. The examiner was a native Turkish speaker who was fluent in English.

Results

ANOVA was used to analyse accuracy data. Two factors were analysed: language (Turkish and English) and task (repetition, writing from dictation, oral reading, spoken picture naming, and written picture naming). Results are summarized in Table 3.

ANOVA found a significant effect of task, $F(1, 39) = 2.53$, $p < .01$, no significant effect of language, $F(1, 39) = 1.82$, *ns*, and a significant interaction between task and language, $F(4, 156) = 2.47$, $p < .01$. Analyses of simple effects found that repetition and writing to dictation were better in Turkish than in English (all $ps < .05$) with no significant differences for oral reading or spoken and written naming. Performance on

Table 3. Effects of task on B.R.B.'s performance in Experiment 2

Task	% correct	
	Turkish	English
Repetition	82	65
Writing to dictation	77	57
Oral reading	100	85
Spoken picture naming	72	80
Written picture naming	77	82

repetition and writing to dictation was worse than oral reading in both languages, and spoken and written naming was worse than oral reading in Turkish (all p s < .05) but not in English. Repetition and writing to dictation was worse than spoken and written naming in English (p < .05) but not in Turkish. No other effects were significant.³

Comment

The results partly support our predictions since language status had an effect on repetition, oral reading, and writing to dictation, and repetition was more difficult than oral reading in both Turkish and English. Some unexpected outcomes were that language status had no effect on spoken picture naming or written picture naming, and B.R.B.'s performance on repetition and writing to dictation was worse than his spoken and written picture naming in L2 but was no different in L1. There was no evidence of a language type effect.

EXPERIMENT 3: EFFECTS OF PRESENTATION MODALITY AND WORD CLASS ON TRANSLATION FROM L2 → L1

Our motivation here was to see whether underactivation of phonological–lexical–semantic representations had graded effects on tasks depending on the direction of activation from presented stimuli (Tree et al., 2001). This claim, which is derived from the PD hypothesis, allows repetition performance to vary according to the modality of stimulus presentation.

All cognitive models assume that translation between languages requires semantic support although proficient speakers need less support (Kroll & Dijkstra, 2002). Translation between languages with spoken words also depends on feedback in the network. However, translation with written-word input, which is equivalent to oral reading, should not require feedback. The translation task therefore provides a test of the PD hypothesis in patients with bilingual deep dysphasia.⁴ Given that tasks depending on bidirectional activation receive less feedback from semantic units in deep dysphasia because of phonological underactivation, our prediction was that spoken-word translation would be more difficult than written-word translation for B.R.B. Raman and Weekes (2003) reported an effect of word class on B.R.B.'s repetition in Turkish. They argued that this is because verbs and verbal nouns are longer than nouns in Turkish. However, verbs and verbal nouns also tend to be relatively abstract in meaning compared with nouns and may also be less frequent and low in imageability. Since any of these variables would make verbs and verbal nouns more vulnerable to phonological decay within an interactive framework, the PD hypothesis allows an effect of word class on translation performance. We therefore expected presentation modality to have larger effects on the translation of verbs and verbal nouns—that is, B.R.B.'s spoken-word translation would be worse than his written-word translation of verbs and verbal nouns.

Method

Materials

B.R.B. was presented with the lexical items used to assess the effects of word class on repetition in

³ Within-language semantic errors were observed on all tasks except oral reading in English whereby errors were regularizations (e.g., shoe → “show”). A small number ($n = 3$) of cross-linguistic errors were given in spoken naming tasks but in L1 only.

⁴ Note that varying presentation modality in repetition can be done with monolingual speakers, though this is not ideal since repetition of written words (oral reading) may be performed without semantic support in these speakers (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001).

Turkish reported in the case description. We presented three word types: nouns (e.g., ağaç/tree), verbs (e.g., açmak/to open), and verbal nouns (e.g., gülme/laughing).⁵ All items and B.R.B.'s responses are reported in Appendix A.

Procedure

The following procedure was used: The examiner presented a stimulus word once in Turkish, and B.R.B. was asked to repeat it in English. For the spoken-word presentation the examiner presented a spoken Turkish word, and B.R.B. was asked to repeat it in English. For the written-word presentation, the examiner presented a Turkish word printed on a card, and B.R.B. was asked to repeat it aloud in English. The response was transcribed, and then the next stimulus was presented. Stimuli were presented in random order. Precautions were taken to prevent lip-reading. The examiner was a native Turkish speaker fluent in English.

Results

ANOVA on accuracy data was used with two factors: repetition modality (spoken and written) and word type (nouns, verbs, and verbal nouns). Results are shown in Table 4.

ANOVA found a significant effect of presentation modality, $F(1, 33) = 12.80, p < .01$, a significant effect of word type, $F(1, 33) = 11.65, p < .01$, and no significant interaction between modality and word type. Analyses of simple effects found that translation was better from written-word input than from spoken-word input and better for nouns than for verbs and verbal nouns (all $ps < .05$). As in the repetition tasks described above, B.R.B. produced semantic translation errors (classified by a Turkish-English speaker). However errors were cross-linguistic—for example, DEFTER (exercise book) was translated as “homework”, and DELMEK (to drill) was translated as “hole”. A paired t test found that the number of translation errors was significantly greater in written-word

Table 4. Effects of modality and word class on translation from Turkish to English

	% correct	
	Spoken	Written
Nouns	62	91
Verbs	3	53
Verbal nouns	0	0

translation ($n = 37$) than in spoken-word translation ($n = 16; p < .05$).

Comment

The results supported our predictions since spoken-word translation was worse than written-word translation of the same items. This finding can be explained by assuming that underactivation of phonological-lexical-semantic representations has graded effects on tasks depending on the direction of activation from presented stimuli (Tree et al., 2001). The effect of word class can be explained by assuming that verbs and verbal nouns are the most vulnerable to phonological decay. However, we cannot determine whether this vulnerability is due to the length, relatively abstract meaning, frequency, or imageability of the items. The dissociation between verb and noun naming is compatible with reports of more impairment to verb naming than noun naming in bilingual aphasia (De Diego Balaguer et al., 2004; Kambanaros & van Steenbrugge, 2005; Poncelet, Majerus, Raman, Warginaire, & Weekes, 2007), although note that Hernandez et al. (2007) reported the reverse dissociation in a bilingual patient with dementia.

EXPERIMENT 4: EFFECTS OF TASK ON TRANSLATION FROM L2 → L1

We reported in the case description that B.R.B.'s comprehension of low-imageability words was

⁵ Items were not matched for concreteness, word frequency, or imageability as values are not available in Turkish. Therefore we cannot exclude the possibility that word class effects result from uncontrolled differences in these variables.

more impaired than his comprehension of high-imageability words in English given spoken- and written-word input. In addition we found that repetition performance with nouns in PALPA 9 was relatively poor (at floor) for low-imageability nouns in Experiment 1. This level of performance is surprisingly low and is comparable to B.R.B.'s repetition of nonwords that have no meaning and have not been heard before. Although we assumed that B.R.B. was a proficient English speaker premorbidly, we cannot be certain that he knew the meaning of the words presented in Experiment 1 premorbidly. Thus, it is not clear whether repetition impairments with the low-imageability L2 words reported above result from not knowing the words.

Our primary aim was to examine B.R.B.'s translation performance with words that he did know premorbidly. Words were therefore selected from his diary. His repetition of these items was poor (see Table 1), suggesting that his repetition does not depend on item familiarity. We also knew that there were graded effects on performance in different tasks since he was able to read these items better than he was able to repeat them or write them to dictation. Experiment 3 showed that translation from L1 to L2 was better for written words than for spoken words. We therefore expected translation performance with premorbidly known items to be better with written-word than spoken-word input. However, here we reversed the translation direction from L2 to L1 to test B.R.B.'s performance with L2 words that he knew premorbidly.

Method

Materials

B.R.B. was presented with the lexical items used to assess his acquired language impairment in English. We presented 40 words taken from his diary written premorbidly in English. All items and B.R.B.'s responses are reported in Appendix B.

Procedure

The following procedure was used: The examiner presented a stimulus word once in English, and

B.R.B. was asked to repeat it in Turkish. For the spoken-word presentation the examiner presented a spoken English word, and B.R.B. was asked to repeat it in Turkish, and for the written-word presentation the examiner presented an English word printed on a card, and B.R.B. was asked to repeat it aloud in Turkish. The response was transcribed, and the next stimulus was presented. Stimuli were presented in random order. Precautions were taken to prevent lip-reading. The examiner was a native Turkish speaker who was fluent in English.

Results

ANOVA was used to analyse accuracy data. As we had previously collected data on B.R.B.'s repetition, writing to dictation, and oral reading with the same lexical items, we included task (spoken translation, written translation, repetition, writing to dictation, and oral reading) as a factor in the ANOVA. Results are summarized in Table 5.

ANOVA found a significant effect of task, $F(1, 39) = 35.97$, $p < .01$. Analyses of simple effects found that performance on the written-translation and oral-reading tasks was better than performance on all other tasks (all $ps < .05$). No other task effects were significant.

Comment

As predicted, B.R.B. was able to translate premorbidly known items better from written-word input than from spoken-word input. These results are compatible with the claim that the direction of activation from the presented stimuli has an impact on performance in deep dysphasia (Tree

Table 5. *Effects of task on B.R.B.'s performance in Experiment 4*

<i>Task</i>	<i>% correct</i>
Repetition	12
Writing to dictation	10
Oral reading	85
Spoken translation	0
Written translation	92

et al., 2001). Another important finding was the observation that although B.R.B. retrieved the meaning of most premorbidly known L2 words to translate them from written-word input, he was completely unable to translate premorbidly known words from spoken-word input. Thus we contend that B.R.B.'s problems with the spoken-word repetition of L2 words does not depend on knowing the items—indeed it is remarkable that he knew the meaning of these abstract items well enough to translate them from written-word input at all. Instead we believe that B.R.B.'s problems with the repetition of L2 words depends on whether or not feedback from phonological units is required, as is the case for translation tasks that use spoken-word input but is not the case for translation tasks using written-word input. Also, because an effect of presentation modality on repetition and also on translation in bilingual deep dysphasic speakers is predicted by the PD hypothesis, we submit that B.R.B.'s problems with the repetition of words in L2 results from rapid phonological decay in the lexical network and not from a lack of familiarity with the words tested. By extension therefore we also contend that his problems with the comprehension of low-imageability words reported in the case description and summarized in Table 1 most probably reflect a pattern of abnormally rapid phonological decay in the lexical–semantic network.

GENERAL DISCUSSION

The results support several predictions derived from the PD hypothesis. Repetition performance was poor in both Turkish and English, and there was an effect of imageability on repetition in both languages. Repetition and writing to dictation was also worse than oral reading of the same lexical items in both languages. In addition, spoken-word translation was more impaired than written-word translation in both languages. However, we also found that B.R.B.'s repetition and writing to dictation was better in Turkish (L1) than in English (L2). These findings support the hypothesis that phonological

underactivation has more impact on performance in L2 in patients with bilingual deep dysphasia. As there was no effect of language type and no evidence of interactions between language type and task, we submit that language type has no significant impact on performance in bilingual deep dysphasia.

The computational account of deep dysphasia (depicted in Figure 1) first proposed by Martin and colleagues (Martin et al., 1994, 1996; Martin & Saffran, 1992; see also Dell, Schwartz, Martin, Saffran, & Gagnon, 1997) can account for B.R.B.'s symptoms in both English and Turkish. This model assumes that phonological activation from spoken-word input automatically leads to lexical and semantic activation within an interactive network representing words and phonemes in a given language. However, because activation decays at an abnormally rapid rate, a semantically related word may be produced in error. B.R.B.'s semantic repetition errors in both languages, as well as the effects of imageability, word class, and lexicality on repetition and his severely reduced digit span performance in Turkish and English, can be explained as a consequence of abnormally rapid phonological decay—that is, the speed that activation of any unit in the network returns to its resting level.

The Martin et al. (1994) account of deep dysphasia can also explain some of the effects that we observed in the experimental investigations. The PD hypothesis can explain imageability effects on repetition in Experiment 1 because low-imageability nouns receive less support than high-imageability nouns as a consequence of pathological phonological decay. Rapid phonological decay also explains the effects of task in Experiment 2 whereby oral reading in Turkish and English was better than repetition and writing to dictation with the same lexical items. This is because both repetition and writing to dictation require feedback from phonological units, whereas oral reading requires no feedback, instead affording direct activation of phonology and thus compensating for rapid phonological decay (Tree et al., 2001). Rapid phonological decay can also explain the effects of presentation

modality and word class on B.R.B.'s translation in both directions. This is because (a) translation from spoken words requires feedback from phonological units, whereas translation from print does not require feedback from phonological units, and (b) verbs and verbal nouns are longer than nouns and hence are more vulnerable to phonological decay.

The Martin et al. (1994) account of deep dysphasia is based on an early variant of a two-step theory of lexical access in speech production (Dell, 1986; Dell, Martin, & Schwartz, 2007). The key feature of this theory for explaining lexical access in patients with aphasia (including deep dysphasia) is the assumption that word retrieval and phonological retrieval are distinct steps that operate in a serial order but do not depend on separate modules. In all models that are based on this theory, word retrieval is achieved through interactive and bidirectional spreading of activation through the phonological-lexical-semantic network. Therefore, information that is relevant for word access—for example, imageability, word class, and potentially language status—can influence phonological retrieval.

Martin et al. (1994) made specific adaptations to the two-step model to explain the performance of their patient N.C. Their account assumes that the first step in repetition is the activation of phoneme units, which spreads throughout the model until activated words are selected. Semantic errors occur during the recognition step and are promoted by a decay lesion—that is, rapid phonological decay leads to semantic errors during that step. A decay lesion promotes semantic errors in word recognition because the initially activated units in the phoneme and word layers have decayed relatively quickly and more than the later activated semantic units. In other words the model “remembers” the meaning of a word it must repeat better than the form of the word leading to semantic repetition errors (Dell et al., 2007).

The assumption that rapid phonological decay is necessary to explain performance in deep dysphasia has been questioned, however, by a recent implementation of the two-step theory reported by Dell et al. (2007) and depicted in Figure 3. Their implementation of repetition

allows lexical and semantic properties to impact on performance. Activation in the network spreads in all directions, allowing the semantic properties of words to impact on phonological retrieval with the most active phoneme units selected to complete the process of word retrieval. Word retrieval also depends on strength of connections in the semantic weights whereas phonological retrieval depends on the selected word unit being given a jolt of activation via phonological weights. These assumptions were supported in tests of the model, against data from monolingual aphasic patients reported by Dell et al. (2007). Of interest to our question about phonological decay in bilingual deep dysphasia, simulations with reductions to independent sets of connection parameters (semantic and phonological weights) explain more of the monolingual data than do simulations using phonological decay.

The modelling of Dell et al. (2007) contrasts with that of Martin et al. (1994) in a number of ways, making the assumption that semantic repetition errors arise in the first step of the two-step framework open to question. First, in the modelling of repetition errors, Dell et al. (2007) assumed that word retrieval in deep dysphasia is intact—the perfect recognition assumption. Second, repetition errors are assumed to occur during phonological retrieval so making repetition independent of word retrieval. Finally, phonological decay, although it is possible, is not necessary to explain repetition performance. The framework in Figure 3 has the potential to explain B.R.B.'s performance because he could recognize most words, thus conforming to the perfect recognition assumption. Also, his poor performance on writing to dictation, picture naming, and translation could be due to phonological retrieval problems. The model explains the effects of imageability on repetition because activation in the model flows up to semantics and back down to the phoneme level, thus allowing greater repetition accuracy for concrete, high-imageability words and effects of word class on repetition because verbs and derived nouns are longer, abstract, less frequent, or lower in imageability.

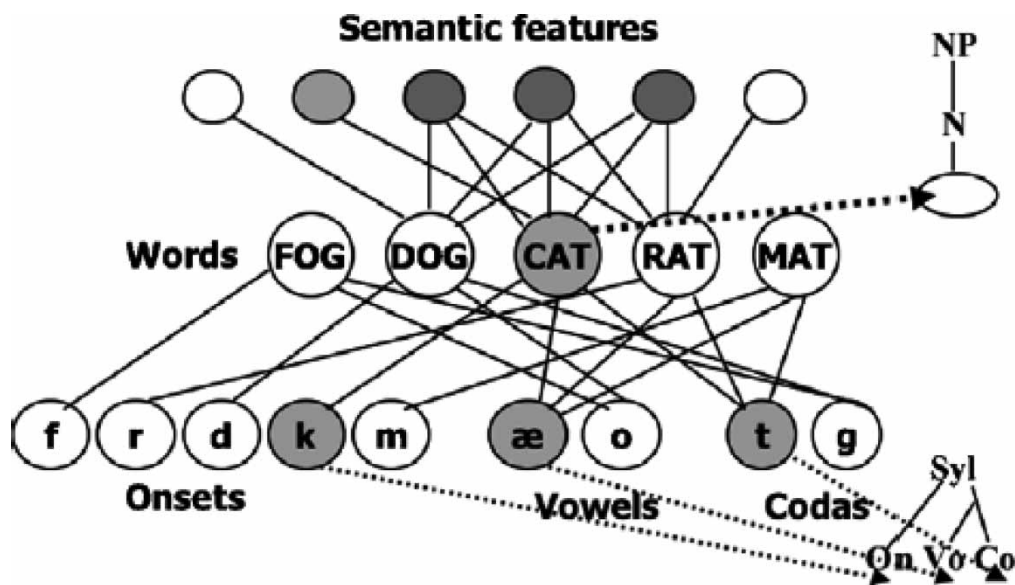


Figure 3. Structure of the interactive two step model. From "A Case-Series Test of the Interactive Two-Step Model of Lexical Access: Predicting Word Repetition from Picture Naming", by G. S. Dell, N. Martin, and M. F. Schwartz, 2007, *Journal of Memory and Language*, 56. Copyright 2007 by the Name of Copyright Holder. Adapted with permission.

As repetition errors are assumed to occur in phonological retrieval, the model also explains why B.R.B. was unable to repeat spoken words that he knew pre-morbidly on translation tasks—that is, knowing words has no effect on repetition performance. It is not clear, however, how the two-step model would explain semantic repetition errors in both languages, effects of task (see also patient P.W. reported by Tree et al., 2001), or the effects of presentation modality on translation.⁶ According to Dell et al. (2007) strong semantic weights cause semantic errors if phonological weights are low. Severe damage to phonological units may impact more on tasks using bidirectional phonological activation (spoken-word repetition and translation). If that is correct then the two-step framework could accommodate B.R.B.'s performance.⁷

The two-step theory makes no assumptions about bilingual language processing, and so it can offer no explanation of the effects of language status. However, the two-step theory does assume parameters that can be adapted to simulate these effects. Interactive activation models of bilingual language processing, such as the BIA+ model of Dijkstra and colleagues (Dijkstra & van Heuven, 2002), assume an integrated lexicon for L1 and L2 with a language nonselective access mechanism in recognition. At the word level, all words inhibit each other, irrespective of their status. However, effects of status on performance are simulated in the model via differential weighted connections between the units representing words in L1 and L2. This contrasts with a modular view of L1 and L2 assumed in some other models of

⁶ We note that the two-step model has not yet been tested against monolingual-patient data with tasks using written-word input, and so this question is largely moot.

⁷ We cannot exclude the possibility that word recognition in English and Turkish was less than perfect, which would allow semantic errors to arise in the first step of the model.

bilingual language processing (for more detailed discussion see Kroll & Dijkstra, 2002).⁸

The two-step theory assumes weighted connections between units in an interactive network. It should therefore be straightforward to incorporate lexical representations for L1 and L2 words with weaker connection weights between L2 words and phonological units. Given the results reported here, a better alternative may be to assume greater decay between phonological units, semantic units, and L2 words. Either approach would locate effects of language status on performance at the level of phonological processing (retrieval or decay). Some points to note from our results are that if picture naming requires feedback in the network (as assumed by Dell et al., 2007), then effects of language status may be independent of feedback. This is because we observed no effect of language status on picture naming—in fact the trend was towards the opposite direction. Dell et al. (2007) assume that poor picture naming but not repetition reflects impaired word retrieval—that is, a process in which meaning is mapped to a holistic lexical item. However, it is not clear how computational models would instantiate all these constraints in simulations of performance in bilingual deep dysphasia.

The BIA + model assumes that written-word input in either language automatically activates words in each language, thus allowing the properties of one language to impact on the oral-reading performance in the other (see Jared & Kroll, 2001). We found evidence of nonselective language access from print. B.R.B. produced cross-linguistic errors on written-word translation and homophone definition in L2. Cross-linguistic errors could arise at many points in the model—that is, orthographic input, semantics, mappings between semantics and phonological output, or output itself. We can exclude orthographic input as the origin as we observed cross-linguistic

errors in spoken-word translation. By contrast, B.R.B. produced within-language regularization errors in English, suggesting selectivity in L2 oral reading, and within-language semantic errors in repetition and writing to dictation.⁹

A preference for within-language over cross-linguistic errors in repetition could be simulated in a two-step model by assuming selectivity in phonological retrieval (see Costa, Miozzo, & Caramazza, 1999). It is more challenging for the model to explain B.R.B.'s cross-linguistic errors in L1 picture naming. In bilingual speakers, picture naming requires word retrieval from among competing responses whereas word repetition does not. Translation and homophone definition in L2 also require target word retrieval. B.R.B.'s cross-linguistic errors were common to tasks that require word retrieval. Therefore, these errors could be located in the first step of a two-step model. We note also that cross-linguistic errors were common if target word retrieval was difficult—for example, translation of verbs and verbal nouns from L1 to L2 (where performance was near to floor). Finally, given that the observed effects of language status were limited to repetition and writing to dictation, and were not observed in picture naming, we would locate these effects in the second step of the model, reflecting either the failure to retrieve phonology or abnormally rapid phonological decay.

Why is B.R.B.'s oral reading of irregularly spelled English words also impaired? B.R.B. presented with surface dyslexia in English and deep dysgraphia in English and Turkish. One interpretation of surface dyslexia comes from dual-route models of reading (Coltheart et al., 2001). These models assume that lexical routes for oral reading are damaged in surface dyslexia causing impaired oral reading of irregular words and poor homophone definition. One puzzle is why deep dysphasic patients are also deep dysgraphic and not

⁸ The revised hierarchical model of Kroll and Stewart (1994) is a developmental model of second-language acquisition although it has been applied to explaining translation performance. We assumed that B.R.B. had developed language skills in English to a proficient level premorbidly. Therefore the model is not relevant to explaining B.R.B.'s normal or impaired performance.

⁹ Within-language errors are reported in other cases of acquired dyslexia in bilingual speakers (Beaton & Davies, 2007; Weekes, Su, Yin, & Zhang, 2007) and is evidence of language selectivity in oral reading.

surface dysgraphic when writing (see also Majerus et al., 2001; Tree et al., 2001). Dual-route models can explain the coincidence of deep dysgraphia and surface dyslexia because damage can exert effects of regularity and lexicality at multiple loci (see also patient B.B. reported by Gerhand, McCaffery, & Barry, 2000). B.R.B.'s poor oral reading of irregular words could therefore result from impairment to lexical routes for oral reading in English and impaired writing of words and nonwords from a damaged nonlexical pathway for writing Turkish and English words.

An alternative account of surface dyslexia comes from interactive activation (IA) models of lexical processing (Plaut, McClelland, Seidenberg, & Patterson, 1996). Crucially, these models assume that surface dyslexia/dysgraphia results from damage to the semantic system (Graham, Patterson, & Hodges, 1997, 2000; Patterson & Hodges, 1992; Woollams, Lambon Ralph, Plaut, & Patterson, 2007) or to an inability to access phonological information from semantics (Watt, Jokel, & Behrmann, 1997; Weekes & Robinson, 1997). As B.R.B. has difficulty accessing phonological information from meaning, poor oral reading of irregular words may result from lack of activation at this level. Errors may be more likely in English because phonological retrieval is more difficult in L2. We note here that B.R.B. could access phonological information in Turkish from printed English on written-word translation tasks.

In our view IA models of reading do not easily accommodate a correlation between surface dyslexia in L2 and preserved retrieval of phonology from semantics in L1 or the coincidence of deep dysgraphia and surface dyslexia. According to these models, semantic paraphasias and impaired nonword writing result from an inability to use direct mappings between phonology and orthography. As these mappings are impaired in deep dysgraphia, writing proceeds via semantic representations—generating semantic paraphasias.

However, use of the semantic pathway should preclude surface dyslexia in IA models, as they assume that the semantic pathway must be impaired for surface dyslexic errors to occur. Therefore, the oral reading and writing of patients with deep dysphasia, including monolingual English and French speakers, are a challenge for IA models to explain.¹⁰

We argued above that B.R.B.'s problems with spoken-word translation and the effects of word class on translation (and repetition) result from phonological decay. Phonological retrieval problems might also produce these effects, however. Most verbs in English stress the final syllable, and patients with monolingual dysphasia tend to repeat stress-initial words (nouns) better than stress-final words (Nickels, 1997). Although stress is not instantiated in the two-step model, final-stress words do require more processing (Mattys & Samuel, 2000), making verbs potentially more vulnerable to decay. Translation of abstract words could be more difficult than concrete words because if the semantic features of words are based on perceptual categories these may be more similar across languages—at least according to the distributed feature model of translation proposed by De Groot (1992). As we did not control items in Experiments 3 and 4 for word frequency, imageability, or the number of translation equivalents (see Tokowicz, Kroll, De Groot, & Van Hell, 2002), we cannot draw any firm conclusions about the locus of word class effects on B.R.B.'s performance.

In sum our data show that lexical status has an impact on language processing in deep dysphasia. A two-step framework might simulate this effect by assuming that connection strengths between semantic representations and word forms are weaker in L2 than in L1. Given the effects of task and presentation modality on B.R.B.'s performance, our preferred view is that rapid decay of phonological representations has more impact on L2 than on L1 in bilingual deep dysphasia.

¹⁰ Cross-linguistic errors during the oral reading of irregular words are not necessary if a lexical reading route for reading in English is damaged but could follow damage to a semantic reading pathway in bilingual speakers (see Raman & Weekes, 2005a).

The effect of language status that we have identified can only be explained in the two-step model by simulating the effects reported. This approach of fitting case data to computational models enhances the explanatory power of the two-step theory (see also Rumelhart, Caramazza, Shelton, & Chialant, 2000). Our finding that language status has an impact on performance in bilingual aphasia has implications for the rehabilitation of bilingual speakers with aphasia (Edmonds & Kiran, 2006; Kiran & Edmonds, 2004; Roberts & Deslauriers, 1999; Roberts & Le Dorze, 1998). Language type may constrain the pattern of symptoms that are observed in bilingual aphasia (Paradis, 1977, 2001). However, this observation has limited utility in cognitive neuropsychology (for a similar conclusion see Beaton & Davies, 2007).

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REFERENCES

- Agliotti, S., & Fabbro, F. (1993). Paradoxical selective recovery in a bilingual aphasic following subcortical lesions. *Neuroreport*, *4*, 1359–1362.
- Aksu-Koç, A., & Slobin, D. (1985). The acquisition of Turkish. In D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Beaton, A., & Davies, W. (2007). Semantic errors in deep dyslexia: Does orthographic depth matter? *Cognitive Neuropsychology*, *24*, 312–323.
- Butterworth, B., & Warrington, E. K. (1995). Two routes to repetition: Evidence from a case of “deep dysphasia”. *Neurocase*, *1*, 55–66.
- Byng, S., Coltheart, M., Masterson, J., Prior, M., & Riddoch, M. J. (1984). Bilingual biscriptal deep dyslexia. *Quarterly Journal of Experimental Psychology*, *36A*, 417–433.
- Campbell, G. L. (1991). *Compendium of the world's languages* (Vol. 12). London: Routledge.
- Cardebat, D., Puel, M., Démonet, J. F., & Nespoulous, J. L. (1991). Les différentes “boîtes” de la répétition: Analyse d'un cas de dysphasie profonde [The different “boxes” for repetition: A case study of deep dysphasia]. *Revue de Neuropsychologie*, *1*, 215–232.
- Coltheart, M. (1984). Writing systems and reading disorders. In L. Henderson (Ed.), *Orthographies and reading: Perspectives from cognitive psychology, neuropsychology, and linguistics*. Hove, UK: Lawrence Erlbaum Associates.
- Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, *108*, 204–256.
- Comrie, B. (1990). *The world's major languages*. Oxford, UK: The University Press.
- Coslett, H. B. (1991). Read but not write “idea”: Evidence for the third reading mechanism. *Brain and Language*, *40*, 425–443.
- Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the two languages compete for selection? *Journal of Memory and Language*, *41*, 365–397.
- Cromer, R. F. (1991). *Language and thought in normal and handicapped children*. London: Basil Blackwell.
- De Diego Balaguer, R., Costa, A., Sebastián-Galles, N., Juncadella, M., & Caramazza, A. (2004). Regular and irregular morphology and its relationship with agrammatism: Evidence from two Spanish/Catalan bilinguals. *Brain and Language*, *91*, 212–222.
- De Groot, A. M. B. (1992). Bilingual lexical representation: A closer look at conceptual representations. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology and meaning* (pp. 389–412). Amsterdam: Elsevier Science Publishers.
- Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, *93*, 283–321.
- Dell, G. S., Martin, N., & Schwartz, M. F. (2007). A case-series test of the interactive two-step model of lexical access: Predicting word repetition from picture naming. *Journal of Memory and Language*, *56*, 490–520.
- Dell, G. S., Schwartz, M. F., Martin, N., Saffran, E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review*, *104*, 801–838.
- de Partz, M. P. (1995). Deficit of the graphemic buffer: Effects of a written lexical segmentation strategy. *Neuropsychological Rehabilitation*, *5*, 129–147.
- Dijkstra, T., & van Heuven, W. J. B. (2002). The architecture of the bilingual word recognition system:

- From identification to decision. *Bilingualism: Language and Cognition*, 5, 175–197.
- Duhamel, J. R., & Poncet, M. (1986). Deep dysphasia in a case of phonemic deafness: Role of the right hemisphere in auditory language comprehension. *Neuropsychologia*, 24, 769–779.
- Edmonds, L. A., & Kiran, S. (2006). Effect of semantic naming treatment on crosslinguistic generalization in bilingual aphasia. *Journal of Speech Language and Hearing Research*, 49, 729–748.
- Eng, N., & Obler, L. K. (2002). Acquired dyslexia in a bicultured reader following traumatic brain injury: A second case. *Topics in Language Disorders*, 22, 5–19.
- Fabbro, F. (1999). *The neurolinguistics of bilingualism: An introduction*. Hove, UK: Psychology Press.
- Ferrand, L., & Humphreys, G. W. (1996). Transfer of refractory states across languages in a global aphasic patient. *Cognitive Neuropsychology*, 13, 1163–1191.
- Franklin, S., Howard, D., & Patterson, K. (1994). Abstract word meaning deafness. *Cognitive Neuropsychology*, 11, 1–34.
- Franklin, S., Howard, D., & Patterson, K. (1995). Abstract word anomia. *Cognitive Neuropsychology*, 12, 549–566.
- Gerhand, S., McCaffery, F., & Barry, C. (2000). Surface or deep dyslexia? A report of a patient who makes both regularization and semantic errors in oral reading. *Neurocase*, 6, 393–401.
- Gollan, T., & Kroll, J. F. (2001). Bilingual lexical access. In B. Rapp (Ed.), *The handbook of cognitive neuropsychology: What deficits reveal about the human mind* (pp. 321–345). Philadelphia: Psychology Press.
- Graham, N. L., Patterson, K., & Hodges, J. R. (1997). Progressive dysgraphia: Co-occurrence of central and peripheral impairments. *Cognitive Neuropsychology*, 14, 975–1005.
- Graham, N. L., Patterson, K., & Hodges, J. R. (2000). The impact of semantic memory impairment on spelling: Evidence from semantic dementia. *Neuropsychologia*, 38, 143–163.
- Gürel, A. (1999). Decomposition: To what extent? The case of Turkish. *Brain and Language*, 68, 218–224.
- Hernández, M., Costa, A., Sebastián-Gallés, N., Juncadella, M., & Reñé, R. (2007). The organization of nouns and verbs in bilingual speakers: A case of bilingual grammatical category-specific deficit. *Journal of Neurolinguistics*, 20, 285–305.
- Jared, D., & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, 44, 2–31.
- Kambanaros, M., & van Steenbrugge, W. (2005). Noun and verb processing in Greek–English bilingual individuals with anomia aphasia and the effect of instrumentality and verb–noun relation. *Brain and Language*, 97, 162–177.
- Karanth, P. (2002). The search for deep dyslexia in syllabic writing systems. *Journal of Neurolinguistics*, 15, 143–155.
- Katz, L., & Frost, R. (1992). The reading process is different for different orthographies: The orthographic depth hypothesis. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology and meaning* (pp. 67–84). Amsterdam: Elsevier Science Publishers.
- Katz, R. B., & Goodglass, H. (1990). Deep dysphasia: Analysis of a rare form of repetition disorder. *Brain and Language*, 39, 153–185.
- Kay, J., Lesser, R., & Coltheart, M. (1992). *Psycholinguistic Assessment of Language Processing in Aphasia*. Hove, UK: Lawrence Erlbaum Associates.
- Kiran, S., & Edmonds, L. A. (2004). Effect of semantic naming treatment on cross linguistic generalization in bilingual aphasia. *Brain and Language*, 91, 75–77.
- Kiran, S., & Tuchtenhagen, J. (2005). Imageability effects in normal bilingual adults and in aphasia: Evidence from naming to definition and semantic priming tasks. *Aphasiology*, 19, 315–325.
- Kroll, J. F., & Dijkstra, A. (2002). The bilingual lexicon. In R. Kaplan (Ed.), *Handbook of applied linguistics* (pp. 301–321). Oxford, UK: Oxford University Press.
- Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, 33, 149–174.
- Majerus, S., Lekeu, F., Van der Linden, M., & Salmon, E. (2001). Deep dysphasia: Further evidence on the relationship between phonological short term memory and language processing. *Cognitive Neuropsychology*, 18, 385–410.
- Martin, N., Dell, G. S., Saffran, E. M., & Schwartz, M. E. (1994). Origins of paraphasia in deep dysphasia: Testing the consequences of decay impairment to an interactive spreading activation model of lexical retrieval. *Brain and Language*, 47, 609–660.
- Martin, N., & Saffran, E. (1992). A computational account of deep dysphasia: Evidence from a single case study. *Brain and Language*, 43, 240–274.

- Martin, N., Saffran, E. M., & Dell, G. S. (1996). Recovery in deep dysphasia: Evidence for a relationship between auditory-verbal STM capacity and lexical errors in repetition. *Brain and Language*, *52*, 83–113.
- Masterson, J., Coltheart, M., & Meara, P. (1985). Surface dyslexia in a language without irregularly spelled words. In K. Patterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading* (pp. 215–223). Hove, UK: Lawrence Erlbaum Associates.
- Mattys, S. L., & Samuel, A. G. (2000). Implications of stress pattern differences in spoken word recognition. *Journal of Memory and Language*, *42*, 571–596.
- Metz-Lutz, M. N., & Dahl, E. (1984). Analysis of word comprehension in a case of pure word deafness. *Brain and Language*, *23*, 13–25.
- Michel, F. (1979). Préservation du langage écrit malgré un déficit majeur du langage oral (à propos d'un cas clinique) [Preservation of written language with major oral language deficits (a clinical case)]. *Lyon Médical*, *241*, 141–149.
- Michel, F., & Andreevsky, E. (1983). Deep dysphasia: An auditory analog of deep dyslexia in the auditory modality. *Brain and Language*, *18*, 212–220.
- Nelson, H. E. (1982). *National Adult Reading Test, NART*. Windsor, UK: Nelson Publishing Company.
- Nickels, L. A. (1997). *Spoken word production and its breakdown in aphasia*. Hove, UK: Psychology Press.
- Nilipour, R., & Paradis, M. (1995). Breakdown of functional categories in three Farsi–English bilingual aphasic patients. In M. Paradis (Ed.), *Aspects of bilingual aphasia* (pp. 123–138). Oxford, UK: Pergamon Press.
- Paradis, M. (1977). Bilingualism and aphasia. In H. A. Whitaker & H. Whitaker (Eds.), *Studies in neurolinguistics* (Vol. 3, pp. 65–121). New York: Academic Press.
- Paradis, M. (2001). Bilingual and polyglot aphasia. In *Handbook of neuropsychology* (2nd ed., pp. 69–91). Oxford, UK: Elsevier Science.
- Paradis, M., & Goldblum, M. C. (1989). Selective crossed aphasia in one of a trilingual's languages followed by antagonistic recovery. *Brain and Language*, *36*, 62–75.
- Patterson, K., & Hodges, J. R. (1992). Deterioration of word meaning: Implications for reading. *Neuropsychologia*, *30*, 1025–1040.
- Plaut, D. C., McClelland, J. D., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review*, *103*, 56–115.
- Poncellet, M., Majerus, S., Raman, I., Warginaire, S., & Weekes, B. S. (2007). Naming actions and objects in bilingual aphasia: A multiple case study. *Brain and Language*, *103*, 158–159.
- Raman, I., & Weekes, B. S. (2003). Deep dysphasia in Turkish. *Brain and Language*, *87*, 38–39.
- Raman, I., & Weekes, B. S. (2005a). Acquired dyslexia in a Turkish–English speaker. *Annals of Dyslexia*, *55*, 71–96.
- Raman, I., & Weekes, B. S. (2005b). Deep dysgraphia in Turkish. *Behavioural Neurology*, *16*, 59–69.
- Roberts, P. M. (1998). Clinical forum: Clinical research needs and issues in bilingual aphasia. *Aphasiology*, *12*, 119–146.
- Roberts, P. M., & Deslauriers, L. (1999). Picture naming of cognate and noncognate nouns in bilingual aphasia. *Journal of Communication Disorders*, *32*, 1–23.
- Roberts, P. M., & Le Dorze, G. (1998). Bilingual aphasia: Semantic organisation, strategy use and productivity in semantic verbal fluency. *Brain and Language*, *65*, 287–312.
- Ruml, W., Caramazza, A., Shelton, J. R., & Chialant, D. (2000). Testing assumptions in computational theories of aphasia. *Journal of Memory and Language*, *43*, 217–248.
- Slobin, D. I. (1991). Aphasia in Turkish: Speech production in Broca's and Wernicke's patients. *Brain and Language*, *41*, 149–164.
- Slobin, D. I., & Bever, T. G. (1982). Children use canonical sentence schemas: A crosslinguistic study of word order and inflections. *Cognition*, *12*, 229–265.
- Tokowicz, N., Kroll, J. F., De Groot, A. M. B., & Van Hell, J. G. (2002). Number of translation norms for Dutch–English translation pairs: A new tool for examining language production. *Behavior Research Methods, Instruments, and Computers*, *34*, 435–451.
- Tree, J., Perfect, T., Hirsh, K., & Copstick, D. (2001). Deep dysphasic performance in non-fluent aphasia. *Neurocase*, *7*, 473–488.
- Trojano, L., Stanzione, M., & Grossi, D. (1992). STM and verbal learning with auditory phonological coding defect. A neuropsychological case study. *Brain and Cognition*, *18*, 12–33.
- Valdois, S., Carbonnel, S., David, D., Rousset, S., & Pellat, J. (1995). Confrontation of PDP and dual-route models through the analysis of a case of deep dysphasia. *Cognitive Neuropsychology*, *12*, 681–724.

- Van Orden, G. C., Pennington, B. F., & Stone, G. O. (1990). Word identification in reading and the promise of subsymbolic psycholinguistics. *Psychological Review*, *97*, 488–522.
- Watt, S., Jokel, R., & Behrmann, M. (1997). Surface dyslexia in nonfluent progressive aphasia. *Brain and Language*, *56*, 211–233.
- Weekes, B. S. (2005). Acquired disorders of reading and writing: Cross-script comparisons. *Behavioural Neurology*, *16*, 51–57.
- Weekes, B. S., & Robinson, G. A. (1997). Semantic anomia without surface dyslexia. *Aphasiology*, *11*, 813–825.
- Weekes, B. S., Su, I. F., Yin, W. G., & Zhang, X. H. (2007). Oral reading in bilingual aphasia: Evidence from Mongolian and Chinese. *Bilingualism: Language and Memory*, *10*, 201–210.
- Wollams, A., Lambon Ralph, M., Plaut, D., & Patterson, K. (2007). SD-squared: On the association between semantic dementia and surface dyslexia. *Psychological Review*, *114*(2), 316–339.
- Yiu, E. M. L., & Worrall, L. E. (1996). Agrammatic production: A cross-linguistic comparison of English and Cantonese. *Aphasiology*, *10*, 623–647.

APPENDIX A

Stimuli used in Experiment 3

Note errors depicted in bold: nr = no response; sem = semantic error; phono = phonological; nw = nonword; un = unrelated error.

<i>Nouns with translations</i>	<i>Spoken translation</i>	<i>Written translation</i>
aday <i>candidate</i>	nr	candidate
anne <i>mother</i>	mother	mother
ağaç <i>tree</i>	tree	tree
ateş <i>fire</i>	burn sem	burn sem
ayakkabı <i>shoe</i>	shoe	shoe
ayna <i>mirror</i>	mirror	mirror
bahçe <i>garden</i>	garden	garden
balık <i>fish</i>	fish	fish
balkon <i>balcony</i>	balcony	balcony
bardak <i>glass</i>	jug sem	glass
bebek <i>baby/doll</i>	baby	baby
çocuk <i>child</i>	child	child
çiçek <i>flower</i>	flower	flower
defter <i>exercise book</i>	homework sem	copybook
deniz <i>sea</i>	sea	sea
doktor <i>doctor</i>	doctor	doctor
dünya <i>earth/world</i>	globe	globe
ekmek <i>bread</i>	bread	bread
erkek <i>male/man</i>	male	male
gazete <i>newspaper</i>	nr	gazette
gece <i>night</i>	night	night
giysi <i>clothes</i>	nr	clothes
güneş <i>sun</i>	sun	sun
haber <i>news</i>	nr	new
insan <i>human</i>	men/human	human
kitap <i>book</i>	nr	book
kardeş <i>brother</i>	nr	brother
okul <i>school</i>	nr	school
para <i>money</i>	money	money
sabah <i>morning</i>	dawn sem	morning
sigara <i>cigarette</i>	cigarette	cigarette
tarak <i>comb</i>	brush sem	brush sem
toplum <i>community</i>	nr	people
yatak <i>bed</i>	bed	bed
	21/34 correct	31/34 correct
	nr = 8; Sem = 5; un = 0	nr = 0; sem = 2; un = 1

<i>Verbs with translations</i>	<i>Spoken translation</i>	<i>Written translation</i>
asmak <i>to hang</i>	hang	hang
açmak <i>to open</i>	<i>long</i>	open
akmak <i>to flow</i>	nr	<i>current sem</i>
atmak <i>to throw</i>	nr	throw
aldatmak <i>to commit adultery/to cheat</i>	<i>width</i>	<i>lie sem</i>
anmak <i>to remember</i>	nr	remember
biçmek <i>to reap</i>	<i>harvest sem</i>	<i>harvest sem</i>
bölmek <i>to divide</i>	nr	separate
basmak <i>to step/to print</i>	nr	press
bilmek <i>to know</i>	nr	know
boğnak <i>to drown</i>	nr	<i>choke sem</i>
çarpmak <i>to strike to / collide with / to multiply</i>	nr	multiply
çizmek <i>to draw</i>	<i>line sem</i>	<i>line sem</i>
dövmek <i>to beat</i>	nr	beat
dolmak <i>to fill</i>	<i>find</i>	nr
delmek <i>to pierce</i>	<i>hole sem</i>	<i>hole sem</i>
doğmak <i>to be born</i>	nr	<i>create sem</i>
ezmek <i>to crash</i>	nr	crash
eşmek <i>to scratch the surface</i>	<i>equal phono</i>	equal phono
geçmek <i>to pass</i>	nr	pass
gezmek <i>to stroll</i>	nr	<i>picnic sem</i>
gitmek <i>to go</i>	nr	go
gülmek <i>to laugh</i>	<i>smile sem</i>	<i>smile sem</i>
haşlamak <i>to boil</i>	nr	nr
inmek <i>to descend</i>	nr	<i>inside</i>
kırmak <i>to break</i>	<i>hard sem</i>	break
kazmak <i>to dig</i>	nr	dug
olmak <i>to be</i>	nr	be
parlamak <i>to shine</i>	<i>bright sem</i>	shine
satmak <i>to sell</i>	<i>sale sem</i>	<i>sale sem</i>
sermek <i>to spread</i>	nr	nr
tatmak <i>to taste</i>	nr	taste
taşmak <i>to overflow</i>	nr	<i>carry</i>
yakmak <i>to burn</i>	nr	burn
	1/34 correct	18/34 correct
	nr = 22; sem = 7; phono = 1; un = 3	nr = 3; sem = 10; phono = 1; un = 2

<i>Derived nouns with translations</i>	<i>Spoken translation L1 > L2</i>	<i>Written translation L1 > L2</i>
aslma <i>hanging</i>	<i>hang sem</i>	<i>grape sem</i>
açma <i>opening</i>	<i>go</i>	<i>open sem</i>
akma <i>flowing</i>	nr	<i>current sem</i>
atma <i>throwing</i>	nr	<i>throw sem</i>
aldatma <i>adultery</i>	<i>bad</i>	<i>lie sem</i>
anma <i>memorial</i>	in	<i>memory/remember sem</i>
biçme <i>reaping</i>	<i>inside</i>	<i>scorrah trw</i>
bölme <i>division</i>	nr	<i>separate sem</i>
basma <i>printed cloth</i>	nr	nr
bilme <i>knowing</i>	out	<i>know sem</i>
boğma <i>suffocating</i>	nr	<i>choke sem</i>
çarpma <i>multiplication</i>	nr	<i>multiply sem</i>
çizme <i>drawing, boots</i>	in	<i>line sem</i>
dövme <i>beating, tatoo</i>	nr	<i>beat sem</i>
dolma <i>filling, dolmades</i>	nr	nr
delme <i>piercing</i>	<i>hole sem</i>	nr
doğma <i>birth</i>	nr	nr
ezme <i>crashing</i>	nr	<i>crash sem</i>
eşme <i>digging</i>	nr	equal <i>phono</i>
geçme <i>passage, passing</i>	nr	<i>pass sem</i>
gezme <i>stoll</i>	nr	<i>picnic sem</i>
gitme <i>going</i>	nr	<i>go sem</i>
gülme <i>laughing</i>	<i>smile sem</i>	<i>smile sem</i>
haşlama <i>boiled</i>	<i>chance</i>	<i>inside</i>
inme <i>climbing down,</i>	nr	nr
kırma <i>pleat, breaking</i>	<i>break sem</i>	<i>break sem</i>
kazma <i>digging, hoe</i>	nr	<i>dug sem</i>
olma <i>being</i>	nr	<i>be sem</i>
parlama <i>shining</i>	<i>buy sem</i>	<i>shine sem</i>
satma <i>sale</i>	nr	<i>buy sem</i>
serme <i>spreading, hanging</i>	nr	nr
tatma <i>tasting</i>	nr	<i>taste sem</i>
taşma <i>overflow</i>	nr	<i>carry sem</i>
yakma <i>burning</i>	<i>sale</i>	<i>burn sem</i>
	0/34 correct	0/34 correct
	nr =21; sem = 5; un =7	nr = 6; sem = 25; phono = 1 un = 1; nw =1

APPENDIX B

B.R.B.'s translation performance with premonitory available words

Note errors depicted in bold: nr = no response; sem = semantic error; un = unrelated error.

<i>Item</i>	<i>Written modality</i>	<i>Spoken modality</i>	<i>Item</i>	<i>Written modality</i>	<i>Spoken modality</i>
june	haziran	nr	base	temel	nr
sir	efendi	nr	hold	tut	nr
shall	çek	nr	with	ile	dar narrow
said	söyledi	dünya earth	greek	elen	rumca
come	gel	nr	well	iyi	nr
your	sen you sem	nr	chief	baş	yüksek high
post	posta	nr	that	şu	bilmek to know
have	dır	sanmak to guess	it	o	uzun long
born	doğmak	nr	has	dır	şapka hat
can	çak will sem	kum sand	to	e	keza also/too
read	okumak	kainat universe	until	teki	için because
speak	konusmak	konuşma speech sern	am	benim	nr
last	son	nr	very	çok	takriben
years	seneler	kedi cat	for	için	nr
dear	pahalı	neşe joy	of	i	nr
clerk	katibe	iş work sem	the	—	—yeni new
feel	his	fayda use	at	ile	yüz hundred
mayor	reis	posta post	my	ben	nr
house	evler	arkadaş friend	also	keza	bazan sometimes sem
vouch	makbuz	nr	from	de postposition sem	nr
please	lütfen	lütfen	find	bul	nr
	Written modality			Spoken modality	
	39/42 correct			2/42 correct	
	nr = 0; sem = 3; un = 0			nr = 18; sem = 3; mi = 19	