Acquired Dyslexia in a Turkish-English Speaker

Ilhan Raman
Middlesex University, United Kingdom

Brendan S. Weekes
University of Sussex, United Kingdom

The Turkish script is characterised by completely transparent bidirectional mappings between orthography and phonology. To date, there has been no reported evidence of acquired dyslexia in Turkish speakers leading to the naïve view that reading and writing problems in Turkish are probably rare. We examined the extent to which phonological impairment and orthographic transparency influence reading disorders in a native Turkish speaker. BRB is a bilingual Turkish-English speaker with deep dysphasia accompanied by acquired dyslexia in both languages. The main findings are an effect of imageability on reading in Turkish coincident with surface dyslexia in English and preserved nonword reading. BRB's acquired dyslexia suggests that damage to phonological representations might have a consequence for learning to read in Turkish. We argue that BRB's acquired dyslexia has a common locus in chronic underactivation of phonological representations in Turkish and English. Despite a common locus, reading problems manifest themselves differently according to properties of the script and the type of task.

Key Words: Acquired dyslexia, orthographic transparency, phonological deficit, Turkish-English bilingual and biscriptal reader

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INTRODUCTION

Research investigating the effects of orthographic transparency on reading and writing has flourished in recent years. However, the study of individuals with acquired reading and writing impairments has ignored the effects of orthographic transparency. This is regrettable since cognitive neuropsychological studies of patients with acquired dyslexia can reveal much about the functioning of the normal reading system as well as how impairments to the normal system can lead to developmental dyslexia (see Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001 for a discussion). Current theories of reading do not commit to a view about effects of orthographic transparency on reading and writing impairments. However, in our view, case studies of acquired dyslexia can contribute to understanding patterns of developmental dyslexia seen in languages other than English.

We know that problems processing the phonological properties of a word are a precursor to dyslexia in several languages (Goswami, 2003; Goswami, Ziegler, Dalton, & Schneider, 2003; Ramus, 2003; Snowling, 2000; Wagner & Torgesen, 1987; Ziegler, Perry, Ma-Wyatt, Ladner, & Shulte-Körne, 2003). These problems include difficulties on verbal short-term memory tasks including nonword repetition and rapid naming, as well as meta-linguistic tasks such as phonological awareness and phonological recoding, leading to the phonological deficit hypothesis, which is now supported by numerous studies. A coherent account of dyslexia must explain how these phonological impairments lead to reading and writing problems across scripts, although clearly, the unique features of a script must constrain the phenotype of dyslexia that is observed in any given language (Yin & Weekes, 2003). There is an emerging view that phonological problems observed in children with reading and writing problems may be independent of language and hence type of script (Goswami, 2003; Goswami et al., 2003; Ziegler et al., 2003).

Type of script can be characterised in terms of the predictability of the mappings between orthography and phonology (O->P). In English, O->P mappings are relatively unpredictable and thus can be called opaque. In other languages such as German, Greek, Italian, and Spanish, O->P mappings are relatively predictable and, therefore, transparent. English orthography is opaque as it is characterised by irregularity and inconsistency, and these variables are highly correlated (see Henderson, 1982 for a review; Venezky, 1970; Wijk, 1966, for an account of spelling-sound rules in English).

Word regularity refers to whether a word conforms to grapheme to phoneme rule knowledge, whereas consistency refers to whether subword units such as the rime can be pronounced in more than one way (e.g., /ead/). Both regularity and consistency have an effect on reading in English although their relative importance is still being debated (see Cortese & Simpson, 2000).

It is not clear how phonological impairments would manifest in a script such as Turkish in which O->P (and P->O) mappings are entirely predictable (Raman, 2003). One hypothesis is that phonological impairments lead to reading and writing problems in any language regardless of the predictability of the script. There is growing evidence to support this from studies of dyslexia in languages ranging from Chinese to Slovakian (see Smythe, Everatt, & Salter, 2004). A different hypothesis is that predictability—or more precisely grain size—of the script is critical to whether or not phonological impairments will manifest as reading and writing impairments (Wydell & Butterworth, 1999). Turkish was omitted from the Smythe et al. review of dyslexia across languages despite reports of dyslexia in transparent orthographies (Finnish, Italian, Portuguese, and Spanish). This must not be taken as support for the view that dyslexia is not present in Turkish speakers. Rather, we believe that reading and writing problems can be observed in Turkish if the critical features of the language are considered when tests for dyslexia are administered.

MODELS OF READING

Orthographic transparency has a central role in models of oral reading in English (e.g., Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart et al., 2001; Plaut, McClelland, Seidenberg, & Patterson, 1996) and also in German (Perry & Ziegler, 2000; Ziegler, Perry, & Coltheart, 2000). The dual-route computational (DRC) model assumes that independent pathways are used to convert print to sound for reading in English (see figure 1). One route is lexical (route A) where stored information about words is retrieved from the mental lexicon. Presentation of a word results in cascaded activation across feature, letter, and word levels, which spread to whole word nodes in the phonological output lexicon, and then to the phonemic buffer and speech. The other route is nonlexical (route D) where phonology is generated using grapheme to phoneme translation rules. This route translates print into a phonological code via the assembly of sublexical spelling-sound correspondences. Output activates the phonemic buffer and speech. Although lexical and nonlexical routes are assumed to operate simultaneously, they may not necessarily deliver output at the same time. This is because different factors influence their operation. For example, word frequency has an impact on route A but not on route D (e.g., Baluch & Besner, 1991; McCann & Besner, 1987), while number of letters has an impact on route D but not on route A (Weekes, 1997). In the extended, three-route model (see Besner, 1999), an additional lexical-semantic route (route B-C) is added to accommodate the effects of rated word imageability on reading in English (e.g., Strain, Patterson, & Seidenberg, 1995). Rated imageability refers to the ease with which a word arouses an image (e.g., apple is a high imageability word and justice is a low imageability word). Imageability is correlated with word class (i.e., nouns are more imageable than verbs).

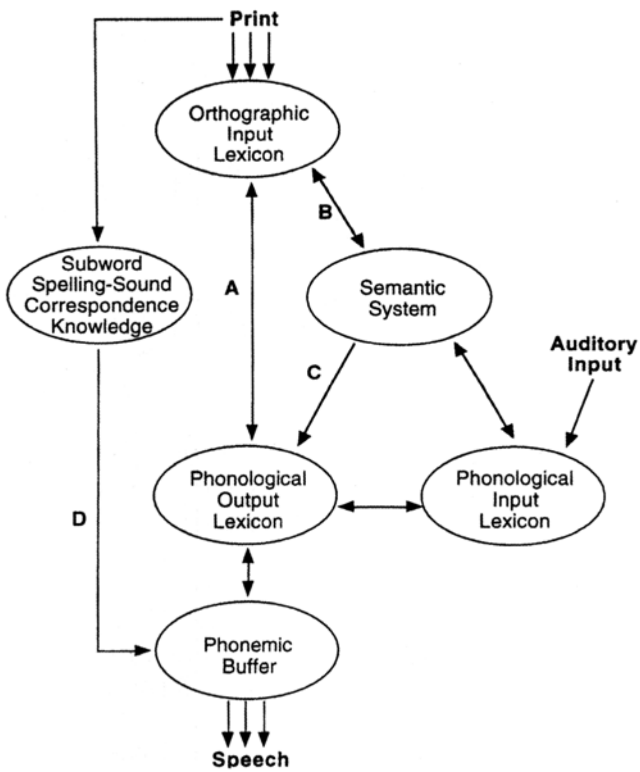

Figure 1: Dual-route model of reading aloud, adapted from Besner (1999).

The DRC model can explain the effects of orthographic transparency (O->P) on reading whereby less predictable words are read more slowly than predictable words (be they irregular or inconsistent). This is because less predictable words generate competing output from the lexical and nonlexical routes whereas predictable words do not. Also, the DRC model can explain different effects of grain size on reading across orthographies (Ziegler, Perry, Jacobs, & Braun, 2001). However, to date, there has been little attempt to apply the DRC model to acquired disorders of reading in languages other than English.

The DRC model can explain all of the acquired reading disorders reported in English. Phonological dyslexia is characterized by poor reading of nonwords and spared ability to read words (e.g., Beauvois & Derouesne, 1979; Warrington & Shallice, 1979). Phonological dyslexia is due to impairment in route D, which fails to generate phonology from novel print (Funnell, 1983) while route A is intact. Deep dyslexia is an acquired reading impairment that involves production of semantic errors and the inability to read nonwords. Patients with deep dyslexia are assumed to have multiple damage including the components of routes A and D, leading to reliance on reading via route B-C (though see Weekes, Coltheart, & Gordon, 1997; Coltheart, 2000 for a different view). In surface dyslexia, reading of irregular words (e.g., yacht) is poor and typically accompanied by regularization errors while reading of nonwords and regular words is preserved (Coltheart, Masterson, Byng, Prior, & Riddoch, 1983; Marshall & Newcombe, 1973). Surface dyslexia results from reliance on route D because one or more parts of the lexical reading system is damaged. Surface dyslexia could result from damage to route A, including damage to the orthographic input lexicon or the phonological output lexicon or damage to route B-C, including the semantic system itself. A related idea is the *summation hypothesis*, which assumes that surface dyslexia is the product of output from a partially preserved semantic route and a partially preserved nonlexical route (Hillis & Caramazza, 1991, 1995).

Surface dyslexia can result from damage at more than one locus according to figure 1 including direct access to the phonological output lexicon from orthographic input, the phonological input lexicon or semantics; impaired semantic system damage; and damage to the phonological output lexicon itself. Weekes and Coltheart (1996) reported patient NW who displayed surface dyslexia, which they showed was the result of damage located at or around the orthographic input lexicon.

Damage to the orthographic lexicon is seen on tests of homophone definition since precise orthographic knowledge is required to perform this type of task. Several other studies report that damage to the semantic system is associated with surface dyslexia (Breedin, Saffran, & Coslett 1994; Graham, Hodges, & Patterson, 1994; Patterson & Hodges, 1992; Patterson, Graham, & Hodges, 1994; Plaut et al., 1996) although some patients with semantic memory problems do not show surface dyslexia (Lambon-Ralph, Ellis, & Sage, 1998). Damage to the semantic system is revealed by poor performance on matching tasks such as word-picture matching tasks and synonym judgment tasks. Watt, Jokel, and Behrmann (1997) argued that damage to the mappings between semantics and phonological output (route C) leads to surface dyslexia although damage to route C does not necessarily lead to surface dyslexia (see Weekes & Robinson, 1997). Deep dysphasic patients who show poor word and nonword repetition performance also display surface dyslexia in reading (Majerus, Lekeu, Van der Linden, & Salmon, 2001; Valdois, Carbonnel, David, Rousset, & Pellat, 1995). Thus damage to the phonological lexicon—as revealed by poor repetition in deep dysphasia—is also associated with surface dyslexia.

Surface dyslexia has most often been reported in languages with opaque, nonalphabetic scripts such as Chinese (Law & Or, 2001; Weekes & Chen, 1999), and Japanese (Patterson, Suzuki, Wydell, & Sasanuma, 1995), but has also been reported in languages with transparent scripts including Dutch (Diesfeldt, 1992), Italian (Miceli & Caramazza, 1993), and Spanish (Cuetos & Labos, 2001; Iribarren, Jarema, & Lecours, 1999). There also are reports of parallels between the impaired lexical reading of brain damaged patients and developmental reading and writing disorders in Italian (Angelelli, Judica, Spinelli, Zoccolotti, & Luzzatti, 2004) and Spanish (see Weekes, 2005). Although Italian and Spanish have relatively predictable O->P mappings and are thus transparent, they are not completely transparent. It is, therefore, of interest to examine reading and writing impairments in languages in which phonology is entirely predictable from orthography.

CHARACTERISTICS OF TURKISH

Turkish is an extreme case of a transparent orthography as it has completely predictable one-to-one mappings between orthography and phonology. Thus, regularity and consistency are not relevant to reading in Turkish. Modern Turkish (Türkçe) belongs to the Turkic languages cluster and is currently the official language of several nations (Turkey, Azarbaijan, Turkmenistan, Uzbekistan, and northern Cyprus). The modern Turkish orthography consists of 29 Roman letters (8 vowels and 21 consonants) and was designed to embody sounds in the spoken language in a totally transparent manner. Each letter in the alphabet directly corresponds to a single phoneme and each phoneme is represented by a single letter. Turkish is, therefore, characterised by total bidirectional transparency in reading (feed-forward) and spelling (feedback). In addition, a high number of vowels allows transparency. There are no silent letters in Turkish. Unlike Italian, stress is not required for monosyllabic and bisyllabic words; and unlike Spanish, stress is always assigned on the penultimate syllable of multisyllabic words. Hence, the salient aspect of Turkish is the computation of nonlexical phonology in an entirely reliable and context independent manner. It thus allows derivation of correct pronunciation from print without any lexical information and is learned with a minimal amount of training. A further remarkable linguistic property of Turkish is its morphology. Languages can be classified into one of three types: isolating or noninflective (e.g., Chinese), agglutinating (e.g., Turkish), and inflecting (e.g., English). The hallmark of agglutinative languages is multisyllabic words composed of linear sequences of morphemes. For example, from the root KAL (meaning stay), KAL-MI-YOR (meaning he or she is not staying), and KAL-MI-YOR-LAR (meaning they are not staying) are typical derivations by adding tense and person suffixes. Thus Turkish orthography is also predictable at the morpheme level with clearly defined syllable boundaries.

We report the oral reading of a biscriptal (Turkish-English) patient (BRB) who has previously been diagnosed with deep dysphasia in Turkish (Raman & Weekes, 2003). Our motivation for testing BRB's oral reading was twofold. First, we wished to know if BRB's reading in English was surface dyslexic. We expected it was, given the evidence from other deep dysphasic patients showing that poor repetition is associated with surface dyslexia (Majerus et al., 2001; Valdois et al., 1995). Second, we wanted to know whether damage to lexical reading would have any impact on oral reading in a transparent script. This was motivated by our assumption that biscriptal reading relies on components in figure 1 that are shared for the two languages (see also Dijkstra & Van Heuven, 1998; Jared & Kroll, 2001). There have been no reports to date of acquired dyslexia in Turkish speakers although according to figure 1, damage to a lexical reading system could result in acquired dyslexia in Turkish.

CASE DESCRIPTION

BRB is a right-handed male who was 67 years of age at the time of testing. Although he is a native speaker of Turkish, BRB's secondary and tertiary education was in English (conducted between the ages of 11 and 21). He is a retired senior civil servant from Cyprus where Turkish is a co-official language. BRB used both languages daily in his working life. Cyprus was a British colony until 1960 and civil servants were highly proficient bilinguals (Turkish-English or Greek-English) in speaking, reading, and writing prior to employment. BRB's premorbid IQ was estimated in the average range based on previous education and work history. BRB was hospitalized in 1999 following an acute CVA to the left parietal-occipital region. BRB's speech was severely reduced after the stroke and he presented with deep dysphasia (i.e., profound repetition impairment in both languages) (Raman & Weekes, 2003). BRB's repetition was severely impaired for words and nonwords, and he had marked short-term auditory-verbal memory problems; for example, he displayed very poor performance on the Digit Span (repeating digits) in Turkish = 1 forward and 1 backward, and English = 1 forward and 1 backward. He produced circumlocutory errors on tests of confrontation naming. BRB's close relatives reported no premorbid difficulties with vision, hearing, or language.

TESTS OF LANGUAGE IMPAIRMENT IN ENGLISH AND TURKISH

We first assessed BRB's language problems in English using the Psycholinguistic Assessment of Language Processing and Aphasia (PALPA) battery (Kay, Lesser, & Coltheart, 1992). Test results are summarized in table I.

BRB completed the written-word picture matching task and the spoken word picture matching test from PALPA with only two errors (no worse than controls), demonstrating that he could recognize objects and that he understood the meaning of printed and spoken words. BRB's auditory lexical decision with high frequency words was also perfect. His knowledge of written synonyms for high imageability words (e.g., start—beginning) was excellent but there was impairment with knowledge of some low imageability words (e.g., detection—discovery).

Table I. Number and percentage correct on PALPA tests for BRB.

Task	Number	% correct
Spoken word-picture matching	38/40	95
Written word-picture matching	38/40	95
Auditory lexical decision	40/40	100
Written synonym judgement		
High imageability	30/30	100
Low imageability	23/30	76
Repetition		
English	26/40	65
Turkish	33/40	82
Speaking picture names		
English	29/40	72
Turkish	32/40	80
Writing picture names		
English	31/40	77
Turkish	33/40	82

BRB's performance on the PALPA homophone definition task revealed that he could comprehend the meaning of print although he often produced the correct definition in Turkish. This is a feature of biscriptal reading reported in other case studies (e.g., Eng & Obler, 2002; Masterson, Coltheart, & Meara, 1985).

Subsequent tests were conducted in English and Turkish (on separate occasions). Word and nonword repetition was poor in both languages suggesting damage to the phonological output lexicon. BRB's performance on the PALPA test of picture naming was poor in both English and Turkish (control subjects made no more than 1 error on this task) and he tended to make semantic intrusion errors (e.g., thumb *başparmak* as finger *parmak*) although phonological errors were also observed (e.g., rabbit—raffit). His writing of picture names was impaired in both languages.

BRB's performance can be summarized with reference to figure 1. There is evidence that BRB is able to understand spoken words, suggesting the phonological input lexicon is intact; he can define printed homophones, suggesting the orthographic input lexicon is intact; and he knows word meanings, so the semantic system is intact. However, BRB is unable to repeat words and name pictures, suggesting damage to the phonological output lexicon or connections to this system (route C). Thus, according to our reasoning above about deep dysphasic patients, BRB might show surface dyslexia in English.

EXPERIMENTAL INVESTIGATIONS

Our first hypothesis was that impaired access to the phonological output lexicon (route C) would result in surface dyslexia. If BRB's lexical reading system is impaired, then effects of predictability on reading should be observed but nonword reading should be intact (via route D). It is not possible to test for effects of predictability on reading in a transparent script (Coltheart, 1984). However, in order to test lexical reading in Turkish, we devised tests that we assumed involved at least some lexical knowledge. Our second hypothesis was that BRB's impairments might lead to an effect of imageability on reading in Turkish. We tested for effects of imageability on reading since it is universally assumed that imageability effects reflect reading via the lexical-semantic system (route B-C). We also tested for effects of word class (nouns versus verbs and verbal nouns) on reading since patients who produce semantic errors—and hence rely on lexical-semantic reading—show effects of word class on reading (Coltheart, 1980a, 1980b). Finally, we predicted that impaired lexical reading in Turkish would cause BRB to have difficulty translating Turkish print into English spoken words, a task we assumed is performed via lexical knowledge (cf., Jared & Kroll, 2001; Kroll & Stewart, 1994).

TESTS OF READING

We tested the first hypothesis by examining BRB's reading of 40 consistent and 40 inconsistent English words using items from Monaghan and Ellis (2002) matched for word frequency, length, neighborhood size, and age of acquisition (AoA), and reading of irregular words and nonwords taken from the PALPA battery. Results are summarized in table II. There was an effect of consistency on BRB's reading with consistent words read better than inconsistent words (note some items are abstract words such as death) $t(39) = 9.2$, $p < .01$]. Irregular words from the PALPA were read poorly and nonwords read perfectly.

We tested the second hypothesis by examining BRB's reading of words rated high and low in imageability. We used four sets of experimental trials, 20 in each condition, matched on initial letter, number of syllables, and number of letters. Statistics for each set are reported in Appendix A. Note that low values

Table II. Number and percentage correct on tests of reading in English for BRB.

Task	Number	% correct
Consistent words (written words with consistent OP mappings [e.g., drill])	31/40	77
Inconsistent words (written words with inconsistent OP mappings [e.g., dough])	19/40	47
Irregular words taken from PALPA	17/40	42
Nonwords taken from PALPA	40/40	100

indicate low frequency but are rated high imageability. Word imageability and word frequency norms were from Raman and Baluch (2001). The following are examples of four types of stimuli: high imageability–high frequency (YATAK *bed*); high imageability–low frequency (YOKUŞ *uphill*); low imageability –high frequency (YEMİN *vow*); and low imageability–low frequency (YORUM *interpretation*). BRB was asked to read each word from the experimental list printed in Arial typeface, size 14. Stimuli and data are presented in table III. There was a reliable effect of Imageability X^2 (1) = 3.8, $p < 0.05$. Errors were phoneme substitutions (e.g., in balkon *balcony* - l was substituted with r leading to barkon).

BRB shows the classic dissociation of poor reading of unpredictable words with intact nonword reading that is the hallmark of surface dyslexia in English, and there is evidence that he is reading via the lexical-semantic reading pathway (route B-C) in Turkish. Thus, although the lexical reading pathway is used for reading in Turkish, he is surface dyslexic.

TESTS OF WORD CLASS ON READING

Test results are summarized in table IV. We presented 34 nouns, 34 verbs, and 34 verbal (derived) nouns for oral reading in Turkish. Given the results from Experiment 2, stimuli were matched for rated word imageability. There was no significant effect of word class on performance (F<1). This suggests that morphological complexity has little impact on BRB's oral reading.

READING TRANSLATION

Our observation that BRB spontaneously defined irregular and inconsistent words in English (e.g., break, colonel, bear, heir, suite, prophet) from the PALPA by producing phonological out-

Table III. Number and percentage correct on tests of reading words and nonwords in Turkish for BRB in Experiment 1 (note errors are in bold; nw = nonword; phoneme substitutions are in bold and denoted).

High Frequency–High Imageability	Low Frequency–High Imageability	High Frequency–Low Imageability	Low Frequency–Low Imageability	Nonwords	
anne	ayran	artık	ablak	alıf	apuk
ateş	arpa	ayıp	ayar	ab	aj
bardak	**balkon 1=r**	bencil	bellek	aruy	apran
bahçe	baston	**biçim nw**	**buhran nw**	bıkaf	botkan
çiçek	çilek	çözüm	**çığır nw**	banım	berzik
dünya	düğme	**duygu nw**	doyum	cava	cuto
göz	gaz	gizli	göç	çiren	çifre
güneş	gitar	güç	gönül	dopul	deset
insan	incir	inat	ilim	eknez	**evsol s=z**
kan	kaygan	**kayıt nw**	kavram	fıran	fazur
kardeş	kukla	kibar	kısır	gep	gaj
kilit	kumar	lisan	Iasan	gıcar	genzit
kitap	küp	**mantık nw**	menzil	hosu	hesel
mavi	maske	onur	**oruç nw**	inser	ircin
para	peçe	önlem	**ölçek nw**	kof	kenyip
saç	saz	sanat	sürgün	kitel	küç
sigara	sevinç	tarih	**tekel nw**	meyu	**merki m=k**
tava	tepe	**tasa nw**	**töre nw**	pese	pepi
tarak	türbe	**yalan nw**	yazgı	sef	süp
yatak t=r	yokuş	yemin	yorum	teley	tapul
Correct					Correct
19/20 (95%)	19/20 (95%)	14/20 (70%)	14/20 (70%)		38/40 (95%)

Table IV. Number and percentage correct on tests of reading nouns, verbs and derived nouns for BRB in Turkish (Note errors are in bold).

Nouns	Verbs	Derived Nouns
aday	**asmak**	asma
anne	açmak	açma
ağaç	akmak	akma
ateş	atmak	atma
ayakkabı	aldatmak	aldatma
ayna	anmak	anma
bahçe	biçmek	**biçme**
balık	bölmek	bölme
balkon	basmak	basma
bardak	bilmek	bilme
bebek	boğmak	boğma
çocuk	çarpmak	çarpma
çiçek	çizmek	çizme
defter	**dövmek**	dövme
deniz	dolmak	dolma
doktor	delmek	delme
dünya	**doğmak**	doğma
ekmek	ezmek	ezme
erkek	eşmek	eşme
gazete	geçmek	geçme
gece	gezmek	gezme
giysi	gitmek	gitme
güneş	**gülmek**	gülme
haber	haşlamak	haşlama
insan	inmek	inme
kitap	kırmak	kırma
kardeş	kazmak	kazma
okul	olmak	olma
para	parlamak	parlama
sabah	satmak	satma
sigara	sermek	serme
tarak	tatmak	tatma
toplum	taşmak	taşma
yatak	yakmak	yakma
Correct 33/34 (97%)	30/34 (88%)	33/34 (97%)

put in Turkish, suggested that the lexical reading routes may be shared by the two languages supporting "visual translation" of print in one language to phonological output in another. It has been known for some time that biscriptal readers can produce oral reading responses in the nontarget language (e.g., Masterson et al., 1985). However, the results may apply to concrete nouns only. Therefore, we wanted to know if there was an effect of word class on visual translation performance for BRB.

Test results are summarized in tables Va and Vb. We presented the printed words described in Section 2 (hence the words were matched for rated imageability and word frequency), and asked BRB to read them aloud in English. He was better at translating nouns (31/34, 91%) than verbs (18/34, 53%), and could not translate verbal nouns at all (0/34, 0%). The most common error was semantic (e.g., ateş fire was translated to burn; tarak comb to brush; biçmek reap to harvest), suggesting that he translated printed Turkish words via the lexical-semantic reading route (route B-C).

BRB's poor performance with verbal nouns is not due to imageability nor to phonological complexity as verbal nouns were often shorter than verbs. His performance could be either due to difficulties processing polysemous words, which have an effect on word recognition (Hino & Lupker, 1996), or to a morphological effect as the morphological structure of verbal nouns in Turkish is quite complex. We favor the latter possibility as his performance was poor with nearly identical words (i.e., verbs and verbal nouns) that were, nevertheless, more complex in morphology when presented as derived forms.

DISCUSSION

BRB is the first reported case of acquired dyslexia in Turkish. Although BRB's reading of many Turkish words was preserved, he was unable to read some low imageability words including words that were high in frequency. This pattern of reading impairment shows that dyslexia can be observed in a transparent orthography, Morever, BRB's preserved nonword reading shows dyslexia in Turkish can be selective (i.e., the nonlexical route can remain intact if lexical reading becomes impaired). BRB's pattern of acquired dyslexia in Turkish is reminiscent of surface dyslexia in Italian and Spanish, which is attributed to loss of lexical knowledge (e.g., Iribarren et al., 1999; Miceli & Caramazza, 1993). We believe that the effect of imageability on

Table Va: Number and percentage correct on tests of translating nouns and verbs for BRB from Turkish to English in Experiment 3 (Note errors are in bold; nw = nonword; sem = semantic error and nr = no response).

Nouns	Visual Translation	Verbs	Visual Translation
aday	candidate	asmak	hang
anne	mother	açmak	open
ağaç	tree	akmak *flow*	**current sem**
ateş *fire*	**burn sem**	atmak	throw
ayakkabı	shoe	aldatmak *cheat*	**lie sem**
ayna	mirror	anmak	remember
bahçe	garden	biçmek *reap*	**harvest sem**
balık	fish	bölmek	separate
balkon	balcony	basmak	press
bardak *glass*	glass	bilmek	know
bebek	baby	boğmak *suffocate*	**choke sem**
çocuk	child	çarpmak	multiply
çiçek	flower	çizmek *draw*	**line sem**
defter *excercise book*	copybook	dövmek	beat
deniz	sea	dolmak *fill*	nr
doktor	doctor	delmek *pierce, drill*	**hole sem**
dünya	globe	doğmak *born*	**create sem**
ekmek	bread	ezmek	crush
erkek	male	eşmek *light digging*	**equal**
gazete	gazette	geçmek	pass
gece	night	gezmek *stoll*	**picnic sem**
giysi	clothes	gitmek	go
güneş	sun	gülmek *laugh*	**smile sem**
haber *news*	**new**	haşlamak *boil*	nr
insan	human	inmek *climb down*	**inside**
kitap	book	kırmak *break*	break
kardeş	brother	kazmak *dig*	**dug (past tense)**
okul	school	olmak	be
para	money	parlamak *shine*	shine
sabah *morning*	morning	satmak *sell*	**sale sem**
sigara	cigarette	sermek *spread*	nr
tarak *comb*	**brush sem**	tatmak	taste
toplum *community*	people	taşmak	carry
yatak	bed	yakmak	burn
	31/34 (91%)		18/34 (53%)

Table Vb: Number and percentage correct on tests of translating derived nouns for BRB from Turkish to English in Experiment 3. (Note errors are in bold; nw = nonword; sem = semantic error and nr = no response).

Derived Nouns	Visual Translation
asma *vine, suspension*	**grape sem**
açma *opening*	**open sem**
akma *flowing*	**current sem/spell.**
atma *throwing*	**Throw sem**
aldatma *adultery*	**lie sem**
anma *memorial*	**memory/remember sem**
biçme *reaping*	**scorriah nw**
bölme *division*	**separate sem**
basma *printed cloth*	nr
bilme *knowing*	**know sem**
boğma *suffocating*	**choke sem**
çarpma *multiplication*	**multiply sem**
çizme *drawing, boots*	**line sem**
dövme *beating, tatoo*	**beat sem**
dolma *filling, dolmades*	nr
delme *piercing*	nr
doğma *birth*	nr
ezme *crushed food*	**crush sem**
eşme *digging*	**equal phono**
geçme *passage, passing*	**pass sem**
gezme *stoll*	**picnic sem**
gitme *going*	**go sem**
gülme *laugh*	**smile sem**
haşlama *boiled*	**inside**
inme *climbing down*	nr
kırma *pleat, breaking*	**break sem**
kazma *digging, hoe*	**dug sem**
olma *being*	**be sem**
parlama *shining*	**shine sem**
satma *sale*	**buy sem**
serme, *hanging on line*	nr
tatma *tasting*	**taste sem**
taşma *overflow*	**carry sem**
yakma *burning*	**burn sem**
	0/34 (0%)

BRB's reading in Turkish is the result of damage to the lexical-semantic reading route (route B-C) in figure 1.

The data from BRB make a contribution to understanding dyslexia in Turkish. BRB's dyslexia in Turkish was observed in the context of deep dysphasia. BRB's poor repetition and confrontation naming suggest damage to phonological representations. A correlation between poor repetition and lexical reading impairments has been reported for French speaking deep dysphasic patients (Majerus et al., 2001; Valdois et al., 1995). Raman and Weekes (2003) argued BRB's repetition and naming disorders were the result of abnormally rapid decay of activation in the phonological word form system as in the computational model of Martin, Saffran, and Dell (1996). BRB's results show that phonological damage is correlated with acquired dyslexia in Turkish. One inference is that the poor repetition observed in some children with dyslexia may also be observed in Turkish speakers. Also, repetition problems may be associated with poor reading of low imageability words in particular. We also noted that late acquired words tend to be less imageable when compared to early acquired words.

The association between BRB's phonological impairments and his reading can be explained by the *lexicalization hypothesis* proposed by Newton and Barry (1997). They argued that imageability effects on reading result from "lexicalization," which describes how a semantic representation selects the appropriate word (lexeme) in the phonological output lexicon for production. Semantic representations drive word production according to concreteness, which is correlated with the rated imageability of a word. The normal lexicalization process is sensitive to imageability (i.e., high imageable, concrete concepts are easier to lexicalize than low imageability, abstract concepts). Concrete concepts have a high degree of specificity in lexicalization so that high imageability printed words activate only a few related concepts. Therefore, high imageability words will easily and uniquely access their corresponding lexemes. The semantic representations of abstract concepts have less specificity and there is more spreading activation to related concepts. Therefore, it will be more difficult to access the corresponding lexeme. According to Newton and Barry (1997), these processes would not necessarily be revealed in skilled reading. However, an effect of imageability may be revealed after brain damage and in reading under speeded naming conditions (Strain et al., 1995).

Our interpretation of imageability effects on BRB's oral reading is controversial. An effect of imageability is typically thought to reflect a semantic deficit for abstract words and to be a signature of deep dyslexia. BRB has no semantic deficit that we could detect and he does not exhibit deep dyslexia (he reads nonwords well). We believe that an effect of imageability on oral reading in Turkish can be observed without a semantic impairment if route C alone is damaged or phonological activation is poor. Note that Watt et al. (1997) offered a similar account of poor reading of abstract, irregular words in surface dyslexia in English.

BRB is the first reported case of a biscriptal reader with acquired reading impairments in English and Turkish. The data from BRB make a contribution to understanding acquired dyslexia in biscriptal readers. We assumed that the same architecture is available for oral reading Turkish and English. However, the lexical route (route A) is not necessary for reading in Turkish. We also assume one potential locus for BRB's surface dyslexia is the lexical-semantic reading route (route B-C). Thus, a damaged lexical-semantic reading route may be sufficient to explain BRB's surface dyslexia in English as well as impaired reading in Turkish. This would be the most parsimonious account since a common locus of damage can lead to surface dyslexia and imageability effects in Turkish. This may be a consequence of abnormally rapid decay of lexemes in the phonological output lexicon. If our view is correct, it should be possible to find a biscriptal Turkish-English speaker who has deep dyslexia in Turkish but retains the ability to read irregular words in English. This point illustrates the value of cognitive neuropsychological studies of patients with acquired dyslexia as novel predictions can be generated on the basis of each new patient.

It is possible, however, that BRB's surface dyslexia in English results from damage to the lexical route alone. Indeed, according to Coltheart et al. (2001), surface dyslexia is independent of damage to the semantic system. Damage to the lexical reading route is best measured with tests of orthographic knowledge. This part of our assessment of BRB was weak. We found some evidence of orthographic damage on a homophone definition task though he did produce correct spoken words (in Turkish). What the results do show is that semantic support from reading via the lexical-semantic pathway is not sufficient to support reading of unpredictable words in English, at least in a biscriptal reader. Thus, we would not exclude the possibility that BRB's surface dyslexia results from damage to the lexical route alone, nor would we deny the need for a lexical route to read in English.

The extent to which models of reading can be applied to reading in other writing systems is now debated (Beland & Mimouni, 2001; Eng & Obler, 2002; Perry & Ziegler, 2000; Yin & Weekes, 2003; Ziegler et al., 2001). The strength of any model depends on its ability to explain a range of phenomena including biscriptal reading. This is important for theoretical as well as practical reasons (e.g., the design of specialized tests of reading and writing problems in biscriptal readers and the rehabilitation of reading impairments). Reading in scripts that have an unpredictable orthography such as English encourages the development of a lexical route. However, reading in transparent scripts such as Turkish may not require the development of such a route. The key evidence for a lexical route in English comes from patients who can read irregular words but who cannot access their meaning (e.g., Franklin, Turner, Lambon-Ralph, & Morris, 1996; Lambon-Ralph, Ellis, & Sage, 1998; Schwartz, Marin, & Saffran, 1979; Shallice, Warrington, & McCarthy, 1983). It is impossible to find this type of patient in Turkish. However, it may be possible to find a patient who reads Turkish words but does not know their meaning. If the same patient cannot read nonwords, this would be evidence for a lexical route in Turkish. Thus, the need for separate lexical and lexical-semantic routes for reading in Turkish is moot. This issue was discussed in relation to developing strategies in attentional control in reading Turkish, and regular versus irregular orthographies (Raman, Baluch, & Besner, 2004).

Yin and Weekes (2003) made a similar case to ours about oral reading in Chinese, which is a relatively opaque script. The claim made by them was the converse of the one made here (i.e., reading cannot be nonlexical in Chinese because each of the components of a character is lexical and thus a nonlexical route [route D] is unnecessary) (see also Coltheart, 1984). Note that the question of whether a lexical route (route A) is necessary for reading in English is still a matter for debate (cf., Hillis & Caramazza, 1991, 1995).

What is the relevance of BRB's data to understanding the impact of type of script on dyslexia? We know already that culture has an effect on reading disability. Paulesu and colleagues (2001) found that Italian dyslexics read more accurately than English and French dyslexics, although all groups read slowly and had phonological impairments, suggesting that orthographic transparency has an effect on the phenotype of dyslexia in different languages. In a study of Chinese dyslexia, Siok, Perfetti, Jin, and Tan (2004) found that script affects the neurobiological abnormality leading to impaired reading. BRB shows that dyslexia is possible in a completely transparent orthography. This is of interest because it seems counterintuitive (i.e., literate speakers learn such scripts quickly).

We also found evidence of morphological constraints on translation, suggesting that damage to the lexical reading system may manifest itself differently according to the morphological complexity of the language. Morphological effects may be restricted to translation tasks resulting from weak lexicalization of the lexemes in a second language for morphologically dense words. However, it may be fruitful to examine morphological effects on dyslexia in Turkish. Children with dyslexia are known to have more difficulties writing the regular (-ed) than the irregular past tense of verbs in English (Egan & Pring, 2004; Leong & Parkinson, 1995). Turkish is a highly inflected language with many morphologically complex words that do not have a single, addressable lexeme, but are assembled on the basis of inflections (Durgunoğlu, 2002). Given that we found a link between phonological impairment and dyslexia, one suggestion for future research is to investigate morphological processing in children and adults with reading and writing difficulties. This phenomenon also could be explored in other cases of acquired reading and writing impairments in Turkish.

CONCLUSION

BRB's data suggest that lexical reading problems in Turkish follow phonological impairments. Thus the naïve view that developmental dyslexia does not exist in Turkish can be rejected. What relevance does the data from a single case study have to our understanding of developmental dyslexia in Turkish? The transparent O->P mappings in Turkish may enhance the acquisition of literacy compared to English (e.g., Öney & Durgunoğlu, 1997). However, this does not preclude difficulties learning to read and write. Developmental dyslexia in Turkish deserves further investigation given the data obtained from BRB.

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Address correspondence to: Brendan S. Weekes, Department of Psychology, University of Sussex, Brighton, East Sussex, BN1 9QN, UK. E-mail: bsw@biols.susx.ac.uk

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APPENDIX A

Imageability and frequency norms of the Turkish words used in Experiment 1, and their corresponding translations in English.

HFHI	Translation in English	Imageability	Frequency	LFHI	Translation in English	Imageability	Frequency
anne	mother	1.12	1.54	ayran	yoghurt drink	2.46	4.84
ateş	fire	1.48	2.60	arpa	barley	1.70	5.28
bardak	glass	1.88	1.76	balkon	balcony	2.00	3.74
bahçe	garden	1.70	2.26	baston	walking stick	1.60	4.56
çiçek	flower	1.44	1.26	çilek	strawberry	2.40	3.90
dünya	earth	1.29	1.72	düğme	button	2.35	3.84
göz	eye	1.50	1.54	gaz	gas	1.98	3.99
güneş	sun	1.38	1.64	gitar	guitar	1.24	3.76
insan	human	1.33	1.32	incir	fig	2.00	4.22
kan	blood	1.56	1.28	kaygan	slippery	2.56	3.53
kardeş	brother	1.44	1.54	kukla	puppet	2.34	4.38
kilit	lock	2.35	2.58	kumar	gamble	2.14	3.64
kitap	book	1.35	1.52	küp	water butt	1.47	4.06
mavi	blue	2.25	1.62	maske	mask	1.50	4.22
para	money	1.42	1.32	peçe	veil	2.46	5.44
saç	hair	1.92	1.32	saz	musical inst.	2.22	4.30
sigara	cigarette	1.68	2.20	sevinç	joy	1.78	2.60
tava	frying pan	2.49	3.04	tepe	hill	2.38	3.04
tarak	comb	2.04	1.96	türbe	monument	2.44	4.76
yatak	bed	1.92	1.51	yokuş	uphill	1.80	3.80
		Mean = 1.67	Mean = 1.77			Mean = 2.04	Mean = 4.09
		SD = .38	SD = .51			SD = .39	SD = .68

HFLI	Translation in English	Imageability	Frequency	LFLI	Translation in English	Imageability	Frequency
artık	leftover	4.74	2.56	ablak	dull person	4.78	6.29
ayıp	shame	4.90	1.89	ayar	timing	4.73	3.50
bencil	selfish	4.60	2.60	bellek	memory	4.59	4.29
biçim	shape	4.37	3.16	buhran	depression	3.70	5.51
çözüm	solution	5.00	2.14	çığır	era	3.20	5.00
duygu	emotion	5.71	1.60	doyum	content	4.44	3.90
gizli	secret	5.40	2.12	göç	migration	4.92	2.03
güç	power/difficult	4.98	2.02	gönül	heart/mind	4.35	3.50
inat	stubborn	5.24	1.96	ilim	science	4.16	3.63
kayıt	register	4.19	2.88	kavram	concept	3.98	4.32
kibar	polite	5.06	2.22	kısır	infertile	4.95	4.30
lisan	language	4.93	2.79	lasan	seedling	3.90	6.23
mantık	logic	5.13	1.88	menzil	firing range	4.72	5.04
onur	honor	5.88	2.53	oruç	fasting	4.84	3.64
önlem	prevention	4.58	1.76	ölçek	scale	4.32	3.92
sanat	art	5.94	2.22	sürgün	exile	4.52	4.49
tarih	history	5.14	2.14	tekel	monopoly	5.09	4.10
tasa	anxiety	5.77	1.90	töre	custom	4.31	3.94
yalan	lie	5.20	2.04	yazgı	destiny	6.42	4.65
yemin	vow	5.21	2.20	yorum	interpretation	4.78	3.87
		Mean = 5.09 SD = .48	Mean = 2.23 SD = .40			Mean = 4.53 SD = .64	Mean = 4.31 SD = .98