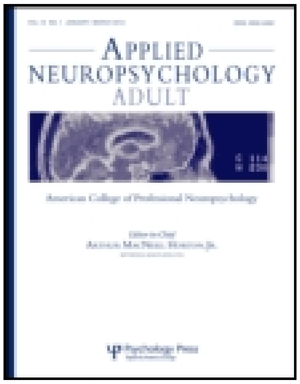

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Cognate Effects and Executive Control in a Patient with Differential Bilingual Aphasia

Nele Verreyt [a], Miet De Letter [b], Dimitri Hemelsoet [c], Patrick Santens [c] & Wouter Duyck [a]

[a] Department of Experimental Psychology, Ghent University, Ghent, Belgium

[b] Department of Oto-Rhino-Laryngology & Logopaedic and Audiologic Sciences, Ghent University, Ghent, Belgium

[c] Department of Neurology, Ghent University Hospital, Ghent, Belgium

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CASE STUDY

Cognate Effects and Executive Control in a Patient with Differential Bilingual Aphasia

Nele Verreyt
Department of Experimental Psychology, Ghent University, Ghent, Belgium

Miet De Letter
Department of Oto-Rhino-Laryngology & Logopaedic and Audiologic Sciences, Ghent University, Ghent, Belgium

Dimitri Hemelsoet and Patrick Santens
Department of Neurology, Ghent University Hospital, Ghent, Belgium

Wouter Duyck
Department of Experimental Psychology, Ghent University, Ghent, Belgium

We describe a case study of a French–Dutch bilingual patient with differential aphasia, showing clearly larger impairments in Dutch than in French. We investigated whether this differential impairment in both languages was due to selective damage to language-specific brain areas resulting in the ''loss'' of the language representation itself, or rather if it reflects an executive control deficit. We assessed cross-linguistic interactions (involving lexical activation in the most affected language) with cognates in a lexical decision (LD) task, and executive control using a flanker task. We used a *generalized* LD task (any word requires a ''yes'' response) and a *selective* LD task in the patient's two languages (only words in a given target language require a ''yes'' response). The cognate data unveil a differential pattern in the three tasks, with a clear cognate facilitation effect in the generalized LD tasks and almost no cognate effect in the selective LD tasks. This implies that a more impaired language can still affect the processing of words in the best-preserved language, but only with low cross-language competition demands (generalized LD). Additionally, the flanker task showed a larger congruency effect for the patient compared with controls, indicating cognitive control difficulties. Together, these results support accounts of differential bilingual aphasia in terms of language-control difficulties.

Key words: *aphasia, behavioral neuropsychology, bilingualism, cognates, cognition, control, differential aphasia, psycholinguistics*

INTRODUCTION

During the last decade, bilingualism has gained interest in the psycholinguistic literature. The fact that this interest developed only recently is surprising, given that

Address correspondence to Nele Verreyt, Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, B-9000 Ghent, Belgium. E-mail: nele.verreyt@ugent.be

it is estimated that more than half of the world population is now bilingual. In this literature, bilinguals are typically individuals who regularly use two languages (Adrover-Roig et al., 2011; Goral, Levy, Obler, & Cohen, 2006; Ibrahim, 2009; Kurland & Falcon, 2011) but are not necessarily equally proficient in both. An important discussion that has dominated this literature is whether bilinguals have an integrated lexicon (and hence, one neural structure representing both languages) or two separated lexicons, one for each language. In other words, is there always activation in both languages during word recognition, even when only a single language is relevant at that time, or not? During recent years, behavioral evidence has accumulated supporting language-nonselective lexical access: Even in unilingual language contexts, words from both languages are activated, and the lexical representations of these different-language words constantly and automatically interact with each other.

An important line of research supporting this hypothesis concerns studies looking at the recognition of cognates. Cognates are words that have the same meaning and a similar orthography/phonology in both languages (e.g., the Dutch–English word pairs *film–film* [identical] or *boek–book* [nonidentical]). Several studies have shown that cognates are recognized faster than noncognates (Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Van Hell & Dijkstra, 2002). This is called the *cognate facilitation effect*. Surprisingly, such a cognate effect even emerges when people are reading unilingual sentences in their native language. Using eye tracking, it was shown that Dutch–English bilinguals showed shorter fixations for Dutch–English cognates, even though they only read Dutch sentences and did not know that English was relevant for the experiment (Van Assche, Duyck, Hartsuiker, & Diependaele, 2009). These cognate effects are generally considered a reliable marker for language-nonselective lexical activation and are commonly explained by convergent activation spreading from the cognate's similar semantic, orthographic, and phonological representations across languages. Noncognate translation equivalents only share a semantic representation, do not benefit from facilitatory convergation spreading, and therefore are recognized slower. This cognate facilitation effect demonstrated that word processing in one language is affected by other languages, supporting the idea of interacting lexicons and an integrated bilingual language system.

In the current study, we investigated the cognate facilitation effect, as the most commonly investigated marker of cross-lingual lexical interactions, in a patient with bilingual aphasia. Aphasia is defined as a general impairment in understanding, formulating, or using verbal messages, in spoken and/or written modality, caused by brain dysfunction to a language-related area. The main cause of aphasia is a stroke, but a tumor, an infection, or degenerative brain diseases can also lead to aphasia.

Interestingly, aphasia in bilinguals does not always affect both languages to the same extent. For functional/psycholinguistic theories of bilingual lexical access, this is interesting. If the two languages of a bilingual are represented in a unitary system, as suggested by the behavioral work discussed earlier, one would expect that both languages rely on the same neural structure. Therefore, one would also expect that damage to that neural structure (aphasia) causes similar functionality loss across both (all) languages represented in that structure. However, in the neuropsychology clinic, it is still a (surprising) fact that some patients still show larger deficiencies in one language than in the other. In addition, language recovery does also not benefit both languages equally. Paradis (2004) described six different ways in which bilingual aphasia recovery may occur. When recovery occurs similarly in both languages (the most frequent case) it is diagnosed as *parallel* recovery (Marangolo, Rizzi, Peran, Piras, & Sabatini, 2009). When this is not the case and improvement is more pronounced in one language compared with the other, the diagnosis is *differential* recovery. Strikingly, it is not always Language 1 (L1; i.e., the native language) that recovers best, as was reported by some authors (Goral et al., 2006; Meinzer, Obleser, Flaisch, Eulitz, & Rockstroh, 2007). Aglioti and Fabbro (1993), for instance, described a patient with better recovery in the weakest language (i.e., L2, the second language). An extreme case of differential recovery is when one language does not recover at all, in which case we speak of *selective* recovery. *Successive* recovery is when one language only starts to recover when the other has fully recovered. The fifth recovery pattern described by Paradis is when there is an alternation in recovery: One language starts to recover and then weaken again when the other becomes stronger. This is called *antagonistic* recovery. Some bilingual patients with aphasia uncontrollably switch and mix their languages; in this case, we can speak of *blended* recovery (Adrover-Roig et al., 2011; Fabbro, Skrap, & Aglioti, 2000; Leemann, Laganaro, Schwitter, & Schnider, 2007; Marien, Abutalebi, Engelborghs, & De Deyn, 2005; Riccardi, Fabbro, & Obler, 2004).

In addition to the *recovery* patterns described by Paradis (2004), similar descriptions may also be used to describe the pattern of *impairment* in both languages. For example, a patient with more serious impairments in one language compared with the other is diagnosed with *differential* aphasia (Adrover-Roig et al., 2011; Aglioti, Beltramello, Girardi, & Fabbro, 1996; Goral et al., 2006; Vajramani, Akrawi, McCarthy, & Gray, 2008), irrespective of the way both languages recover.

When only one language is affected, with no apparent impairments in the other, this is called selective aphasia (Ibrahim, 2009). In theory, a patient with differential aphasia (i.e., both languages are damaged to a different extent) might show parallel recovery (both languages recover equally fast), although this distinction is virtually never made in case studies.

Because the first cases of differential and selective aphasia were identified in the neuropsychological literature when the psycholinguistic literature on bilingualism had not yet developed and reports of cross-lingual lexical interactions did not exist, such aphasias were explained by asymmetrical neural damage: Because both languages were assumed to be represented in distinct brain areas, a lesion in the language-specific area would then lead to impairments in that particular language, without affecting the other language.

However, as stated earlier, much evidence has now been found against the idea of language-specific brain areas. Both of a bilingual's languages do not only interact functionally (e.g., cognate effects in the behavioral literature), but it has also been confirmed that languages overlap with respect to their neural representation. For instance, Klein and colleagues found largely overlapping brain areas for English and French (Klein, Zatorre, Milner, Meyer, & Evans, 1994) and for English and Chinese (Klein, Milner, Zatorre, Zhao, & Nikelski, 1999) during word-production tasks. In addition, Hernandez and colleagues found no difference in the brain activation pattern between picture naming in Spanish and in English (Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001). Vingerhoets and colleagues (2003) found that fluency tasks, picture naming, and word generation engaged largely the same cerebral areas in Dutch, French, and English. From this, Green (2005) developed the convergence hypothesis: When learning a second language, the processing of this language will rely on the same neural network and control circuits that are involved in L1 processing.

At first, it seems hard to reconcile these behavioral and neurological demonstrations and models of overlapping/interacting languages (one unitary language system) with the mere existence of differential/selective aphasia. How can a stroke affect only one language if the languages are largely represented in the same areas? Interestingly, Pitres hypothesized already in 1895 that a control deficit might be the cause of selective and differential loss in bilingual aphasia. Pitres stated that every language could be independently inhibited, temporarily or permanently. Therefore, he stated that bilingual aphasia would not be the result of a lesion in the neural substrate of a language, but rather the result of a functional inhibition of the language (Pitres). In other words, he alludes to a problem in language control (i.e., in the selection of [words in] the intended language, and the inhibition of [words in] nonattended languages). Regrettably, his interesting hypothesis was never empirically tested. More recently, however, Abutalebi and Green (2007) revitalized this idea, describing a neural network for cognitive control and language control, which consists of the prefrontal cortex, the anterior cingulate cortex, the inferior parietal cortex, and the basal ganglia. Damage to the components of this network might lead to the language-control deficits underlying bilingual aphasia. Hence, in this view, selective language loss is not due to the damage of the language representations itself, but rather to the cognitive control mechanisms necessary to handle these competing languages.

If this control hypothesis is correct and the lexical representations themselves are indeed intact, patients with bilingual aphasia could indeed show effects of a language that is heavily damaged onto the processing of another language, even though that language in itself is not very functional. A weak test of this hypothesis has already been reported in *some* bilingual aphasic patients with *parallel* aphasia. For instance, Roberts and Deslauriers (1999) found that bilingual aphasic patients with parallel aphasia were able to name more pictures of cognates than of noncognates, in both languages. Similarly, Detry, Pillon, and de Partz (2005) administered a picture–word verification task and a naming task with cognates and noncognates in a patient with French–English parallel aphasia with agrammatism and word-finding difficulties. In both tasks, the patient's performance was higher for the cognates compared with the noncognates. So, even though functionality of the languages in these patients was severely impaired, these languages were still able to influence processing/activity in another language.

In addition, two studies have investigated the role of cognates in aphasia *treatment* in patients with parallel aphasia. Kohnert (2004) treated a Spanish–English bilingual patient with severe transcortical motor aphasia, with a parallel impairment in both languages. It was observed that therapy effects generalized across languages to untrained items, but only for cognates. A more recent study (Kurland & Falcon, 2011) studied a similar hypothesis in a Spanish–English bilingual patient with severe expressive aphasia in both languages. Surprisingly, this study revealed detrimental, rather than facilitatory, effects of cognate status in aphasia treatment. Although the reason for this inconsistency is unclear, at least this finding also indicates cross-lingual interactions and confirms that functionally affected languages may still influence processing in another language.

Although these cognate effects in patients with parallel aphasia are very interesting, a more challenging test for the control hypothesis of Pitres (1895) is of course the existence of cross-lingual interactions in patients who show *differential* (or selective) aphasia. Is a language that is more affected than the other still able to influence the best-preserved language? To the best of our knowledge, only one study has yet investigated cognate effects in differential aphasia, about 10 years ago. Lalor and Kirsner (2001) described a balanced English–Italian bilingual patient with aphasia who showed larger impairments in Italian (L2) compared with English (L1) on expressive-language tasks. They assessed naming in both languages and found a cognate effect. More importantly for the current study is that they also administered a generalized lexical decision (LD) task (both Italian and English words require a "yes" response, nonwords require a "no" response). They found no differences in reaction times (RTs) between cognates and noncognates, as patients with aphasia typically yield highly variable LD RTs. However, the patient showed fewer errors with cognates compared with noncognates. Although this is an interesting finding in relation to the control hypothesis discussed earlier, Lalor and Kirsner did not interpret this effect as such, nor did they assess cognitive control performance of this patient.

AIMS AND METHODS

The aim of the current study was twofold. First, we aimed to gain a more profound insight into how cognates are processed in bilingual aphasia with *differential* language loss, as a marker of cross-lingual interactions. More specifically we aimed to investigate the cognate facilitation effect in relation to language-control demands in a French–Dutch bilingual patient with differential aphasia, with a larger impairment in L2 (Dutch). We report the data of three different LD tasks, each yielding different language-control demands, with cognates as the critical stimuli. We administered a generalized LD task ("Is it an existing word or not?") and a selective LD task in L1 and L2 ("Is it either an L1/L2 word or not?"; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998). Because a generalized LD task requires a *yes* response for words from both languages, whereas words in the nontarget language require a *no* response in a selective LD task, these tasks differ in terms of language-control demands. The selective LD task imposes much more cross-lingual competition than does the general LD task, in which no language selection/decision has to be made.

Because the generalized LD task does not require inhibiting representations of either of the languages, unlike the selective LD tasks (lexical activation from *any* language requires a yes response), we expected to find a clear cognate effect in the current patient. We assumed that the most impaired language (Dutch) might still interact with the processing of French words, because the word/nonword decision in the generalized task does not require suppression of any language. This interlingual interaction should yield a cognate facilitation effect. Because the selective LD task requires a decision as to whether the letter string is a word specifically in the target language, more control is needed to map lexical activation in the nontarget language to *no* responses. Therefore, we expected a much smaller cognate facilitation effect here. In addition, we expected that the patient would experience less difficulty in suppressing his most affected language (in this case, Dutch) compared with the better-preserved language (French). This should lead to differential results in the two selective LD tasks.

The investigation of the cognate effects in generalized versus selective LD tasks and finding different cross-lingual effects would provide indirect evidence for the hypothesis that a control deficit is underlying the differential impairment pattern in our patient. Additionally, we also aimed to investigate this control hypothesis in a more direct way. Thus, the second aim of this study was to directly assess the executive control abilities of our patient. To that end, we also administered a congruency task. If the differential aphasia is caused by an executive control deficit, rather than by damage to a language-selective lexical area, this deficit should be reflected in the congruency task performance. Similar to the study of Green and colleagues (2010), we also used an Eriksen flanker task[1] (Eriksen & Eriksen, 1974). This task typically consists of five stimuli, most often arrows. The participant is required to react to the direction of the central arrow. The direction of the arrows presented next to the central arrow can be the same as the direction of the central arrow (congruent trials) or opposite (incongruent trials). The congruency effect is the difference in error rates or RTs between congruent and incongruent trials. We expected our patient to show a larger congruency effect in this task compared with controls. To our knowledge, this is the first study to directly measure performance on a cognitive control task by a patient with differential aphasia.

CASE REPORT

We report the data of H. D. M., a right-handed 78-year-old man. He is a French–Dutch bilingual with 15 years of formal education. He worked as a technical engineer until his retirement at the age of 65. His native language is French, but at age 2.5, he started school in Dutch. During his later life, he used both Dutch and French on a daily basis, living in a Dutch-speaking environment, being married to a French–Dutch bilingual woman, and raising their children in Dutch. He kept speaking French with family

[1]The Eriksen flanker task is one of the most frequently used tasks to assess cognitive control.

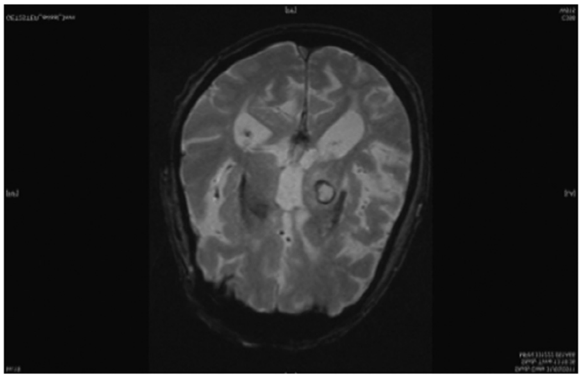

FIGURE 1 T2* weighted image of the lesion.

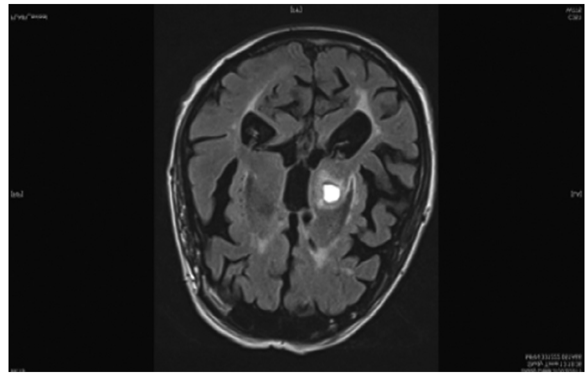

FIGURE 2 Axial FLAIR image of the lesion.

and friends and also watched French television and read French books and papers. He reported being equally proficient in both languages.[2] Both the patient and his wife agreed to participate in our study, and an informed consent form was obtained.

In March 2011, H. D. M. suffered an acute left thalamic hemorrhagic stroke (Figures 1 and 2) and was admitted to the hospital with complaints of feeling ill and word-finding difficulties.

Dutch- and French-language functions were assessed about 3 weeks postonset with the Dutch and the French version of the Aachen Aphasia Test (AAT; Graetz, De Bleser, & Willmes, 1992). Individual scores on each subtest can be found in Table 1. Significant differences ($p < .05$) between the two languages were found on the subtests Token Test and Naming, for which the patient performed significantly worse in Dutch compared with French. Based on the AAT scores, he was diagnosed with clinical aphasia in both languages, with a clearly larger impairment in Dutch compared with French. Therefore, the patient received the diagnosis of differential aphasia, with a better preservation of L1. His wife, who is used to communicating with him both in French and in Dutch, confirmed this. She clearly noted a difference in her husband's communication skills, and she reported reporting more word-finding difficulties and semantic paraphasias in Dutch. Showing fluent language production with severe anomia and word-finding difficulties, (mild) comprehension problems, writing difficulties, and intact repetition, the patient was diagnosed with thalamic aphasia (Fabbro, Peru, & Skrap, 1997). At the moment of testing, the patient did not (yet) receive any speech or language therapy.

TABLE 1
Scores on the Subtests of the AAT in French and Dutch

	French AAT	*Dutch AAT*
Spontaneous Speech	26/30	19/30
Token Test (# errors)*	6	19
Repetition	146/150	143/150
Written Language	66/90	69/90
Naming*	113/120	90/120
Comprehension	100/120	94/120

*The patient showed a significant difference between the French and the Dutch scores on this subtest ($p < .05$).

In addition to the AAT, we administered Part C of the Bilingual Aphasia Test (Paradis & Libben, 1987), which concerns passive translation (translation recognition). The score for the French–Dutch part was 4/5, whereas the patient had a perfect score (5/5) for passive translating into French. We also administered the Controlled Oral Word Association Test (COWAT) in Dutch (Miatton, Wolters, Lannoo, & Vingerhoets, 2004), which he found difficult and frustrating. In the phonological part, he only generated one word, and in the semantic part, he was able to give four words. To get an idea of the patient's IQ, we administered the Coloured Progressive Matrices (Raven, Raven, & Court, 1998). Our patient had a raw score of 21/36, which corresponds with the 75th percentile.

EXPERIMENTAL METHOD

LD Task

We administered three versions of the LD task: a generalized LD task, a selective LD task in French (L1), and a selective LD task in Dutch (L2). In the generalized LD

[2]We are aware of the fact that not all people who are able to use two languages can be regarded as fully bilingual, in the sense that language proficiency takes long periods of acculturation and assimilation to reach a deep structural level (Cummins, 1979). Such mastery should not be confused with the simple ability to use a language in social situations such as conversations. However, because the patient described here acquired both languages at a very young age, and kept using both languages equally often in his daily life, we argue that he can be regarded as a fully balanced bilingual, at least for the rather low level of (lexical) language processing that is assessed in this study. We do not assume complete equivalency of all higher linguistic levels.

task, the patient had to indicate if the word is an existing word or not, in any language. In the French selective LD task, he had to indicate if it was a French word or not. Similarly, in the Dutch selective LD task, he had to make the distinction "Dutch word or not." The three tasks were administered on 3 separate days, to exclude order effects.

The stimuli used in each LD task were 30 Dutch–French cognates, 30 Dutch noncognates, 30 French noncognates, and 90 nonwords. So, the selective LD tasks also contained words in the nontarget language to increase language-control demands specifically for this task. Different stimuli were used for the three tasks. In the selective LD tasks, the cognate was presented in the target language (i.e., in Dutch for the Dutch task, in French for the French task). In the generalized LD task, both the French and the Dutch cognates were used. Cognates and controls were matched for word length, frequency, neighborhood size, and imagability using the WordGen stimulus generation software (Duyck, Desmet, Verbeke, & Brysbaert, 2004).

Flanker Task

Each stimulus of the flanker task consisted of five arrows horizontally presented on the screen. The central arrow could be pointing to the left or to the right, and flankers could be pointing in the same direction as the central arrow (congruent trials) or in the opposite direction (incongruent trials). We included 40 congruent and 40 incongruent trials. The patient had to react to the central arrow by pressing a left button (i.e., the *Enter* button) or the right button (i.e., the *Caps Lock* button).

RESULTS

Similar to Lalor and Kirsner (2001) and other bilingual aphasia case studies, we will focus on accuracy for interpretations. Because RTs are highly variable in patients with aphasia, these are less useful, but will still be reported for the interested reader.

Generalized LD Task

Error rates. H. D. M. made significantly fewer errors on cognates (3%) relative to French words (33%), $t(58) = 3.203$, $p < .002$, and words (28%), $t(118) = 2.888$, $p < .005$. No differences were found between the error rates for cognates (3%) and Dutch noncognates (3%), $t(58) = 0.000$, $p > 1.000$. He showed a statistically significant overall cognate effect, making fewer errors on cognates (3%) compared with noncognates (18%), $t(87.751) = 2.483$, $p < .015$. This shows that even the most affected language still interacts with processing in the most preserved language, at least in a task (general LD task) in which language-control demands are low. Values are shown in Table 2.

Reaction times. Only the RTs on correct trials were included in the analyses. The results of the generalized LD task show that on average, H. D. M. reacted faster on cognates (1,615 ms) compared with noncognates (1,915 ms), $t(76) = -1.216$, $p > .228$. More specifically, he responded much faster for cognates (1,615 ms) compared with both French noncognates (1,878 ms) and Dutch noncognates (1,952 ms). These comparisons did not, however, reach statistical significance for the French noncognates, $t(47) = -1.014$, $p > .316$, or the Dutch noncognates, $t(56) = -1.179$, $p > .243$. Response latencies (2,834 ms) on nonwords were significantly slower than both cognate and noncognate words (all ps $< .014$). Taken together, in the generalized LD task, cognates were recognized 16% faster than L1 words and 21% faster than L2 words, thus showing a clear cognate facilitation effect. Values are shown in Table 2.

French Selective LD Task

Error rates. In the French selective LD task, the patient had a perfect score on cognates and L1 words and made no errors at all. He made significantly more errors on L2 words (13%), $t(29) = 2.112$, $p < .043$. In addition, he made more errors on nonwords (7%) compared with cognates and L1 words, $t(89) = 2.521$, $p < .013$. Values are shown in Table 3.

Reaction times. H. D. M. responded almost equally fast on (French) cognates (1,496 ms) as on French noncognates (1,537 ms), $t(58) = -0.11$, $p > .912$, showing a cognate "facilitation effect" of only 3%. When giving a "no" response, the patient reacted faster to Dutch noncognates (2,122 ms) compared with the nonwords (4,102 ms), $t(108) = -3.795$, $p < .000$. Values are shown in Table 3.

Dutch Selective LD Task

Error rates. In the Dutch (L2) selective LD task, the patient scored equally accurately on (Dutch) cognates

TABLE 2
Error Rates and RTs in the Generalized LD Task

Stimulus	*% Errors*	*RTs (ms)*
Cognates	3%	1,615
L1 words (French)	33%	1,878
L2 words (Dutch)	3%	1,952
Nonwords	28%	2,834

TABLE 3
Error Rates and RTs in the French (L1) Selective LD Task

Stimulus	*% Errors*	*RTs (ms)*
Cognates	0%	1,496
L1 words (French)	0%	1,537
L2 words (Dutch)	13%	2,122
Nonwords	7%	4,102

(10% errors), L1 noncognates (10% errors), and nonwords (7% errors; all $ps > .55$). He made no errors on the L2 noncognates. The difference between the error rate on cognates (10%) and the error rate on Dutch noncognates (0%) was marginally significant, $t(29) = -1.795$, $p < .083$, implying a cognate *interference* effect. Presumably, the cognates activate the French representation more strongly, so that he is inclined to give a "no" response in a Dutch language-selective LD task, whereas these Dutch cognates require a "yes" response (see the "General Discussion"). Values are shown in Table 4.

Reaction times. The RTs for the (Dutch) cognates (3,210 ms) were slightly smaller than the RTs for the Dutch noncognates (3,494 ms), $t(35, 534) = 1.830$, $p < .076$. "No" responses were (nonsignificantly) faster to French noncognates (2,185 ms) than to nonwords (3,999 ms), $t(109) = -1.066$, $p > .289$. Considering these results together, H. D. M. showed a cognate facilitation effect of 8%, which did not reach statistical significance, $t(82) = 0.785$, $p > .435$. Values are shown in Table 4.

In addition, overall RTs in the Dutch selective LD task (3,221 ms) were slower compared with the generalized LD task (2,070 ms) and the French selective LD task (2,314 ms). When comparing the RTs in both languages across the three tasks, we find that the patient reacted more slowly on the Dutch (2,695 ms) compared with the French (1,774 ms) stimuli.

Flanker Task

H. D. M. made more errors on incongruent trials (12% errors) compared with the congruent trials (2% errors), showing a congruency effect of 10%. We also tested 19 control subjects, who were balanced Dutch–French bilinguals in a separate experiment. None of them had an error rate greater than 3.7% on both incongruent and congruent trials, with a mean of 0.6%, resulting in a small congruency effect on error rates. The 95% confidence interval of the error rates in the control group was 0.0% to 1.0%, so performance on the flanker task by the patient is significantly and dramatically worse compared with control subjects, even though this is a nonlinguistic task. This indicates a clear executive control deficiency.

TABLE 4
Error Rates and RTs in the Dutch (L2) Selective LD Task

Stimulus	*% Errors*	*RTs (ms)*
Cognates	10%	3,210
L1 words (French)	10%	2,185
L2 words (Dutch)	0%	3,494
Nonwords	7%	3,999

DISCUSSION

We report the data of a patient with differential aphasia on three versions of the LD task: a generalized LD task, a selective LD task in L1, and a selective LD task in L2. We hypothesized that the pattern would be different in the three tasks, due to the differential need for language control in the generalized versus the selective LD task. In addition, we administered a flanker task to directly assess the executive control functions of the patient. Because we hypothesized that a control deficit might underlie his bilingual aphasia pattern, we expected that he would show a larger congruency effect compared with control subjects.

Because we are aware of the fact that RTs typically show large variance in patients, interpretations were mainly based on error rates. In the generalized LD task, we found a clear cognate facilitation effect when comparing the performance on cognates with the performance on both L1 and L2 noncognates. This implies that the most affected language (Dutch) is still able to influence activation in the most preserved language (French), given that cognates were better recognized than were L1 (French) noncognates. As we argued in the "Introduction," control demands are lower in the generalized LD task compared with the selective LD task, because the former does not require the participant to inhibit (words in) one language. Because this task requires a much smaller amount of language control, even a bilingual patient with aphasia with differential language loss still shows cross-lingual lexical interactions, with activation spreading for the most affected language to the strongest language. RTs showed that cognates were also recognized faster (but not significantly due to high RT variance) than were controls in both languages, which corroborates the findings. These findings are in line with previous studies that reported more efficient processing of cognates compared with noncognates (Detry et al., 2005; Kohnert, 2004; Roberts & Deslauriers, 1999) in patients with *parallel aphasia*.

Additionally, the performance on the flanker task showed that H. D. M. performed significantly worse compared with the control group, showing a large congruency effect, which implies a large amount of interference from the incongruent flankers. This suggests that it was difficult to select the relevant information (i.e., the direction of the central arrow), while ignoring the irrelevant information (i.e., the direction of the flanker arrows), directly supporting our hypothesis of an executive control deficit.[3]

In the L1 selective LD task, we did not find a difference between cognates and L1 noncognates on both RTs and accuracy. However, in the L2 selective LD task, cognates were recognized less accurately compared with L2 noncognates. This differential pattern in the two versions of the selective LD task can again be explained by the tasks' language-control demands, which differ from those in the generalized LD task. Because the patient's most affected language is Dutch, the control hypothesis of bilingual differential aphasia would assume that it is harder for the patient to suppress his French lexicon than to suppress the Dutch. Thus, in the French selective LD task, the Dutch lexicon is easily suppressed and influences the recognition of the French cognate only to a very small amount, leading to the absence of a cognate effect in the French selective LD task. However, because the French lexicon is not that easily inhibited, it affects the recognition of the Dutch cognates in the Dutch selective LD task more strongly. However, because the cognates are likely to activate their French representation more strongly, competition between the activation in that French representation (requiring a "no" response in the Dutch LD task) and that in the Dutch representation (requiring a "yes" response in the Dutch LD task) might cause the cognate *interference* effect in the Dutch (L2) selective LD task. Because the selective LD task appeals more to the control system compared with the general LD task (cf. Aims and Methods), the patient's control deficit leads to the reduction (and inverse) of the cognate effect.

The aphasic symptoms in the patient described here were caused by a subcortical (thalamic) lesion. It was only recently claimed that not only cortical but also subcortical lesions may cause aphasia (Murdoch, 2004). Structures that have been hypothesized to be involved in linguistic representation are the basal ganglia, the thalamus, the subcortical white-matter pathways, and the cerebellum. To the best of our knowledge, only four studies have investigated the implications of a subcortical lesion causing aphasia in bilingual patients (Aglioti & Fabbro, 1993; Azarpazhooh, Jahangiri, & Ghaleh, 2010; Fabbro et al., 1997; Reynolds, Turner, Harris, Ojemann, & Davis, 1979). Importantly, seven out of eight bilingual aphasics with subcortical lesions showed differential aphasia, just as the patient described here (Aglioti & Fabbro; Azarpazhooh et al.; Fabbro et al., 1997, Cases 1 and 2; Reynold et al.). Additionally, similar to our patient, six of them showed larger impairments in their L2 compared with L1 (Azarpazhooh et al.; Fabbro et al., 1997, Cases 1 and 2; Reynolds et al.). This might suggest an important role of subcortical structures in showing differential impairments in both languages. Because ample evidence has already been found against distinct or spatially separate brain areas representing different languages (see the "Introduction"), we suggest that a deficit in cognitive control might underlie the differential impairments in both languages (Green, 2005; Paradis, 2004; Pitres, 1895).

It has been shown that subcortical lesions can lead to decreased activation in cortical areas through diaschisis (i.e., a lesion leads to the dysfunction of other brain areas through the disruption of the connectivity between the lesioned and the physically intact area) or hypoperfusion (e.g., Hillis et al., 2002). However, because we do not have positron emission tomography or single-photon emission computed tomography data from our patient, we cannot confirm this anatomically. Nevertheless, also based on the executive control problem, we hypothesize that the disruption of the thalamus might cause a hypometabolism in frontal areas, which are known to be involved in language control. For example, an anterior loop (frontal associative cortex, caudate nucleus, globus pallidus, ventral anterior nucleus, frontal associative cortex) has been proposed to be involved in language planning, whereas language selection would rely more on a posterior loop (temporoparietal cortex, pulvinar, temporoparietal cortex; Fabbro et al., 1997). We suggest that the frontal hypometabolism might cause the worse performance on the flanker task and might underlie the language-control deficits leading to the cognate pattern shown by the patient described here.

As far as treatment is concerned, there is a lack of clear support favoring either training in one language or training in both languages in bilingual patients. Initially, it was hypothesized that giving language therapy in both languages might result in a reciprocal inhibition and might therefore be disastrous for language recovery in any language (Fabbro et al., 1997; Green, 2005; Hilton, 1980; Lebrun, 1988; Paradis, 2004). In addition, it was found that the effects of language therapy in one language might generalize to the untrained language(s) (Edmonds & Kiran, 2006; Filiputti, Tavano, Vorano, De Luca, & Fabbro, 2002; Kiran & Edmonds, 2004; Marangolo et al., 2009; Miertsch, Meisel, & Isel, 2009). However, this generalization does not always occur (Abutalebi, Rosa, Tettamanti, Green, & Cappa, 2009; Galvez & Hinckley, 2003; Meinzer et al.), so that some authors argue for therapy in all languages (Ansaldo & Marcotte, 2007; Ansaldo, Marcotte, Scherer, & Raboyeau, 2008; Kohnert

[3]We are aware of the fact that the way executive functioning was evaluated in this patient is rather limited (using COWAT and the flanker task). For further research, we suggest assessing executive functions more profoundly (e.g., using the Wisconsin Card-Sorting Task, a switching paradigm, a go–no go task, etc.; see also Garcia-Molina, Tomos, Bernabeu, Junque, & Roig-Rovira, 2012; Segura et al., 2009).

& Goldstein, 2005). For a more detailed overview, see Kohnert (2004) and Faroqi-Shah, Frymark, Mullen, and Wang (2010).

We would like to add a caveat about the limitations of this study. We were only able to estimate premorbid language proficiency. Evidently, we did not have any formal premorbid language proficiency assessments of the patient. However, given the unpredictable nature of stroke and aphasia, this is almost unfeasible. In addition, the premorbid language assessment is not meant to reveal slight functional differences between languages. Instead, its aim is to have a rough indication of quasi-equivalent proficiency. To assess executive functioning, we only used a flanker paradigm, given that we already needed a very extensive test battery. We opted for the flanker task because it is the most often used task in cognitive psychology literature to assess executive control functioning. It would, however, be very interesting to assess executive functioning using more than one task. Evidently, because this is a case study, it should be replicated with a larger group of patients to ensure generalizability. In addition, the data of this group should be compared to the data of a matched control group. The normative data of the neuropsychological tests used in this patient are also not always suitable for these types of small data sets ($n = 1$). We also agree a distinction should be made between basic language skills and fully integrated language performance. It is clear that the present article focuses on differential loss of quite low-level processes of language use (lexical processing) and that language-control problems will probably also affect functioning at other linguistic levels, not assessed in this article. As far as the bilingual language representations are concerned, results obtained by neural imaging techniques indicate that common representations for different languages are highly unlikely. This alternative, however, although it cannot be completely ruled out, also cannot be detected with the spatial resolution of current imaging techniques.

To summarize, we found cognate facilitation and cognate interference effects across three LD tasks, providing evidence for cross-linguistic interactions in a bilingual patient with aphasia with differential language loss, even arising from the most affected language. In addition, this patient showed large congruency effects in a flanker task, indicating a deficit in executive control. Together, these results suggest that a control deficit may explain differential aphasia while still assuming an anatomically and functionally integrated bilingual lexicon.

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