Interference and facilitation in phonological encoding: two sides of the same coin? Evidence from bilingual aphasia

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1. Introduction

Word-finding difficulties are one of the most frequent impairments in patients with aphasia after stroke (Laine and Martin, 2006). Research has identified at least two possible loci of origin for these deficits: the first housed at the meaning level of processing (semantic) and the second at the phonological level (Schwartz, 2014). Since semantics and phonology are connected to the lexical system (Dell, 2004) in a cascading and interactive way, whatever impairments in patients affecting these connections would result in word retrieval failures (e.g., Lambon Ralph, Sage, & Roberts, 2000). In a similar vein, psycholinguistic research has highlighted that semantic control processes influence lexical selection during naming in monolinguals (Nozari & Novick, 2017; Rapp & Goldrick, 2006) and, when this system is affected in patients with aphasia, disruptions may cause word retrieval deficits (Lambon Ralph et al., 2017).

Addressing this line of thought, a number of studies have used semantic blocked cyclic naming tasks to investigate the relationship of semantic control and lexical retrieval both in healthy individuals (Damian and Bowers, 2003; Belke et al., 2005; Damian and Als, 2005; Navarrete et al., 2012; Belke, 2017) and in monolingual patients with aphasia (McCarthy and Kartsounis, 2000; Wilshire and McCarthy, 2002; Schnur et al., 2006; Biegler et al., 2008; Harvey and Schnur, 2015). Within this paradigm, participants are required to name pictures in two conditions: (a) homogeneous, where pictures belong to the same semantic category (e.g., only animals), and (b) heterogeneous, where pictures belong to different semantic categories (e.g., animals, furniture, tools, etc.). The difference in naming latencies between these two conditions, the semantic interference effect, is usually increased in patients with aphasia compared to healthy individuals (e.g., Schnur et al., 2006, 2009; Biegler et al., 2008; Scott and Wilshire, 2010). This finding has been interpreted as being related to semantic control deficits, with explanations positing either hyper-activation or excessive inhibition of semantic competitors during lexical selection and retrieval (for a recent review see Nozari and Hepner, 2019).

Nevertheless, although we have obtained crucial findings from patients with cycling naming tasks regarding the role of semantic control processes during lexical retrieval, the contribution of phonology is still largely unexplored. At behavioural level, phonological context in cycling naming tasks produces a difference in naming latencies while responding to pictures whose names overlap in the segmental proprieties (e.g., *me*lon, *me*tal) and to pictures without this segmental overlap. Crucially, phonological manipulations in blocked naming tasks, as opposed to semantic ones, have shown facilitation, in the form of smaller naming latencies when naming phonologically-related versus unrelated items in the majority of studies (Roelofs, 1999; Schnur et al., 2009; Wang, Shao, Chen, & Schiller, 2018).

With the current experiment, we aimed to explore the underlying mechanisms that link phonology and lexical retrieval by measuring the phonological blocking effect in patients with aphasia and, more specifically, within the context of bilingualism. The motivation to study this issue in patients with aphasia is largely theoretical. A number of findings have shown that facilitation, derived from the phonological overlap of co-activated items, is not compatible with the interpretation of lexical retrieval processes in terms of selection-by-competition (for a review, see Nozari & Pinet, 2020; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992, 1997; Roelofs & Piai, 2015; Shao et al., 2013). Also, the critiques of this theory have been fuelled by studies where that facilitation, and not interference, has been observed in some conditions of semantically blocked naming conditions (Caramazza & Costa, 2000; Costa, Alario, & Caramazza, 2005; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007). In bilingualism research, studies have found that it is possible to obtain facilitation with phonologically-related distractors for both same- and different-language conditions (Costa, Miozzo, & Caramazza, 1999), a finding that questions the role of the inhibitory control in lexical selection of a bilinguals' languages (Branzi et al., 2018; Finkbeiner et al., 2006). In this debate, there is a real need for an integrated model of language production that explains both facilitation and interference, whether it is based on lexical competition or not. In attempts to address this need, studies have used patient data to help disentangle the nature of mechanisms related to the semantic interference and their results have highlighted the role of semantic control mechanisms in lexical selection (Schnur et al., 2006; Jefferies, Baker, Doran, & Lambon Ralph (2007). The evidence for a role of phonology in lexical retrieval and selection is mixed and mainly based on healthy individuals. In some cases, phonological facilitation is found while, in other conditions, phonological components act to increase competition and generate interference (Cohen-Goldberg, 2012; O'Seaghdha & Marin, 2000). Therefore, gathering data that centre upon phonological cyclic naming tasks from patients with aphasia may help clarify the nature of an underlying mechanism in lexical retrieval. While lexical retrieval deficits are a clear burden for these patients, they can also serve as an opportunity to shed light on underlying mechanisms that are affected and, in this specific case, a chance to explore whether phonology induces interference or not.

Additionally, the findings of this research have the potential to be highly informative for our conceptualization of bilingual language production. Specifically, they may inform us as to whether there is language-specificity within bilingual lexical retrieval. Two prominent groups of models have been proposed for lexical retrieval in bilinguals: those that support the involvement of language-specific mechanisms and those that maintain the engagement of non-language specific mechanisms. According to the first group, lexical access in bilinguals is not a competitive process between languages but rather is carried out by selection mechanisms similar to those seen in monolingual lexical selection (Costa et al., 1999; Finkbeiner et al., 2006; Hartsuiker, Costa, & Finkbeiner, 2008; La Heij, 2005). Accordingly, speaking in one language would activate the selection process (at the lexical level) in the intended language without considering potential competitors in the other language. Conversely, other models predict the opposite. For instance, the Inhibitory Control Model (ICM) by Green (1986) would predict different degrees of inhibitory control in each language that, once applied at the schema level, would modulate lexical selection according to the relative dominance/proficiency of the two languages. Gollan et al. (2008) also claimed that difference in frequency of language usage might explain why word production in the less dominant language is more demanding, and thus more affected in bilinguals following brain damage (see also Kroll et al., 2010).

Given these competing theories, the comparison of naming performance within the context of phonological cycling naming in patients may inform us whether lexical retrieval mechanisms work similarly or differently in the two languages. In our previous study, we have already investigated this issue in the context of semantic interference (Calabria et al., 2019). The results of that study revealed that patients with aphasia showed higher semantic interference effects than healthy individuals and even more so when they named pictures in their non-dominant language. The analysis of error types indicated that omissions were the most frequent type of error for patients in their non-dominant language when they named in semantically related blocks. These results were interpreted as supporting the competitive model of language production, with patients' performance primarily seen as due to an excessive inhibition applied to the lexical representations as a consequence of the language deficits (McCarthy & Kartsounis, 2000). This interpretation of results was more favourable than other hypotheses that have proposed over-activation at the semantic level that builds up across cycles, given that these hypotheses would predict more semantic errors than omissions (Belke, Meyer, & Damian, 2005; Schnur, Schwartz, Brecher, & Hodgson, 2006). According to competitive views, inhibitory control may play a critical role in resolving competition among possible candidates for naming and reaching the selection of one representation (Roelofs & Piai, 2015; Shao, Meyer, & Roelofs, 2013). Therefore, one may argue that lexical retrieval deficits in patients with aphasia might be engendered by decreased efficiency in inhibitory control during lexical selection.

In exploring the results of this previous study further, the pattern of errors in patients was similar across languages, but the magnitude of semantic interference was larger in the non-dominant than dominant language. These results led us to conclude that semantic control in bilinguals could have some degree of language-specificity, a finding that should be investigated further. In the present study, we aim to test the language-specificity hypothesis of lexical retrieval in bilinguals within the context of phonology. This kind of evidence is essential for the formulation of a model of bilingual language production that can explain the findings from both the semantic and phonological realms in patients with aphasia.

1.1. The present study

We tested 13 patients with aphasia and 15 healthy controls that were early bilingual speakers of Catalan and Spanish on the phonological blocked cyclic naming task for each of their two languages. It is important to note that differential language impairments in bilinguals with aphasia may depend on the type of bilingualism, context of language acquisition and on the typological features (or language similarity) of two languages (Lorenzen and Murray, 2008). For instance, it is has been shown that nonparallel recovery in bilingual aphasia is influenced by pre-morbid language proficiency, with some cases where the less-proficient language is recovered to a greater degree (Gil and Goral, 2004; Goral et al., 2012; Kiran and Iakupova, 2012). In our study, we focussed on bilinguals with early acquisition (before the age of 6), high proficiency in their two languages, and that showed parallel language deterioration post-brain insult (at least in clinical language assessment). These inclusion criteria are based on a recent review by Kuzmina, Goral, Norvik, and Weekes (2019) that concluded that individuals with aphasia who acquired their second language (L2) before the age of 7 show comparable performance in both of their languages. This form of early bilingualism is what is typically found in the unique linguistic environment of Barcelona (Spain), where a large portion of the population is highly bilingual and is constantly exposed (newspapers, radio and television broadcast) to the two co-official languages, Catalan and Spanish. This is also the type of bilingualism that we have investigated in previous studies with individuals with aphasia (Calabria et al., 2019) and with other neurological diseases (Costa et al., 2012; Calabria et al., 2017; 2018).

Catalan and Spanish are two Romance languages with a large degree of similarity at varying linguistic levels. At the lexical level, a high degree of similarity is shown with an estimated 70% of words in the two lexicons being cognates between languages. At phonological and phonetic level, some differences among the vowel and consonant repertoires can be appreciated. Concerning vowel sounds, Catalan has 8 phonetic sounds and Spanish has 5. Also, Catalan has vowel reductions in unstressed positions for /a/, /e/, → [ə] and /o/ → [u], whereas Spanish does not. The consonant repertoire between the two languages has its peculiarities. The voiceless fricative sounds /θ/ and /x/ are present only in Spanish and the following sounds are only found in Catalan: velar nasal /ŋ/, voiced affricates /dz/ and /dʒ/, voiced fricatives /z/ and /ʒ/, central approximants /j/ and /w/. Also, in Catalan, the sounds /n/, /m/, and /l/ may be geminated. Despite these differences, the consonant sounds that these two languages share outweigh their differences. Because language similarity has been proposed as one of the factors that might influence the similarity of impairment in an individual's two languages (Lorenzen and Murray, 2008), this could play a role in recovery patterns for Catalan and Spanish bilinguals who suffer an onset of language deficits. However, Kuzmina et al. (2019) in their extensive reviews of bilingual aphasia data demonstrated that linguistic similarity is not a key factor in determining the pattern of language impairement in bilinguals when the assessment is based on a clinical task. Likewise, as they suggested, language proficiency and usage are better predictors of the performance within each language for bilinguals with aphasia. Therefore, we would argue that the linguistic similarities between Catalan and Spanish will have a lesser impact on any cross-language comparisons of results obtained in our experiment.

We explored two main hypotheses with our study, one related to the underlying mechanisms of the phonological blocking effect and the other one related to bilingualism.

Our first main hypothesis is that, if the phonological context works differently, as compared to the semantic context, we should find phonological facilitation and not interference, as reported in most of studies with healthy individuals. This assumption is based on some previous studies that have found facilitation with monolingual healthy individuals (Roelofs, 1999; Schnur et al., 2009; Wang, Shao, Chen, & Schiller, 2018). From a psycholinguistic point of view, the facilitation and interference that occur in cycling naming tasks have proven difficult to explain with one underlying mechanism; previous studies have thus interpreted them as results of two different mechanisms. For instance, interference has been interpreted in terms of competitive processes during lexical selection, but facilitation then becomes difficult to explain within the same theoretical framework of selection by competition (for a review, see Nozari & Pinet, 2020). Moreover, the effects of phonological context on naming have been less consistent compared to semantic context that, in most of the manipulations, induces interference; therefore, we may think that their underlying mechanisms might be qualitatively different. In case of facilitation, we expect that naming latencies should be faster for phonologically-related items compared to unrelated ones in healthy individuals and this facilitation should be reduced in patients with aphasia, since their word-finding deficits should negatively impact their performance. Accuracy should not be modulated by the phonological naming condition in healthy controls, however, in patients we should expect some facilitation in the phonologically related condition.

Overall, we expect that patients should produce more omissions than any other type of error. Previous studies with the semantic cycling naming task have also reported semantic or unrelated errors, but at a much lower rate than omissions (e.g., Calabria et al., 2019; Schnur et al., 2006). This is based on the idea that the phonological context may modulate the activation of the lexical representations, which in turn affects word retrieval.

Conversely, if we won't find facilitation, we could conclude that similar mechanisms underlie lexical retrieval in semantic and phonological contexts. Or, at least, the absence of a facilitation effect could be explained as a result of an imbalance between facilitatory and inhibitory mechanisms, which vary in degree of involvement depending on the task. For instance, Breining, Nozari, and Rapp (2016) found that phonologically-related items were named more slowly than unrelated ones. Likewise, the mechanism responsible for both semantic-lexical and lexico-phonological mapping could be the same; in cyclic naming, both facilitation and interference may coexist (see also Belke & Meyer, 2007). Alternatively, the presence of interference could be explained by a distinct mapping of phonological units onto words within the language production system. This has been proposed as a means of interpreting the semantic blocking effects on naming based on non-competitive processes, such as incremental learning (Oppenheim et al., 2010) or priming (Navarrete et al., 2014; Navarrete, Prato, & Mahon, 2012).

Second, we tested the hypothesis of language dependency in lexical retrieval mechanisms for bilinguals. With the semantic blocking effect (Calabria et al., 2019), we found some language differences, where performance in the non-dominant language suffered due to greater amounts of semantic interference. However, this result was limited to patients, as we found the same amount of semantic interference within both languages for healthy individuals. We expect that the facilitation effect should be reduced or absent in the non-dominant compared to dominant language for patients, based on our previous results of a differential language effect of semantic context in patients with the same pattern of a larger effect in the non-dominant than in the dominant language. This could be due to a difference in frequency of language usage that makes non-dominant language retrieval more demanding for bilinguals (Gollan et al., 2008) or in the level of activation of the two languages (Kroll et al., 2010). Similarly, patients should be less accurate in their non-dominant language, as was observed in the semantic manipulation. However, we predict that omissions will account for the majority of errors across both languages, similar to our finding in the semantic cyclic naming task.

Finally, we explored word durations as the time elapsing between the acoustic onset and offset of response articulation. Word duration serves as a measure of the articulatory processes and any difference in word duration between phonologically related and unrelated items could suggest a link between phonology and word articulation. This link has been proposed based on the notion that phonological encoding may have modulatory, cascading effects onto speech-motor planning through the lexicon (Damian & Bowers, 2003; Fink, Oppenheim, & Goldrick, 2018). Also, it has been shown that speakers produce words with longer durations when they share their first morpheme compared to words that overlap in their final morpheme (Watson, Buxó-Lugo, and Simmons, 2015). This result suggests that phonological encoding and selection are partially serial, as the access to phonemes is modulated by the order in which they appear in a word.

Therefore, if the overlap of segmental information in a word influences phonological selection, we should expect that words sharing their initial segment would require more time in phonological selection and would have longer durations in their articulation. This would suggest an interaction between phonology and word articulation through the lexical system. On the other hand, if we do not find any difference in word duration between phonologically unrelated and related items, we might deduce that lexical access is a unstoppable process that, after motor initiation has begun, the articulation plan cannot be changed or modified (Logan & Cowan, 1984; Navarrete et al., 2014).

2. Method

2.1. Participants

A total of 13 Catalan-Spanish bilingual patients with bilingual aphasia (mean age= 59.2 ± 5.4 yo; mean education= 13.7 ± 1.5) were recruited from the Speech Therapy Unit of La Santa Creu i Sant Pau Hospital in Barcelona. All patients were speakers of both Catalan and Spanish prior to stroke, exhibited adequate hearing and vision, demonstrated stable health status and were in the chronic stage of their language disorders (more than eight months post-injury). The aetiologies behind their aphasias were brain tumours for two patients (Pt2 and Pt11) and cerebrovascular (either ischemic or haemorrhagic stroke) for all other patients. All patients had lesions localized in the left hemisphere, as documented in their clinical records (no brain images were available).

A group of 15 healthy individuals also participated in the study as controls; their demographic and linguistic characteristics were matched to those of patients with aphasia (mean age= 57.4 ± 4.4 yo; mean education= 14.5 ± 1.5) (see Table 1).

Language assessment of patients with aphasia. To define the type and degree of language impairment, the Spanish version of the Western Aphasia Battery (Kertesz and Pascual-Leone García, 1990) was administered by a clinical neuropsychologist with expertise in aphasia from the same hospital. In Table 1, we report the individual scores for: fluency (max. score= 20), comprehension (max. score= 10), repetition (max. score= 10), naming (max. score= 10), and the

Aphasia Quotient (AQ) (max. score= 100). Patients were only tested in Spanish since a Catalan version of the WAB is not currently available. According to WAB assessment, 1 patient was classified as having conduction aphasia, 2 with Wernicke's aphasia, 3 with transcortical motor aphasia and 7 were classified as presenting anomic aphasia. The degree of language impairment ranged from mild to moderate (57.6 to 93.4 out of 100) and the mean values for each subtest were: 14.5/20 (±2.8) for Fluency, 8.2/10 (±1.4) for Comprehension; 7.5/10 (±1.7) for Repetition, and 7.6/10 (±1.4) for Naming.

Patients' cross-language abilities were also tested using part C of the Bilingual Aphasia Test (BAT, Paradis & Libben, 1987) including four subtests: Word Recognition (5 words per language; max. score = 10), Word Translation (10 words per language; max. score = 10), Sentence Translation (scoring based on correct translations of 3 sections of each sentence for 6 sentences in each language; max. score = 36), and Grammatical Judgement (scoring based on correct judgement of grammatical structure and accurate correction of grammatical mistakes, if applicable, for 8 sentences per language; max. score = 28).

TABLE 1 ABOUT HERE

Language profile. Language history and dominance were determined by means of a questionnaire administered to the participants and an interview (Calabria et al., 2019; Calabria et al., 2018). Pre-morbid language proficiency in the two languages (Catalan and Spanish) was self-rated by each participant on a four-point scale of their abilities in speaking, comprehension, writing and reading (1=poor, 2=regular, 3=good, 4=perfect) of each language. As can be appreciated in Table 2, both patients and healthy controls were highly proficient in all four linguistic domains. Moreover, participants were considered early bilinguals as, on average, they were regularly exposed to both languages by 6 years of age. Finally, lifetime language usage was rated based on ten questions in which participants were required to report with what frequency they spoke each of the two languages across different periods of their lives from birth to adulthood (with 0% signifying using only Spanish, 100% meaning using only Catalan, and around 50% denoting balanced use of the two languages). Both patients and healthy controls reported relatively equal amounts of Catalan and Spanish usage and thus would be considered balanced bilinguals.

The bilinguals that participated in this study acquired their two languages at the same time (age of language usage for Dominant vs. Non-dominant: patients with aphasia, $t(12) = .85$, $p = .41$; healthy controls, $t(14) = .77$, $p = .45$). Therefore, as it is difficult to say which would be considered their first language (L1) or L2 chronologically speaking, we used the terms 'dominant' and 'non-dominant' to refer to their languages. The use of 'dominant' refers to the language that they prefer to use (or they feel more comfortable speaking), even if they reported that their 'non-dominant' language was at the same level of proficiency and frequency of usage as their dominant. According to this definition, 3 patients and 3 healthy controls were classified as Spanish-dominant bilinguals, while the rest were classified as Catalan-dominant bilinguals.

TABLE 2 ABOUT HERE

2.2. Materials and procedure

Stimuli consisted of two sets of 16 different coloured pictures (one set for each language) and were selected from the Moreno-Martínez and Montoro (2012) database as well as from other free databases (see Appendix I for more details on the stimuli). The pictures were selected to create 4 groups of 8 exemplars, each sharing a phonological overlap in the initial segment of the word. The segmental overlap was different for the two languages (Spanish: me-, co-, ha-, ra-; Catalan: po-, ga-, ca-, na-) and words were either mono- or bisyllabic. Since it was not possible to completely exclude cognate words across languages given the high degree of lexical similarity between these languages, the percentage was kept at around 50% (Spanish: 7 no-cognate words, 9 cognate words; Catalan: 6 no-cognate words; 10 cognate words).

The experimental procedure was the same as was used in the previous study with the semantic blocked cyclic naming task (Calabria et al., 2019). Participants were required to name 8 blocks of pictures: 4 blocks containing phonologically-related items (Homogenous) and 4 blocks containing phonologically-unrelated items (Heterogeneous). Sets of 16 different pictures for each language were presented four times (cycles) in 4 Homogenous as well as 4 Heterogeneous blocks, with a total number of 128 naming trials per participant. 10 different lists consisting of 128 stimuli each were created for each language, avoiding the repetition of the same set of pictures between languages.

Half of the participants named two Homogenous blocks followed by four Heterogeneous and finished with two Homogenous blocks while the other half named pictures in this pattern but reversed. We followed a blocked presentation (AABBBBAA) instead of an alternating presentation for two reasons. First, this was design used in our previous study with the semantically blocked cyclic naming task (Calabria et al., 2019) and, by replicating this presentation of stimuli, direct comparisons between the results can be drawn. Second, the blocked presentation provides us with the opportunity of exploring the facilitation that may arise within the first cycle. The facilitation effect found in some studies but not in others (for a review, see Belke, 2017) for the first cycle has been attributed to differences in blocked or alternating presentation of Heterogeneous and Homogeneous blocks within semantic tasks. According to Belke (2017) it is found in blocked presentations, but not in the alternating ones. However, the different effect of cycle 1 as compared to the other cycles has not yet been reported in phonologically blocked naming; we therefore employed a blocked presentation with the aim of exploring this in the phonological realm.

Each trial included the following elements: a fixation point presented for 750 ms followed by the picture to be named, which appeared for up to 2000 ms or until a response was provided. After each block, participants were allowed to rest. In order to reduce the number of errors due to possible name disagreement/confusion, participants were presented with the set of pictures before the task and were asked to name them in the required language. Participants were tested in two languages (Catalan and Spanish) and, when possible, over two different sessions staggered one week apart. The order of language testing was counterbalanced across participants.

Before starting the experimental procedure, the patients signed an informed consent approved by the 'Parc de Salut MAR' Research Ethics Committee under the reference number 2018/8029/I.

The experimental software used for the tasks was DMDX (Forster & Forster, 2003) and performances (naming latencies, word durations, and accuracy) were analysed off-line with Checkvocal (Protopapas, 2007). Naming latencies were defined as the time elapsing between picture onset and the acoustic onset of response articulation. Word durations were defined as the time elapsing between the acoustic onset and offset of response articulation.

Errors were classified as the following:

a. 'Omission': when the patient was unable to name the object;

b. 'Semantic'; when they produced an incorrect word that was semantically related to the target;

c. 'Unrelated': when they produced a real word with no semantic relation to the target word;

d. 'Formal': when they deleted, substituted or added phonemes to the target word for the picture. We followed the criterion for phonological similarity defined by Schwartz (2014) where 'response and targets must share one phoneme in corresponding syllable or two phonemes in any position'.

e. 'Cross-language intrusion', when they produced the correct word but in the incorrect language;

d. 'Hesitations/autocorrections', when they paused in their utterance but they subsequently produced the target word without any cue.

3. Results

We first explored the effect of phonological blocking by performing repeated-measures ANOVAs including Condition (Homogenous vs. Heterogeneous), Language (Dominant vs. Non-dominant), and Cycle (1, 2, 3, and 4) as within-subject factors and Group as a between-subject factor (patients with aphasia vs. healthy controls). The analyses were performed for three dependent variables—naming latency, word durations and accuracy—separately. RTs were analysed for correct responses only. Moreover, RTs across all conditions exceeding 3 standard deviations above or below the mean were excluded from analyses for each participant in both patient and healthy control groups.

To test how many patients showed a significantly different performance from healthy controls, we ran single t-tests across languages and cycles. We first calculated proportional individual differences between related and unrelated items: for naming latencies $\frac{RTs_{hom}-RTs_{heter}}{Mean\ (RTs_{heter}+RTs_{hom})} * 100$ and for accuracy $\frac{ACC_{heter}-ACC_{hom}}{Mean\ (ACC_{heter}+ACC_{hom})}$. We then ran modified t-tests for independent samples described by Crawford and Howell (1998) that allow for the comparison between individual performances and the mean of a control group. The t values were calculated as follows: $t = \frac{X_1 - X_2}{s^2 \sqrt{\frac{X_2+1}{N}}}$ where, x_1 is the individual's performance, and x_2 is the mean of the control group, s^2 is the standard deviation of the control group, and N is the sample size.

Naming latencies (RTs). The main effect of Group was significant [F (1, 26) = 44.40, p < .001, $\eta p^2 = 0.63$], indicating that patients with aphasia (1054 ms) were overall slower that healthy controls (716 ms) to name their stimuli. However, no interaction between Group and other main effects was significant, suggesting no modulation due to language or phonological blocking.

The analysis also showed a significant main effect of Language [F (1, 26) = 4.23, p = .05, $\eta p^2 = 0.14$], suggesting that participants were faster in naming in the dominant (865 ms) than in non-dominant language (905 ms). The main effect of Cycle was significant [F (3, 78) = 19.86, p < .001, $\eta p^2 = 0.43$], indicating that naming latencies were significantly different between the first cycle (944 ms) and all the other cycles ($p_s < .001$) and between the second (881 ms) and the fourth cycle (849 ms, p < .01). However, neither the main effect of Condition [F (1, 26) = .49, p = .49] nor the interaction between Condition and Cycle [F (3, 78) = 1.58, p = .20] were significant, suggesting that there no effect of phonological blocking in naming over repetitions.

Individual data analyses for naming latencies showed the following results (see Supplementary materials): 9 patients in the dominant language and 11 patients in the non-dominant language had performances significantly different from controls. However, only 2 patients in the dominant language and 6 in the non-dominant showed an interference effect as compared to controls, as they were slower in naming pictures in the homogenous than heterogeneous condition.

FIGURE 1 ABOUT HERE

Word durations. The main effect of group was significant [$F (1, 26) = 18.68$, $p < .001$, $\eta p^2 = 0.43$]. indicating that patients with aphasia (611 ms) were slower in articulating than healthy controls (415 ms). However, neither the within-subject factors [Language: $F (1, 26) = .76$, $p = .36$; Condition: $F (1, 26) = .40$, $p = .53$; Cycle: $F (3, 78) = 1.35$, $p = .26$] nor the interaction between Condition and Cycle [$F (3, 76) = .11$, $p = .95$] were statistically significant.

FIGURE 2 ABOUT HERE

Accuracy. The main effect of Group was significant [$F (1, 26) = 52.70$, $p = .001$, $\eta p^2 = .67$], indicating that patients with aphasia were less accurate (75.5%) than healthy controls (99.3%).

Additionally, the analysis showed that the main effects of Condition were significant [$F (1, 26) = 15.23$, $p = .01$, $\eta p^2 = .37$], indicating higher accuracy while naming in the Homogenous (88.6%) compared to naming in Heterogeneous condition (86.2%). The main effect of Cycle was also significant [$F (3, 78) = 5.10$, $p = .01$, $\eta p^2 = .16$], revealing that accuracy significantly increased from the first cycle (85.2%) to the second one (2nd cycle: 87.9%; 3rd cycle: 88.4%; 4th cycle: 87.9%; $p_s < .05$). Moreover, the interaction between Cycle and Condition was significant [$F (3, 78) = 3.49$, $p < .05$, $\eta p^2 = .12$].

Furthermore, the following interactions with the effect of Group were statistically significant: Group x Condition [$F(1, 26) = 17.97$, $p < .001$, $\eta p^2 = .37$], Group x Cycle [$F(3, 78) = 4.09$, $p < .01$, $\eta p^2 = .14$], and Group x Condition x Cycle [$F(3, 78) = 2.89$, $p < .05$, $\eta p^2 = .10$]. To understand this triple interaction, further analyses were performed for the two groups of participants separately.

The analysis that included only healthy controls did not show significant results in any main effects [Condition: $F(1, 14) = .48$, $p = .50$; Cycle: $F(1, 14) = 1.36$, $p = .27$; Language: $F(1, 14) = .59$, $p = .45$] nor for the interaction between Condition and Cycle [$F(3, 42) = 1.37$, $p = .27$].

The analysis that included only patients showed a significant main effect of condition [$F(1, 12) = 15.32$, $p < .01$, $\eta p^2 = .56$], indicating that they performed better in the heterogeneous (78.0%) than in homogeneous conditions (72.9%). The main effect of Cycle was also significant [$F(3, 36) = 4.00$, $p < .05$, $\eta p^2 = .25$] and post-hoc analyses showed that the accuracy increased significantly from the first (71.4%) to the second cycle (76.5%, $p < .05$) and did not differ in the third (77.4%, $p = .59$) and fourth (76.6%, $p = .52$) cycles (see Figure 3 and Table 3 for the frequency of error types in patients).

Furthermore, the significant interaction between Cycle and Condition in the patient group [$F(3, 36) = 2.81$, $p < .05$, $\eta p^2 = .18$] demonstrates the presence of the phonological blocking effect over cycles. To understand the trend of the effect, two repeated-measures ANOVAs were performed including Cycle as a within-subject factor for the heterogeneous and homogenous conditions separately. For the homogeneous condition, the effect of Cycle was significant [$F(3, 36) = 5.79$, $p < .01$, $\eta p^2 = .32$] and a post-hoc analysis showed a significant increase in performance from the first (72.8%) to the second cycle (77.2%, $p < .01$) and from the second to the fourth cycle (81.2%, $p = .05$). However, for the heterogeneous condition, the effect of Cycle was not significant [$F(3, 36) = .64$, $p = .60$], suggesting the accuracy was not increasing over repetitions.

Individual data analyses for accuracy revealed the following (see Supplementary materials): 9 patients in the dominant language and 8 patients in the non-dominant language had performances significantly different from controls. Also, 9 patients in the dominant language and 11 in the non-dominant showed an interference effect as compared to controls, as they were less accurate in naming pictures in the homogenous than heterogeneous condition.

Finally, to see whether naming performance was dependent on the severity of language impairment, we performed correlations between accuracy and the individual aphasia quotient from the WAB, separated based on condition. The correlations were not significant in any cycle for both heterogeneous (1st cycle: $r = .43$, $p = .15$; 2nd cycle: $r = .39$, $p = .19$; 3rd cycle: $r = .27$, $p = .36$; 4th cycle: $r = .11$, $p = .71$) and homogeneous (1st cycle: $r = .49$, $p = .10$; 2nd cycle: $r = .25$, $p = .41$; 3rd cycle: $r = .31$, $p = .29$; 4th cycle: $r = .51$, $p = .09$) conditions.

FIGURE 3 ABOUT HERE

TABLE 3 ABOUT HERE

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4. Discussion

In this study, we aimed to investigate the nature of the mechanisms underlying lexical retrieval within a phonological context, with a special focus on bilingualism. This research was motivated by the questioning of the consistency in facilitatory effects of phonology on lexical retrieval and by the limited evidence of its effects on word-finding deficits in individuals with aphasia. Additionally, the study of these phonological effects in bilinguals may help add evidence into the theoretical debate surrounding whether lexical mechanisms are language dependent or not.

To understand the underlying mechanisms of lexical retrieval, we investigated the phonological blocking effect in patients with aphasia and healthy controls, using a similar methodology to that which we utilized in our previous study on semantic interference with bilingual individuals with aphasia (Calabria et al., 2019).

Our main hypothesis was that phonological context should have facilitated word retrieval for phonologically related items to a greater degree than unrelated ones. This hypothesis was based on findings from studies that used the phonological blocked cyclic naming task with healthy individuals, observing that participants exhibited faster picture naming for words with segmental overlaps compared to those without any overlap (Damian, 2003; Roelofs, 1999; Schnur et al., 2009; Wang et al., 2018). In our healthy controls, said hypothesis was not supported, as our data suggests that naming latencies and accuracy were the same in both homogenous and heterogeneous conditions[1]. One way to explain this result is the idea that the degree of facilitation or interference may depend on the sum of two different mechanisms, as proposed by Breining et al. (2016). In their study, participants were asked to name pictures whose words overlapped for some segmental features in a non-systematic way, such as at different points of the words (e.g., ‘cat’, ‘mat’, ‘cot’, ‘cap’, ‘mop’). This manipulation was introduced to prevent participants from predicting the position of the segmental overlap within the upcoming trials, thus reducing any kind of anticipatory strategy. Following this manipulation, the results showed an effect of interference instead of facilitation, a finding that researchers suggested was due to the predictability in the segmental overlap. That is, when participants cannot predict the pattern of overlap, the facilitation disappears. In our study, the segmental overlap of words in the phonologically related condition was always at the initial word segment; therefore, participants could have predicted the overlap in the upcoming words in the block. This manipulation should have led to facilitation, but this was not the case. Another element at play, also suggested by Breining et al. (2016), is that the degree of facilitation or interference may depend on the sum of two opposing forces, as the result of the

[1] The absence of phonological facilitation was also found in the pilot study (unpublished data) conducted with 15 young bilingual adults (mean age= 23 years old). The main effect of cycle was found to be significant [$F(3, 42) = 7.96$, $p < 0.01$, $\eta p^2 = 0.36$], but the main effect of condition [$F(1, 14) = 0.04$, $p = 0.85$], language [$F(114) = 0.28$, $p = 0.61$] and the interaction between cycle and condition [$F(3, 42) = 0.97$, $p = 0.42$] were not.

facilitatory and inhibitory effects that might coexist at lexical level (see also Sevald and Dell, 1994). Therefore, it could be possible that any phonological facilitation experienced by our participants was cancelled out by opposing interference, resulting in no appreciable difference between conditions.

Surprisingly, the results from patient data show that phonological overlapping harms lexical retrieval accuracy, whereas naming latencies were not affected by the phonological manipulation. We predicted a reduced facilitation effect or its absence in patients as compared to controls, but this hypothesis was not confirmed because patients produced more errors in the homogeneous (phonologically related items) than in the heterogeneous (phonologically unrelated items) condition. This result was quite consistent across patients, with our individual data analysis showing that most of the patients showed this effect in the phonological context condition (9/13 patients in their dominant language and 11/13 in their non-dominant language).

Hodgson, Schwartz, Schnur, and Brecher (2005) found a similar pattern of results, where they showed that patients with Broca's aphasia exhibited less accurate performance when they named pictures in phonologically-related conditions. This led the authors to interpret this finding as an effect of excessive inhibition applied to competitors, similarly to what has been shown for the semantic blocking effect. Also, in line with Breining et al. (2016)'s interpretation, Hodgson et al. (2005) suggested that patients with aphasia would not be able to predict the pattern of segmental overlap and thereby would not benefit from this condition of phonologically related items.

The crucial point here is that, if we compare these results and those from our study with bilingual patients with aphasia (Calabria et al., 2019), both semantic and phonological overlaps between blocked stimuli interfere with naming accuracy (see analysis in the Supplementary materials). This might suggest that both lexico-semantic and lexico-phonological connections could function similarly in the language production system. According to some speech production accounts, word retrieval is a selection process following the competition among a number of potential candidate words (La Heij, 2005; Levelt et al., 1999; Roelofs, 1992). That is, a co-activation at the semantic or phonological level spreads to the lexical level for those candidates that share related features with the target word and then competitive processes select the correct word by inhibiting the non-target words. Following this logic, the degree of inhibition applied to non-targets would need to be greater when pictures that have to be named are presented in a homogenous block, generating interference for subsequent trials. This interference could be explained as the result of competition at the lexical level and might impede patients' abilities to retrieve words, given that they have deficits in lexical retrieval.

However, we acknowledge that alternative accounts could also explain these results. This competitive view of lexical retrieval has been challenged by the evidence of facilitation, instead of interference, arising after the manipulation of some variables in blocked naming tasks. For instance, semantic interference may turn into facilitation if one manipulates semantic distance, and phonological similarity between the distractor and the target in picture-word interference tasks decrease naming latencies instead of increasing them (for some discussions on this issue, see Costa et al., 1999; Finkbeiner et al., 2006; Mahon et al., 2007; Navarrete et al., 2010; Nozari & Hepner, 2019). This set of results becomes problematic when attempting to explain word production by way of selection by competition.

In order to reconcile theoretical conflicts and distil all the evidence into one account, we need to consider the facilitation found in previous studies along with our own results of interference effects for accuracy in patients and no effect of phonological context for naming latency. One such account that may explain both effects is that of incremental learning theories (Oppenheim et al., 2010), which has been put forth to explain the interference effect of phonological overlap by Breining et al. (2016). The main idea behind this theory is that blocking effects are based on both the strengthening and weakening of semantic-lexical or phonological-lexical connections. When an item is correctly named, the connections between its semantic or phonological features (phonemes) are strengthened and at the same time, for other items that are related but not retrieved, these connections become weaker. That is, in the cyclic tasks, interference accumulates incrementally as a function of naming semantically (or phonologically) related pictures, but it is unaffected by naming unrelated pictures. Therefore, interference emerges as an adjustment of the mapping from semantics (or phonology) to words within the language production system. In some cases, as in healthy individuals, the ability to predict the pattern of segmental overlap could modulate the mapping from one level to the lexical system with the effect of showing either interference or facilitation (Damian et al., 2005).

Similarly, the pattern of errors found in patients could be explained in terms of incremental learning. We expected patients to produce more omissions than other type of errors and indeed we found that they did have more omissions, especially for phonologically related items. This indicates that phonological context may modulate the activation of lexical representations, which in turn affects word selection. Interestingly, within error analysis, we found no cross-language intrusions. We interpret this result as the effect of within-language mechanisms, as participants were performing the task in one language and they were using language-specific mechanisms of word retrieval.

Finally, an alternative account that is, to some extent, in line with the incremental learning hypothesis is that of priming. This account has been proposed by Navarrete and colleagues (Navarrete et al., 2014; Navarrete, Prato, & Mahon, 2012) to explain the effects of semantic blocking on naming. According to these authors, the difference in naming performance between homogenous and heterogeneous conditions is explained by a greater amount of priming applied at the lexical level to semantically-unrelated items than to related items, which does not require any selection by competition processes (Navarrete et al., 2014; Navarrete, Prato, & Mahon, 2012). According this view, our results could be explained by the fact that patients had less benefits of priming for phonologically-related items versus phonologically-unrelated items; therefore, they were less accurate in the former than in the latter condition.

The second hypothesis that we tested concerned the degree of language dependency in lexical retrieval mechanisms for bilinguals. In our previous study (Calabria et al., 2019), we found that the semantic blocking effect was modulated by the two languages, with the non-dominant language showing a greater degree of semantic interference. The differing effects of semantic interference between two languages were not explained by the varying degrees of language impairment, as patients had similar levels of lexical diversity in connected speech and no qualitative or quantitative differences in the scores on part C of the BAT in their two languages. To some extent, the performance difference between the two language was explained by extra-linguistic mechanisms; we showed that the magnitude of semantic interference in their non-dominant language, but not in their dominant one, was correlated with the speed of processing on a non-linguistic control task (flanker task). This result led us to interpret the differential language effect upon semantic control as being related to some conflict monitoring deficits observed in the potentially more demanding lexical retrieval of their non-dominant language. Thus, the contribution of some control processes outside the language system would be limited to specific language conditions, as we did not find such a correlation in either healthy individuals or patients' dominant-language (for a more detailed discussion on this issue, see Calabria, Costa, Green, & Abutalebi, 2018; Calabria, Baus, & Costa, 2019).

The results of the present study do not indicate differential language effects of phonological activation in modulating bilingual lexical access. One may argue that the linguistic similarity of the Catalan and Spanish language might explain the lack of language differences in performance. However, Kuzmina et al. (2019), in their extensive reviews of bilingual aphasia data, demonstrated that linguistic similarity is not a key factor in determining the pattern of language impairement in bilinguals when the assessment is based on clinical task. Likewise, we think that these results are largely explained by the type of bilingualism of our participants, with their high proficiency and early acquisition of both languages.

This finding supports the assumption that lexical retrieval mechanisms work within each language in a very similar way for both bilinguals and monolinguals (Costa & Caramazza, 1999; Finkbeiner et al., 2006; Runnqvist, Strijkers, Alario, & Costa, 2012). Additionally, this study could support models that propose that lexical selection is not a competitive process, either in monolingual or in bilingual language production (see "differential activation account" in Finkbeiner, Gollan, & Caramazza, 2006). Similarly, blocking effects in naming could be explained by non-competitive models of lexical retrieval, such as incremental learning (Oppenheim et al., 2010) or priming (Navarrete et al. 2014; Navarrete, Prato, & Mahon, 2012) for bilingual language production.

Finally, we explored the effect of phonological context on word durations as a way of testing the link between phonology and word articulation through lexical representations. This link has been proposed on the basis that phonological encoding may have modulatory cascading effects onto speech-motor planning (Damian & Bowers, 2003; Fink, Oppenheim, & Goldrick, 2018). We proposed the hypothesis that, if there were cascade effects from phonological selection onto articulatory system, we would likely see shorter durations for related compared to unrelated items. Our results did not support this hypothesis, as we were unable to find any modulation of word duration due to phonological context. We have to acknowledge that, since we didn't find any significant effect of phonological context on naming latencies, it would be difficult to find a significant effect on word durations. However, we also failed to find a significant effect of item repetition on word durations, an effect that was significant for naming latencies. The findings from previous studies of the blocked naming effects on word durations are mixed; some have found such an interaction (Fink et al., 2018; for word repetitions, see Watson, Buxó-Lugo, and Simmons, 2015) while others have reported null effect of blocking on word durations (Damian, 2003). As stated beforehand, our results are more compatible with the view that lexical access is a unstoppable process that, after motor initiation has begun, the articulation plan cannot be changed or modified (Logan & Cowan, 1984; Navarrete et al., 2014).

In conclusion, our results from patients with aphasia support the view that phonology modulates lexical access by eliciting interference, possibly via incremental learning mechanisms. Under this theory of incremental learning, findings of facilitation and interference from healthy individuals might be thought of as two sides of the same coin; depending on the predictability of segmental overlap or task-specific elements, both effects could arise from contexts of phonological similarity. This is in line with the non-competitive view of language production that has been proposed to explain lexico-semantic effects of naming. Also, the results suggest that lexico-phonological processing acts in the same way within a bilingual's two languages, suggesting that they are language-independent.

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Figure captions

Figure 1

Naming latencies (ms) of the blocked cyclic naming task as a function of languages, phonological conditions, cycles, and groups of participants. Error bars indicate standard errors

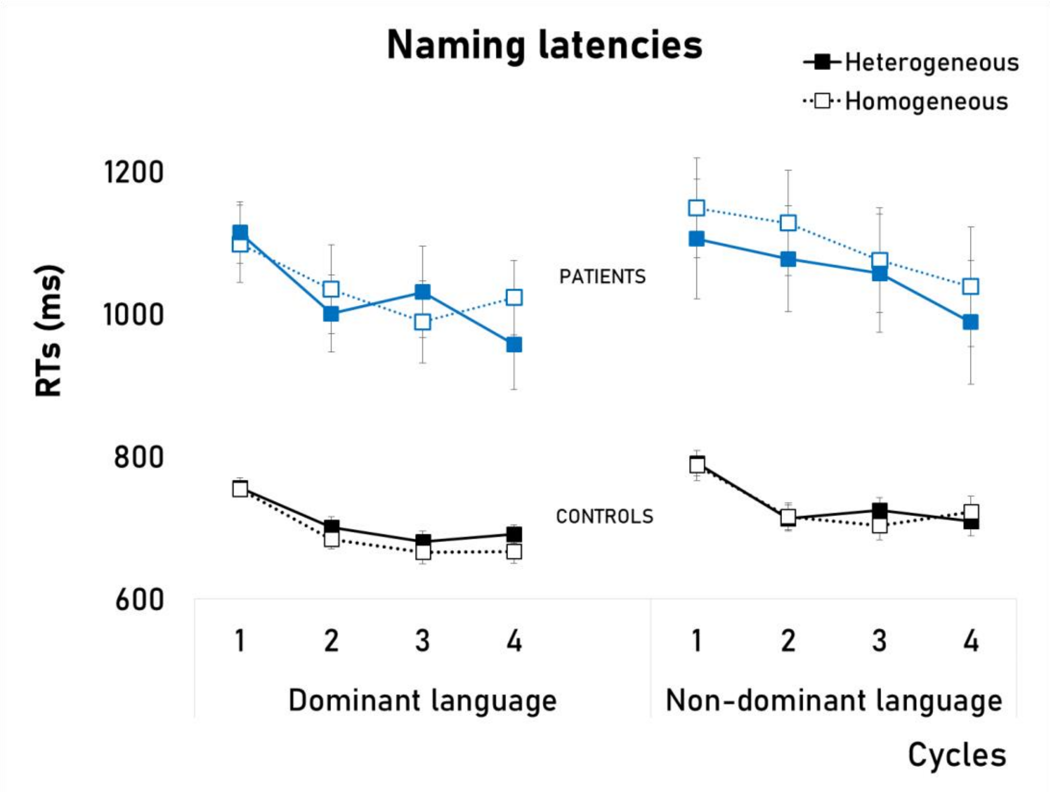

Figure 2

Word durations (ms) of the blocked cyclic naming task as a function of languages, phonological conditions, cycles, and groups of participants. Error bars indicate standard errors.

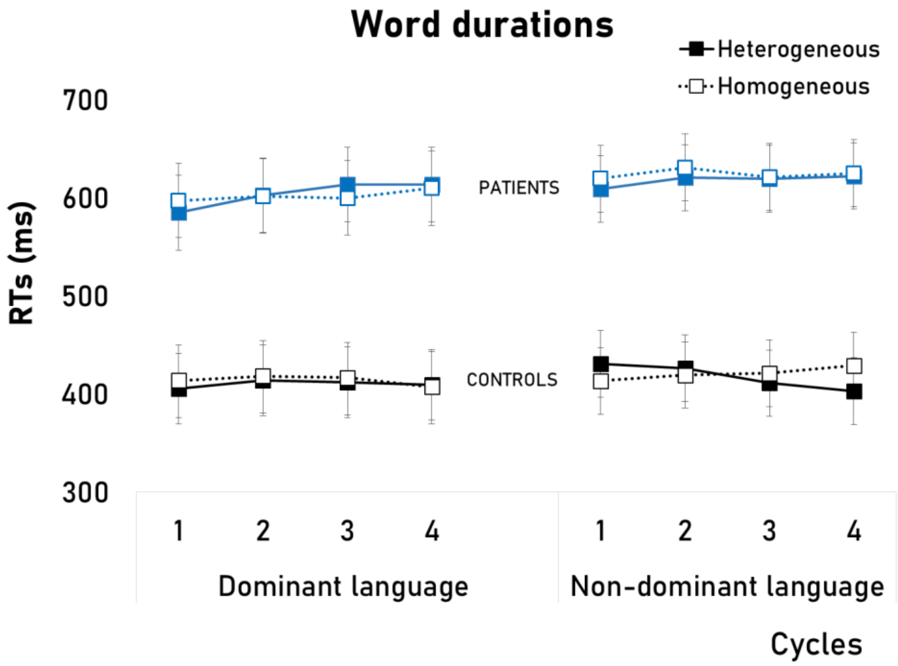

Figure 3

Accuracy (%) of the blocked cyclic naming task in patients with aphasia as a function of languages, phonological conditions, and cycles. Error bars indicate standard errors.

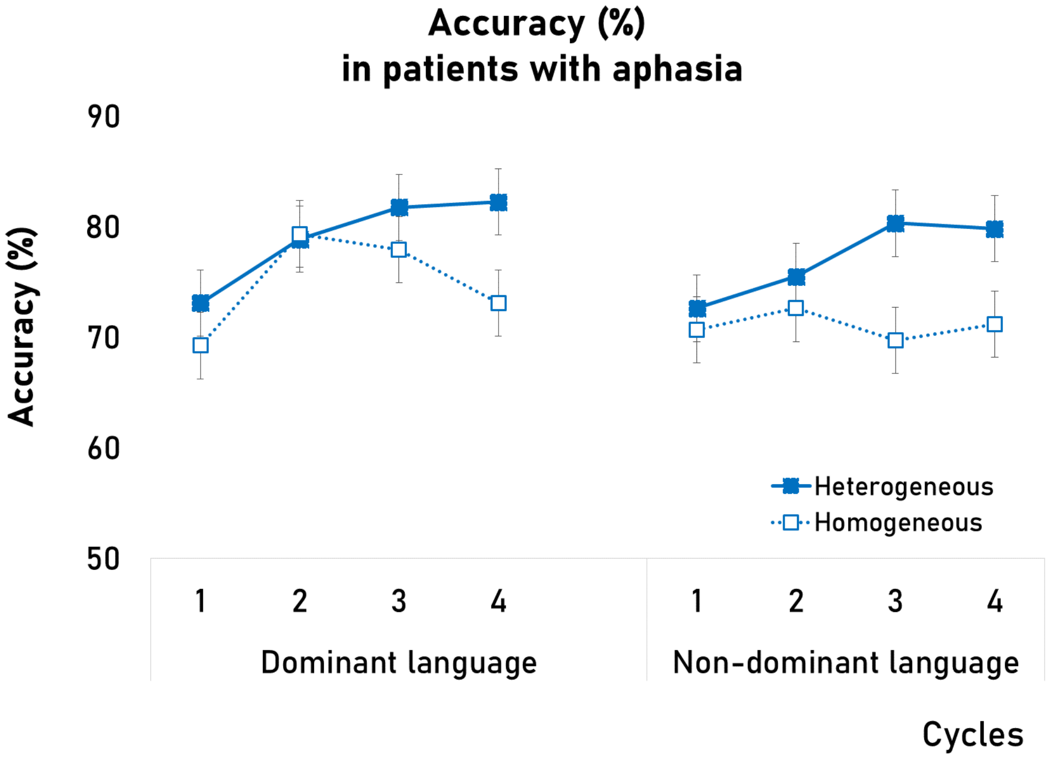

Table 1. Individual scores of patients for the Western Aphasia Battery and Bilingual Aphasia Test (Part C).

	Age	**Aetiology**	**Months post-onset**	**Aphasia quotient** (max. 100)	**Severity WAB**	**Aphasia type**	**Fluency** (max. 20)	**Comprehension** (max. 10)	**Repetition** (max. 10)	**Naming** (max. 10)	**Dominant language**	**Non-dominant language**	**BAT-C DL** (max. 48)	**BAT-C NDL** (max. 48)
Pt1	53	CVA	119	57.6	Moderate	ANOMIC	10.0	6.9	7.1	5.8	CAT	SPA	35	44
Pt2	46	Tumor	131	84.5	Mild	CONDUCTION	18.0	9.2	6.4	8.6	CAT	SPA	36	26
Pt3	58	CVA	122	64.0	Moderate	ANOMIC	10.0	7.3	8.2	6.5	CAT	SPA	37	35
Pt4	62	CVA	82	87.2	Mild	ANOMIC	15.0	10.0	9.7	8.9	CAT	SPA	41	41
Pt5	67	CVA	108	75.7	Mild to Mod.	WERNICKE	16.0	6.7	6.2	8.9	CAT	SPA	27	28
Pt6	56	CVA	83	72.2	Moderate	ANOMIC	14.0	7.9	7.3	6.9	CAT	SPA	25	15
Pt7	64	CVA	31	63.8	Moderate	TRANS. MOTOR	12.0	7.0	9.4	5.7	SPA	CAT	26	13
Pt8	68	CVA	26	93.4	Mild	ANOMIC	18.0	10.0	9.6	9.1	SPA	CAT	46	36
Pt9	69	CVA	51	73.4	Moderate	ANOMIC	15.0	8.4	7.0	6.3	CAT	SPA	43	40
Pt10	61	CVA	141	62.1	Moderate	WERNICKE	15.0	5.6	3.7	6.7	CAT	SPA	N/A	N/A
Pt11	45	Tumor	49	84.1	Mild	ANOMIC	17.0	8.7	7.1	9.2	CAT	SPA	29	31
Pt12	70	CVA	8	77.9	Moderate	TRANS. MOTOR	16.0	9.2	7.4	7.3	SPA	CAT	27	25
Pt13	58	CVA	10	92.2	Moderate	TRANS. MOTOR	18.0	9.9	9.0	9.2	CAT	SPA	30	46

WAB, Wester Aphasia Battery (Spanish version); **CVA,** cerebrovascular accident; **BAT-C,** Part C of the Bilingual Aphasia Test; **DL,** dominant language; **NDL,** non-dominant language; **CAT,** Catalan; **SPA**, Spanish; **N/A**, not available

Table 2. Socio-demographic and linguistic characteristics of the samples.

	Patients with aphasia (n=13)		**Healthy controls** (n=15)		
	M	***SD***	***M***	***SD***	***p values***
Age (years)	**59.2**	5.4	**57.4**	4.4	*.38*
Education (years)	**13.6**	1.7	**14.5**	1.5	*.42*
Age of regular L1 usage	**2.2**	.4	**2.1**	.1	*.51*
Age of regular L2 usage	**5.6**	3.4	**5.3**	3.5	*.85*
Language proficiency (1-4)					
L1 speaking	**4.0**	.0	**4.0**	.0	-
L1 comprehension	**4.0**	.0	**4.0**	.0	-
L1 reading	**3.8**	.3	**4.0**	.0	*.61*
L1 writing	**3.8**	.6	**3.9**	.3	*.55*
L2 speaking	**3.9**	.3	**4.0**	.0	*.30*
L2 comprehension	**3.9**	.3	**4.0**	.0	*.30*
L2 reading	**3.9**	.5	**3.8**	.4	*.56*
L2 writing	**3.7**	.6	**3.8**	.2	*.34*
% Language use	55.5	10.3	49.7	16.9	*.42*

Table 3. Frequency of error types in patients for the two languages in Homogenous and Heterogeneous conditions.

Dominant language	Homogenous	Heterogeneous
Omissions	27.0	21.0
Unrelated	7.2	7.5
Formal	5.9	5.6
Semantic	4.3	5.3
Hesitations/Autocorrections	2.8	1.8

Non-dominant language	Homogenous	Heterogeneous
Omissions	29.4	22.2
Unrelated	7.8	7.2
Formal	4.7	6.5
Semantic	4.0	4.4
Hesitations/Autocorrections	1.9	2.1

Appendix 1. List of stimuli

Catalan words	English words	Frequency	Cognate status	Familiarity	Length	Spanish words	English words	Frequency	Cognate status	Familiarity	Length
POMA	APPLE	17.0	Non-cognate	6.5	4.0	**MESA**	TABLE	172.1	Non-cognate	6.6	4.0
PORC	PORK	138.0	Non-cognate	6.2	4.0	**MEDIAS**	SOCKS	36.2	Non-cognate	6.0	6.0
POLZE	THUMB	214.0	Non-cognate	6.7	4.0	**MECHA**	WICK	3.2	Cognate	na	5.0
POTA	PAW	156.0	Cognate	6.4	4.0	**METRO**	SUBWAY	30.9	Cognate	5.4	5.0
Means		*131.2*		*6.5*	*4.0*	*Means*		*60.2*		*6.0*	*5.0*
GÀBIA	CAGE	1081.0	Non-cognate	6.4	4.0	**COCHE**	CAR	122.9	Cognate	6.6	5.0
GALTA	CHEEK	2664.0	Non-cognate	5.3	4.0	**COLA**	TAIL	39.9	Non-cognate	6.4	4.0
GALL	ROOSTER	1606.0	Cognate	6.1	4.0	**CODO**	ELBOW	7.5	Non-cognate	5.6	4.0
GASA	GAUZE	171.0	Cognate	5.1	4.0	**CONO**	CONE	4.3	Cognate	4.3	4.0
Means		*1380.5*		*5.7*	*4.0*	*Means*		*42.9*		*5.7*	*4.25*
CABRA	GOAT	1212.0	Cognate	5.9	5.0	**HACHA**	AXE	6.2	Non-cognate	3.9	5.0
CAIXA	BOX	4210.0	Cognate	6.5	4.0	**HADA**	FAIRY	3.7	Non-cognate	3.5	4.0
CAMA	LEG	5205.0	Non-cognate	6.4	4.0	**HABAS**	BEANS	2.4	Non-cognate	na	5.0
CAPA	CAPE	4341.0	Cognate	6.7	4.0	**ASAS**	HANDLES	1.4	Non-cognate	na	3.0
Means		*3742.0*		*6.4*	*4.2*	*Means*		*3.5*		*3.7*	*4.0*
NANSA	HANDLE	288.0	Non-cognate	4.6	5.0	**RADIO**	RADIO	83.2	Cognate	6.3	5.0
NAP	TURNIP	393.0	Cognate	4.5	4.0	**RAMA**	BRANCH	47.3	Cognate	6.1	4.0
NAS	NOSE	3607.0	Cognate	6.5	4.0	**RANA**	FROG	6.2	Non-cognate	5.8	4.0
NAU	SHIP	3393.0	Cognate	5.3	4.0	**RAYO**	BOLT	16.4	Non-cognate	6.1	4.0
Means		*1920.2*		*5.2*	*4.2*	*Means*		*38.3*		*6.1*	*4.2*