Variation in language mixing in multilingual aphasia

Abstract

Mixing languages within a sentence or a conversation is a common practice among many speakers of multiple languages. Language mixing found in multilingual speakers with aphasia has been suggested to reflect deficits associated with the brain lesion. In this paper we examine language mixing behaviour in multilingual people with aphasia to test the hypothesis that the use of language mixing reflects a communicative strategy. We analysed connected language production elicited from 11 individuals with aphasia. Words produced were coded as mixed or not. Frequencies of mixing were tabulated for each individual in each of her or his languages in each of two elicitation tasks (Picture sequence description, Narrative production). We tested the predictions that there would be more word mixing: for participants with greater aphasia severity; while speaking in a language of lower post-stroke proficiency; during a task that requires more restricted word retrieval; for people with non-fluent aphasia, while attempting to produce function words (compared to content words); and that there would be little use of a language not known to the interlocutors. The results supported three of the five predictions. We interpret our data to suggest that multilingual speakers with aphasia mix words in connected language production primarily to bypass instances of word-retrieval difficulties, and typically avoid pragmatically inappropriate language mixing.

Key words: code-switching, lexical retrieval, anomia, connected speech, bilingual aphasia

Introduction

Aphasia is an acquired language impairment resulting from brain damage. Following brain lesion, most often as a result of a cerebrovascular accident (CVA), people with aphasia experience difficulty in one language domain (auditory comprehension, verbal production, reading, writing) or more. A common characteristic of aphasia is anomia, that is, pervasive word retrieval difficulties. Individuals who use more than one language prior to the aphasia onset typically experience impairments in all their languages, although patterns of selective or differential impairments of the languages of multilinguals[1] have been reported (e.g. Kuzmina, Goral, Norvik, & Weekes, in press; Paradis, 2004). Many multilingual speakers, especially those who have had extensive use and high levels of proficiency in their languages prior to the aphasia onset exhibit comparable levels of difficulty in their languages following the aphasia onset (e.g. Albert & Obler, 1978; Fabbro, 1999; Paradis, 1998). However, Paradis (e.g. 1998; 2004) has identified a number of non-parallel patterns of impairment. These include a *selective* impairment, whereby only one language is available to the multilingual speaker after their stroke; *successive,* whereby one language recovered first and another, initially more impaired or inaccessible, recovers as well; and *alternate* patterns, whereby the languages alternate in their degree of accessibility (e.g. Albert & Obler, 1978; Nilipour & Ashayeri, 1989).

Variables that affect the degree of impairment in a multilingual's languages include age and manner of language learning, degree of language proficiency and use, and language-specific characteristics, among others (e.g. Albert & Obler, 1978; Gitterman, Goral, & Obler, 2012; Goral, 2017; Kuzmina et al., in press). One question that has been discussed in the literature on multilingual aphasia is the extent to which selective difficulty in one language

[1] In this paper we use the terms *bilingual* and *multilingual* to refer to an individual who uses more than one language. The terms are used interchangeably.

reflects loss of abilities in that language or inefficient control mechanisms leading to insufficient activation and inhibition of the languages (Abutalebi & Green, 2007; Paradis, 1998). Impaired control mechanisms can lead to decreased accessibility of one language, inappropriate language selection, or inappropriate language mixing. Language mixing, also termed code-switching, refers to the use of two or more languages in the same conversation (e.g. de Houwer, & Ortega, 2019; Milroy & Muysken, 1995) and is a normal linguistic behaviour of multilingual speakers.

Many multilingual speakers with aphasia, like neurotypical multilingual speakers, mix their languages. Whether language mixing in aphasia is different from language mixing in neurologically healthy speakers and to what degree it reflects an impairment of language control or results from the language impairment, has not been established to date. In this paper, we examine patterns of language mixing observed in multilingual speakers who acquired aphasia.

There are three main approaches to linguistic research of code-switching. The structural approach studies the grammatical principles constraining code-switching (e.g. Milroy & Wei, 1995). The sociolinguistic approach studies different functions of and settings for code-switching, for example, how it is used to indicate a quote, to emphasize, to focus, to elaborate, or to convey emotional content and identity (e.g. De Fina, 1989). A third approach is the psycholinguistic approach (e.g. Bullock & Toribio, 2012), which focuses on how code-switching can shed light on the cognitive mechanisms underlying bilingual language representation and processing. The latter guided the current investigation.

There is a general consensus among researchers who study multilingual speakers that, at least in experimental settings, there is parallel activation of all the languages of a multilingual speaker, even when he or she is producing words in only one of the languages (e.g. Green, 1998; Hoshino, & Thierry, 2011; Titone et al., 2011). Consequently, in order to produce words in one language, the other languages must be suppressed, or inhibited. Activation of a language depends on factors such as the amount of contact and use of a language, the level of proficiency, and when and how the language was acquired (Green & Abutalebi, 2013), as well as on sociolinguistic factors, such as habits of language mixing (Grosjean, 2001). One model of bilingual language processing that may be relevant for discussing language mixing is the Inhibitory Control (IC) model (Green, 1998). According to this model, inhibition is assumed to be proportional to activation levels. Since the first language (L1) is supposed to be more strongly activated than a second language (L2) – for people who learned their L2 after their L1, the L1 is thought to be the most strongly inhibited when it is not the target language. Thus, inhibition of the first language takes more executive effort and therefore takes longer to overcome when a speaker is switching back from the L2 to the L1 (Costa, Santesteban, & Ivanova, 2006; Meuter, & Allport, 1999). In communities where language mixing is common, individuals may maintain high activation of both languages and a 'cooperative' relationship between the languages to allow for frequent mixing, whereas in communities where mixing is the exception, not the rule, individuals may maintain a more 'competitive' relationship between their languages that exercises inhibition and restricts the insertion of elements from the non-target language (Green & Wei, 2014).

In aphasia, frequent word-finding difficulties may necessitate a cooperative relationship between the languages to facilitate language mixing as a strategy to bypass anomia (Riccardi, 2012). Alternatively, more frequent or atypical language mixing can be due to impaired control mechanisms. The term *pathological code-switching* has been used to some degree by several researchers in recent years to describe non-voluntary language mixing in aphasia (Abutalebi, Miozzo, & Cappa, 2000; Anslado et al., 2010; Fabbro, 1999; Fabbro, Skrap, & Aglioiti, 2000). Language mixing in multilingual aphasia is characterised by alternating language use at the word or sentence level, spontaneous translation, unexpected language switches, and linguistic interference (Fabbro, 1999; Junqué et al., 1989; Paradis, 1995). Research has shown that these behaviours may also be found in healthy speakers (e.g. Isurin, Winford, & de Bot, 2009). Indeed, recent studies have found no qualitative differences in language mixing among healthy speakers and speakers with aphasia, but there seem to be differences in quantity – speakers with aphasia tend to mix more than healthy speakers (e.g. Bhat & Chengappa, 2005; Gardner-Chloros, 2009; Paplikar, 2016). People with aphasia may mix their languages with greater frequency than neurotypical speakers due to their frequent word-finding difficulties. Relatively little is known about the language mixing patterns of multilingual speakers with aphasia and the relation between these patterns and word-finding difficulties.

The aim of the present study was to investigate language mixing in connected speech in multilingual individuals with aphasia to answer the question whether patterns of language mixing are suggestive of psycholinguistic sources, that is, a communicative strategy to resolve word-finding difficulties. To this end, we focused our investigation on lexical-level language mixing. We were particularly interested in the instances of language mixing during connected language production in testing situations. In such testing situations, each language is tested separately. Therefore, there is a clear target language, which serves as the base or matrix language (e.g. Bullock & Toribio, 2012). For example, during testing in English, a Norwegian-English bilingual speaker is expected to answer all questions in English only. In this state, lexical concepts from both languages may be relatively active, but the base language (here, English) is more strongly activated than the speaker's other language (in this case, Norwegian). However, when the speaker experiences word-finding failure in the target (i.e. base) language, elements such as single words or phrases from the other, 'guest' language may be inserted. This may be more common when the proficiency in the non-target, guest, language is higher than in the target language.

We predicted that if language mixing in aphasia was primarily a communicative strategy to resolve instances of anomia, more frequent language mixing would be observed a) for participants with greater aphasia severity, b) while speaking in a language of lower post-CVA proficiency, c) during a task that requires more restricted word retrieval (i.e. a picture-based description), and d) while attempting to produce word types that are more difficult to retrieve (i.e. function words in non-fluent aphasia). Finally, we predicted that e) multilingual speakers with aphasia would rarely switch to a language not shared with their interlocutor. We note that a faulty control mechanism could also result in greater frequency of language mixing in the language that appears less accessible. Faulty control, but not the employment of a communicative strategy, would result in inappropriate language choice.

The rationale of our predictions of greater frequency of language mixing in more severe aphasia, in a language of lower proficiency, and in a more restrictive task is that those factors would be associated with greater specific word-finding difficulties. Regarding word type, healthy speaking individuals tend to mix more content words than function words (Paplikar, 2016; Prince & Pintzuk, 2000). Whereas people with fluent aphasia and especially those with anomic aphasia may show a similar pattern, people with non-fluent aphasia may demonstrate higher frequency of language mixing when attempting to retrieve function words, such as prepositions and pronouns, that are typically more difficult for them to retrieve. Finally, we assume that for the most part, the ability to use the appropriate language with the appropriate interlocutors is preserved in aphasia and that the term 'pathological' code-switching is inappropriate to describe communication patterns in multilingual aphasia.

Methods

Participants

Data from 11 multilingual speakers with stroke-related chronic aphasia are included in this paper (see Table 1). All signed consent forms as part of their participation in assessment or treatment studies in Oslo, Norway or New York, the U.S. Participants were assessed using a formal aphasia test (Western Aphasia Battery, WAB, Kertesz, 1982; Bilingual Aphasia Test, BAT, Paradis & Libben, 1987), a language background questionnaire (a modified version of the Language Experience and Proficiency Questionnaire, LEAP-Q, Marian, Blumenfeld, & Kaushanskaya, 2007; Language Use Questionnaire, LUQ, Muñoz, Marquardt, & Copeland, 1999; part A of the BAT, Paradis & Libben, 1987), and a number of language production tests as described below. Aphasia severity was determined based on the formal aphasia test used; classification of pre- and post-CVA language proficiency (stronger, weaker, or equal) was determined based on responses to the questionnaires, including self-ratings of language proficiency.

Participants 1 and 2 have severe aphasia. Participant 1 is a native speaker of English who learned Norwegian in adulthood. Before retiring, she spoke both languages at work, and reported that she had good oral and written skills in both languages prior to her stroke. Her aphasia is characterised by fluent speech production and comprehension deficits, with greater difficulties in Norwegian than in English. Participant 2 is a native speaker of Spanish who learned English in adulthood and reported high proficiency in both languages prior to her stroke. Her aphasia is characterised by non-fluent, effortful speech production, with apraxia of speech and mild comprehension deficits. Following her stroke, her English appears more impaired than her Spanish.

Participants 3-5 exhibit moderate aphasia. Participant 3 is a native speaker of Japanese who learned English at age 10 and German at age 18. She learned Norwegian after age 20. Her aphasia is characterised by non-fluent speech production and relatively well preserved comprehension. Following her stroke, German was reported to be her weakest language and Japanese her strongest. Participant 4 is a trilingual who acquired Ronga and Portuguese simultaneously, growing up. She learned Norwegian in adulthood and the proficiency level was reported as high for all languages. Her aphasia is characterized by non-fluent speech production with relatively spared comprehension, with greater impairment in Norwegian than in Ronga and Portuguese. Participant 5 is a native speaker of Hebrew who learned English in late childhood and was highly proficient in both languages prior to his stroke. His aphasia is characterised by non-fluent speech production, agrammatism, and mild comprehension deficits. Post-CVA his English appears more impaired than his Hebrew.

Participants 6-11 have mild aphasia, characterised primarily by anomia. Participant 6 is a Spanish-English bilingual who was born in Puerto Rico and learned English at age 13 upon moving to the U.S. She reported high proficiency in both languages prior to her stroke and her language abilities appear comparable in both languages following the stroke. Participant 7 was born in Spain and grew up in Uruguay between the ages of 11 and 30, then lived in Mexico before moving to the U.S. at age 36. He had high proficiency in both Spanish and English pre-CVA and experiences greater difficulty in English post-CVA. Participant 8 learned Spanish and English from early childhood in the U.S. and in Puerto-Rico, had high proficiency in both languages prior to her stroke and comparable mild impairment in both post-CVA. Participant 9 was born in Honduras and acquired Garifuna and Spanish from early childhood. She learned English in adulthood and reported best proficiency in Spanish before and after the stroke. Participant 10 is a native speaker of Spanish, who learned English in childhood and reported better proficiency in English than in Spanish at the time of testing. Participant 11 was born in Belgium and had acquired Dutch as well as French and German in early childhood, English in late childhood, and Spanish and Norwegian, among a few other languages, in adulthood. He reported high proficiency in five languages pre-CVA but his Dutch proficiency is highest and Norwegian lowest, both pre- and post-CVA.

TABLE 1 ABOUT HERE

Procedures

Data were collected in all languages of the participants, except Ronga for Participant 4 and Garifuna for Participant 9 (due to lack of assessment tools and accessibility of proficient speakers); we tested seven of the languages of Participant 11 but he only produced language mixing in Spanish and Norwegian and for space considerations we report data from these two and from his native Dutch here. All assessments were done by highly proficient or native speakers of each of the languages. Furthermore, the data were collected in relatively monolingual settings, with each language tested in a separate session by a different examiner. However, a completely monolingual setting is not easy to achieve. The participants knew that the examiners or the interpreters – who all lived in Norway or the U.S, respectively – spoke at least two if not all of each participant's languages. All examiners refrained from language mixing. The participants were tested on a number of tests but for the purpose of this paper, data are reported from two elicited production tasks: A picture sequence description ('Cartoon'), of 6 or 4 drawings taken from the BAT (Paradis & Libben, 1987) or from Narrative Story Cards (Helm-Estabrooks & Nicholas, 2003) respectively, and a personal narrative ('Narrative').

Analysis

Native speakers of each of the languages orthographically transcribed the language samples. We then counted, for each participant in each language tested, the total verbal units (words and part words in the target and non-target languages) and the number of words produced in the non-target language, i.e. language-mixed words. All language-mixed words were counted (e.g. three language-mixed words were counted when a noun-phrase containing an article, an adjective, and a noun was produced in the non-target language). We then calculated the percentages of language-mixed words out of total words per participant for each language task.

Words were divided into two categories: function words and content words. When calculating averages of language-mixed words in the strongest and weakest languages we did not include languages that were equally proficient for a participant.

Because the frequency data were generally skewed and hence not normal, non-parametric Mann-Whitney U-tests and Wilcoxon rank-sum tests were used on the frequency values to compare the frequency of language mixing in mild vs. moderate/severe aphasia, in languages of lower vs. higher post-stroke proficiency, and in the more vs. the less restrictive task. For the analysis of word type, differences between function and content words were examined descriptively for the four participants with moderate/severe aphasia who exhibited non-fluent aphasia (Participants 2-5). Inappropriate language choice was not documented in any of our 11 participants and no statistical testing was applied.

Results

Descriptive results for the participants are presented in tables 2 and 3. We first report the results of three statistical comparisons used to test our first three predictions; we then describe the results for word type in the relevant participants.

On average, the participants produced 258 words (sd ≈ 140) for each task in each language, but the variation was great; the smallest number of words produced for a task was 11 and the greatest was 910. The mean proportion of language-mixed words was 8.6% (sd ≈ 12), with individuals' averages ranging from 0.56% to 40%.

Language mixing by aphasia severity

The participants with severe or moderate aphasia (Participants 1-5) produced a mean of 188 words (sd ≈ 90) in each task in each language, ranging from a minimum of 70 to a maximum of 326. The participants with mild aphasia (Participants 6-11) produced a mean of 315 words (sd ≈ 156), ranging from 138 to 567. The severe/moderate group produced a mean of 16% language-mixed words (sd ≈ 14), ranging from 4.3% to 40%, whereas the mild group produced a mean of 2.2% language-mixed words (sd ≈ 2.9), ranging from 0.56% to 8.1%. The difference in frequency of language mixing between the two severity groups is shown to be significant by a Mann-Whitney U-test (N = 11, U = 1, p ≈ 0.0087). The effect size measure Cohen's *d* ≈ 2.5 indicates a strong effect and the result supports our prediction a) that persons with more severe impairment will produce more language mixing (see figure 1).

Language mixing by language proficiency

Out of the 11 participants, nine had better (post-stroke) proficiency in one of their languages (Participants 6 and 8 had equal proficiency in their two languages). Generally, these nine participants produced the same amount of text in their strongest and their weakest language, m ≈ 262 (sd ≈ 124) and m ≈ 252 (sd ≈ 178), respectively. However, a Wilcoxon signed-rank test revealed significant differences in frequency of language mixing (N = 9, V = 4, p ≈ 0.027, *d* ≈ 1.8) between the strongest and the weakest language for these nine participants. The mean values were m ≈ 1.5% (sd ≈ 2.8) for the strongest language and m ≈ 22% (sd ≈ 26) for the weakest. The result supports our prediction b) that people produce more language mixing in their post-CVA weaker language (see figure 2).

Language mixing by task

Examining the 11 participants as a group, we found that they produce more output in the Narrative task (m ≈ 335, sd ≈ 232) than in the Cartoon task (m ≈ 180, sd ≈ 104). There was, however, no significant difference between the two tasks in their percentage of language-mixed words (m ≈ 8.5, sd ≈ 13; m ≈ 8.7, sd ≈ 11), according to a Wilcoxon signed-rank test (N = 11, V = 39, p ≈ 0.64), giving no support to the hypothesis that more language mixing would be produced in the Cartoon task (see figure 3).

Also, there was no indication of any interaction between severity of aphasia and task; the mean percentage values are virtually the same for both tasks for each severity level, as shown in table 4. We tested the interaction with a Mann-Whitney U-test with difference in frequency values between the tasks as the dependent variable and the result was non-significant ($N = 11$, $U = 16$, $p \approx 0.93$).

Similarly, language proficiency does not seem to affect the task results, as shown in table 5. We tested the interaction with a Wilcoxon signed-rank test with the difference in frequency values between the tasks as the dependent variable, and the result was non-significant ($N = 9$, $V = 13$, $p \approx 0.30$).

Language mixing by word type

On average, participants with non-fluent aphasia (Participants 2-5), produced a mean of 154 words per task per language, ranging from a minimum mean of 77 words to a maximum mean of 203 words. When comparing the proportion of content words and function words that were language-mixed, respectively, we found no systematic pattern. In two participants (2, 3), the proportion of content words with language mixing was higher than the proportion of function words with language mixing; for the other two, the situation was the opposite. There was substantial variation in frequency of language mixing in the participants, ranging from 0 to 49% in the content words and 9% to 37% in the function words. The size of the difference in frequency of language mixing between content words and function words is less varied, however, ranging from 6 to 15 percentage points.

A different perspective on word type is the proportion of content and function words of the language-mixed words for each individual. This approach is complicated by the great variation in the amount of language mixing between the different languages in an individual, but when looking only at the language with a considerable amount of language mixing, we see that the majority of language mixing takes place in function words, ranging from 64% to 100%.

Tables 2-5 HERE

Figures 1-3 HERE

Discussion

In this paper, we discuss data from 11 multilingual individuals with aphasia, examining language mixing patterns. We predicted that if our participants used language mixing as a strategy to cope with instances of anomia, we would observe a) greater frequency of language-mixed words for participants who had more severe impairment and b) when participants spoke in their post-CVA weaker language. We found evidence that supported both these predictions. That is, the participants with greater impairments (Participants 1-5) mixed more frequently than those with milder impairment (Participants 6-11), and there was more language mixing when participants were tested in their weaker language. These findings are consistent with previous reports of greater frequency of language mixing in people with aphasia as compared to neurotypical (Muñoz, Marquardt, & Copeland, 1999; Paplikar, 2016) and with the assumption that people with aphasia mix languages when they encounter word-finding difficulties.

Abutalebi, Miozzo, and Cappa (2000) reported on a trilingual individual with aphasia who mixed words and phrases from one language while being tested in another. Their participant was aware of the mixing, which was often used in instances of word-finding difficulties, similar to the pattern reported here. However, the authors noted that not all instances of language mixing appear under voluntary control and many were not in the expected direction, that is, switching to a stronger language while speaking a weaker one. We found switches from a stronger language to a weaker language in only one of our 11 participants.

We also predicted effects of c) task and d) word type. We predicted greater frequency of language mixing in the task that required the retrieval of more specific lexical items, namely, the Cartoon task, as compared to the less-constrained Narrative task, but found no statistical difference between the frequency of mixing in the two tasks with a variable pattern of results among our participants, and thus no support for this prediction. Nor were there significant interactions between task type and aphasia severity or language proficiency. Whereas the effect of task on aphasia performance in connected speech production has been demonstrated in the literature (e.g. Olness, 2006), few studies have compared frequency of language mixing in relation to the elicitation task used in multilingual people with aphasia. One such study examined language-mixing patterns in people with aphasia and in neurotypical speakers from the same community (Karnataka, India), and found – similar to our findings reported here – no consistent differences between the more- and less-constrained elicitation tasks (Paplikar, 2016).

Regarding our prediction that multilinguals with non-fluent aphasia would experience greater difficulty with function words and would therefore demonstrate greater frequency of language-mixed function words than language-mixed content words, we found mixed results. There was no consistent difference in the proportions of content and function words among the participants with non-fluent aphasia; when the proportions of the mixed-words were compared for the two word types, greater proportions of mixed function words were revealed. We therefore interpret these findings with caution. The finding of greater language-mixed function words in non-fluent aphasia has been reported in a more detailed analysis of one of the participants with non-fluent aphasia included here (Participant 5), see Lerman et al. (in press).

Finally, as we predicted (e), we did not find evidence for inappropriate language-mixing in that none of our participants switched to a language that was not known to their interlocutors. Moreover, the socio-linguistic context likely played a role in our findings: because the participants were tested in more than one language on the same day, mixing may have been more likely than if each language was tested on a different day. As well, the participants were likely aware that their interlocutors were multilinguals. We therefore argue that we found no evidence for what has been referred to in the literature as ‘pathological code-switching’. There has been some discussion in the literature concerning the underlying causes of various types of language mixing in aphasia (e.g. Fabbro et al., 2000; Perecman, 1984) and there is no obvious consensus regarding the terminology or the atypicality of the behaviour. We join Grosjean (1985) and call for a refrain from using the terms ‘pathological switching’ and ‘pathological mixing’ in future studies of aphasia in multilingual speakers.

We propose that regardless of the language-mixing behaviour typical of the communities to which the speakers belong, people with aphasia may adopt a cooperative, rather than a competitive, schema of language activation (Green & Wei, 2014), which allows for the use of language mixing as a communicative strategy.

This study has several limitations, including the small sample size. Future studies could expand the investigation into language mixing in multilingual aphasia by examining additional participants and by assessing qualitative, in addition to quantitative, patterns of the behaviour (e.g. item analysis). As well, the contribution of linguistic similarity, such as the presence of cognates, among the relevant languages may be studied (e.g. Broersma, Insurin, Bultena, & de Bot, 2009; Clyne, 2003). Additionally, language-mixing behaviour prior to the stroke could influence the presence of language mixing post stroke and should therefore be considered. Another limitation of the current study is that a variety of drawings and topics in the Cartoon and Narrative tasks, respectively, were employed across participants, which may have contributed to the variability of the results. Finally, other indications of language mixing, such as part-word mixing and blends, as well instances of lexical transfer have not been examined here. These may present areas for future study.

Conclusion and clinical implications

As may be expected for any research in aphasia, there was individual variation in the frequency of language mixing among the participants in this study. Nevertheless, we found that three of our five predictions were supported by the findings obtained: We found no evidence for so called pathological mixing in our participants and our data suggest that language mixing in aphasia is associated with degree of retrieval difficulty (with greater frequency of language mixing in more severe aphasia, while speaking a more impaired language, and, to some extent, while attempting a word type that is more difficult). It may be the case that accommodating multilingual language use in multilingual speakers with aphasia could have beneficial effects on communicative success. We would like to emphasise the advantages of studying language mixing in connected-speech contexts rather than at the single-word level. The focus on types and frequency of language mixing would not have been achievable in an experimental single-word setting. Finally, even if our approach was mainly psycholinguistic, in order to understand the phenomenon of language mixing we would like to advocate for a combination of psycholinguistic and sociolinguistic approaches, as they are complementary to each other.

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Table 1. Details of the participants

Participant	Age	MPO	Severity	Aphasia type	Languages	Language most proficient post-CVA	Dominant language in the country of residence post-CVA
1	75	18	Severe	F	Eng, Nor	Eng	Nor
2	56	108	Severe	NF	Spn, Eng	Spn	Eng
3	59	7	Moderate	NF	Jap, Eng, Ger, Nor	Jap	Nor
4	50	10	Moderate	NF	Por, Nor	Por	Nor
5	72	60	Moderate	NF	Heb, Eng	Heb	Eng
6	56	9	Mild	A	Spn, Eng	Eng/Spn	Eng
7	74	19	Mild	A	Spn, Eng	Spn	Eng
8	54	59	Mild	A	Spn, Eng	Eng/Spn	Eng
9	58	9	Mild	A	Spn, Eng	Spn	Eng
10	51	324	Mild	A	Spn, Eng	Eng	Eng
11	65	12	Mild	A	Dut, Spn, Nor	Dut	Eng/Dut

Note. MPO = Months post onset, F = Fluent aphasia, NF = Non-fluent aphasia, A = Anomic aphasia

Table 2. Individual and group data for total words and language-mixed words for the Cartoon task

Participant	Language	# words	# LMW	% LMW
1	**Eng**	327	1	0
	Nor	482	116	24
2	**Spn**	208	7	3
	Nor	75	50	67
3	**Jap**	63	0	0
	Eng	301	3	1
	Ger	11	8	73
	Nor	54	0	0
4	**Por**	56	1	2
	Nor	50	0	0
5	**Heb**	89	3	3
	Eng	112	30	27
6	Spn	67	1	1
	Eng	136	0	0
7	**Spn**	160	0	0
	Eng	292	11	4
8	Spn	314	2	1
	Eng	296	1	0
9	**Spn**	200	0	0
	Eng	243	4	2
10	Spn	145	4	3
	Eng	123	0	0
11	**Dut**	210	0	0
	Spn	160	8	5
	Nor	181	40	22
Mean All (sd)		180(104)	12 (18)	9 (11)

Note. LMW = Language-mixed words. Languages presented in bold are strongest languages.

Table 3. Individual and group data for total words and language-mixed words for the Narrative task

Participant	Language	# words	# LMW	% LMW
1	**Eng**	134	0	0
	Nor	359	84	23
2	**Spn**	237	0	0
	Nor	144	128	89
3	**Jap**	520	5	1
	Eng	108	4	4
	Ger	110	14	13
	Nor	198	1	1
4	**Por**	91	14	15
	Nor	112	0	0
5	**Heb**	310	3	1
	Eng	300	82	27
6	Spn	209	4	2
	Eng	139	0	0
7	**Spn**	910	2	0
	Eng	907	4	0
8	Spn	453	4	1
	Eng	530	2	0
9	**Spn**	308	2	1
	Eng	279	7	3
10	Spn	567	10	2
	Eng	519	1	0
11	**Dut**	242	0	0
	Spn	191	6	3
	Nor	165	30	18
Mean All (sd)		335 (232)	17 (22)	9 (1)

Note. LMW = Language-mixed words. Languages presented in bold are strongest languages.

Table 4: Mean percentages values for language mixing by task and severity, standard deviations in brackets.

	Cartoon		Narrative	
Severe	16.3	(12.4)	16.5	(16.1)
Mild	2.4	(3.3)	1.9	(2.6)

Table 5: Mean percentages values for language mixing by task and proficiency, standard deviations in brackets.

	Cartoon		Narrative	
Strong	0.98	(1.5)	2.0	(5.0)
Weak	24.5	(27.7)	19.5	(28.0)