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Why do bilingual speakers with aphasia alternate between languages? A study into their experiences and mixing patterns

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ABSTRACT

Background: The factors that contribute to language alternation by bilingual speakers with aphasia have been debated. Some studies suggest that atypical language mixing results from impairments in language control, while others posit that mixing is a way to enhance communicative effectiveness. To address this question, most prior research examined the appropriateness of language mixing in connected speech tasks.

Aims: The goal of this study was to provide new insight into the question whether language mixing in aphasia reflects a strategy to enhance verbal effectiveness or involuntary behaviour resulting from impaired language control.

Methods & procedures: Semi-structured web-based interviews with bilingual speakers with aphasia ($N = 19$) with varying language backgrounds were conducted. The interviews were transcribed and coded for: (1) Self-reports regarding language control and compensation, (2) instances of language mixing, and (3) in two cases, instances of repair initiation.

Outcomes & results: The results showed that several participants reported language control difficulties but that the knowledge of additional languages could also be recruited to compensate for lexical retrieval problems. Most participants showed no or very few instances of mixing and the observed mixes appeared to adhere to the pragmatic context and known functions of switching. Three participants exhibited more marked switching behaviour and reported corresponding difficulties with language control. Instances of atypical mixing did not coincide with clear problems initiating conversational repair.

Conclusions: Our study highlights the variability in language mixing patterns of bilingual speakers with aphasia. Furthermore, most of the individuals in the study appeared to be able to effectively control their languages, and to alternate between their languages for compensatory purposes. Control deficits resulting in atypical language mixing were observed in a small number of participants.

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Introduction

The ability to speak more than one language allows for mixing[1] these languages when necessary or permitted, requires monitoring of the target language in a given situation, and may call for suppression of the irrelevant language. In other words, processing multiple languages demands *control* over these languages. The extent to which bilingual individuals with aphasia experience difficulties with language control has been a topic of investigation in the research literature, and an approach to this question is to examine their language mixing behaviour.

Language mixing, the use of two or more languages within the same conversation (e.g., Milroy & Muysken, 1995), is common linguistic behaviour of neurologically healthy bilingual speakers. Language mixing can occur between utterances or sentences (*inter-sentential*) or within utterances by inserting words into the structure of the other language (*intra-sentential*). Content words are more likely to be mixed than function words (e.g., Muysken, 2000), and mixing is driven by a number of factors (e.g., Appel & Muysken, 1987). Accessibility of a lexical item may be an important reason to mix languages (Heredia & Altarriba, 2001), thereby serving a *psycholinguistic* function. Moreover, mixing can serve *pragmatic* purposes (e.g., to include or exclude interlocutors), *sociolinguistic* functions (e.g., to emphasise one's own identity, Poplack, 1980), or *metalinguistic* purposes (to comment on the languages or to show off linguistic skills, Myers-Scotton, 1979).

The underlying motives for the language mixing behaviour of bilingual speakers with aphasia and whether these patterns align with those observed in neurologically healthy bilingual speakers have been subject of ongoing debate (Grosjean, 1985; Perecman, 1984; see; Fyndanis & Lehtonen, 2022, for a review). One perspective suggests that language mixing in aphasia originates from control deficits, while an alternative view proposes that bilingual individuals with aphasia actively engage in switching to circumvent language-selective word-retrieval difficulties.

Several clinical reports, typically of single cases, provided evidence for "atypical" mixing among individuals with aphasia. This may include involuntary switching (Abutalebi et al., 2000; Fabbro, 2000), switching in monolingual settings (Ansaldo et al., 2010), or switching to a language of low proficiency (Leemann et al., 2007). Conversely, Riccardi (2004) described a trilingual case with Wernicke's aphasia who demonstrated remarkable sensitivity to the pragmatic rules governing language mixing. Studies proposed various explanations for atypical switching patterns, including deficits in implicit memory systems, insufficient activation and inhibition resources, or impairments in control mechanisms (Abutalebi et al., 2000; Ansaldo et al., 2010; Fabbro, 2000; Kong et al., 2014; Leemann et al., 2007).

Moving beyond clinical reports, studies employing more constrained tasks also offered diverging interpretations of language mixing by bilingual individuals with aphasia. Chengappa et al. (2004), who administered the Bilingual Aphasia Test (Paradis & Libben, 1987) to investigate switching, observed increased mixing of bilingual individuals with aphasia compared to neurologically healthy controls. They suggested that the higher frequency of switching is the result of a strategy to compensate for lexical access difficulties in one language. Similarly, two studies that conducted language switching experiments observed results largely consistent with the idea that difficulties in lexical access may underlie language switching in

bilingual individuals with aphasia (Hameau et al., 2022; Mooijman et al., 2024). Conversely, Grunden et al. (2020) obtained several results from a switching experiment that could best be explained by deficits in language control.

Most studies into language mixing by bilingual individuals with aphasia investigated switching in *narrative production*. Muñoz et al. (1999) observed an increase in normally occurring mixing patterns, which was taken as evidence that persons with aphasia adopt mixing patterns to improve their verbal effectiveness. This proposal was further supported by subsequent studies demonstrating that persons with aphasia switched more often in the less-proficient language, when their aphasia was more severe, and in more demanding language contexts (Bihovsky et al., 2023; Chen, 2018; Goral et al., 2019; Lerman et al., 2019; Neumann et al., 2017; Neumann-Werth et al., 2010). Therefore, language switching has been interpreted as a compensatory mechanism to overcome lexical retrieval difficulties and enhance verbal functional communication in these studies.

Paplikar (2016) followed up on this proposal by directly evaluating the effectiveness of language mixing as a strategy. The findings aligned with the other studies, indicating higher frequency of switching by bilingual individuals with aphasia compared to a control group. Importantly, this increased switching did not result in higher communicative success, although participants produced more spoken language output and fewer pauses when they switched. Consequently, Paplikar (2016) proposed that a language control deficit, specifically difficulty inhibiting the non-target language, may underlie increased mixing in aphasia.

This discussion of the literature shows that existing research came to varying conclusions regarding the underlying reasons of switching by individuals with aphasia. Most studies evaluated the "appropriateness" of mixing patterns in terms of frequency, pragmatics, realisation, and context. However, another way to examine whether language mixing is related to control abilities is to explore whether it co-occurs with other communicative behaviour that may rely on control.

Language control is important for not only *bilingual* language production but also in everyday language use, particularly when language production is no longer automatic (Frankel et al., 2007; Penn et al., 2010; Spitzer et al., 2020). Individuals with aphasia who have control deficits may exhibit behaviours such as perseveration or difficulties initiating repair when a breakdown in communication occurs, because these conversational strategies require control abilities such as active monitoring, interference suppression, updating of working memory, and cognitive flexibility. Several studies observed a relationship between control abilities and the use of strategies to compensate for communicative difficulties (Beckley et al., 2013; Frankel et al., 2007; Fridriksson et al., 2006; Penn et al., 2010; Spitzer et al., 2020).

Building on this, if a control deficit underlies language mixing in aphasia, there may be co-occurring problems implementing communicative strategies. Conversely, if language mixing serves a compensatory strategy, individuals with aphasia may demonstrate (other) communicative strategies, such as gestures, which we take to indicate intact control abilities. In the present study, we focused on conversational repair initiation as a communicative strategy for the following reasons: Because repair initiation was expected to occur frequently during interviews, because it is hypothesised to rely mostly on cognitive flexibility or shifting abilities, and because it is often impaired in individuals with aphasia (Beckley et al., 2013; Frankel et al., 2007).

In the present study, we follow-up on previous research by investigating whether language mixing in aphasia should be understood as a strategy to enhance verbal effectiveness or as involuntary behaviour resulting from an impaired control mechanism. While the question itself is not novel, we aim to provide new insight by approaching it from various perspectives.

Firstly, we explored what individuals with aphasia report about their language control and compensatory abilities in semi-structured interviews. Secondly, we examined instances of mixing observed during these interviews and evaluated how these switches correspond to the self-reports and whether they resemble the mixing patterns as described in the literature on neurologically healthy bilingual speakers. Finally, we aimed to relate bilingual language control abilities to language control capacities outside the bilingual domain. We selected two participants who reported diverging experiences with bilingual language control, and were thus assumed to be at opposite ends of the "control continuum". We assessed their experiences reported during the interview, their observed language mixing behaviour, and its relation to instances of conversational repair initiation.

We formulated predictions based on the hypotheses that language mixing resulted from a control deficit or from lexical compensation. If a control deficit underlies switching, participants should report co-occurring control difficulties. In contrast, if participants use switching as compensation, they might also report benefits of bilingual language knowledge. The underlying cause of language mixing should also impact language mixing patterns. We hypothesised that in cases when language mixing was the result of a control deficit, participants may switch to languages not shared between interlocutors. In addition, they may mix on more marked word types (e.g., function words, Muysken, 2000) and switching may not serve functions as seen in neurologically healthy bilingual speakers. In cases when mixing is employed as a compensatory strategy, participants would switch to shared languages, on typical linguistic units (e.g., content words, interjections), and to serve functions often seen in neurologically healthy bilingual speakers. Finally, we predicted that if mixing results from a control deficit, switches should coincide with other impaired language control behaviour, whereas this should not be the case for lexical compensation. Table 1 summarises these predictions, and Appendix A provides the framework for coding the behaviour observed in the interviews, further discussed below.

Table 1. Predictions for control deficit versus lexical compensation in self-reports, language mixing, and language control behaviour.

	Indicating control deficit	Indicating lexical compensation
Self-reports	Reported difficulties with bilingual language control (e.g., "I find it difficult to suppress my second language".)	Bilingual language knowledge reported to be beneficial in word-retrieval (e.g., "If I don't know a word in Dutch, I say it in Turkish".)
Language mixing		
Pragmatic appropriateness	Switches to languages not shared with interlocutor	**No** switches to languages not shared with interlocutor
Realisation	Switches on **marked** word types	Switches on **typical** word types
Function	Switches **do not** have functions that correspond to those seen in neurologically healthy bilingual speakers	Switches have functions that correspond to those seen in neurologically healthy bilingual speakers
Language control	Switches coincide with other impaired language control behaviour, specifically difficulties initiating conversational repair (e.g., use of gestures, descriptions, or signals)	Switches **do not** coincide with other impaired language control behaviour, specifically difficulties initiating conversational repair (e.g., use of gestures, descriptions, or signals)

Methods

Participants

Nineteen participants with a range of bilingual backgrounds were included in the study. Their (former) speech-language therapists confirmed the presence of chronic (>6 months post onset) aphasia. Sufficient spoken language comprehension abilities were a prerequisite for participation. Two authors (SM and MR) rated features of the participants' connected speech on the six spontaneous speech rating scales of the Dutch Aachen Aphasia Test (AAT; Graetz et al., 1992). Ten participants exhibited speech disorders (dysprosodic speech, dysarthria, and/or apraxia of speech) alongside aphasia, but their speech was sufficiently intelligible to participate in the interviews. (i.e., at least 90% intelligible speech output). The clinical information of the participants is provided in Table 2.

Participants had different first and second languages, and they sometimes knew multiple additional languages. Before the onset of their aphasia, they had an excellent command of Dutch. During the interview, participants reported discrepancies in post-stroke abilities between the languages. Four participants noted that one language initially recovered more quickly or better compared to the other language(s). In the chronic phase of recovery, some interviewees continued to experience differences between their languages. Factors such as age of acquisition,

Table 2. Demographic and clinical characteristics of the participants.

						AAT spontaneous speech rating scales[e]						
Code name[a]	Sex	Age[b]	TPO[c]	Aetiology	Localisation[d]	*A*	*B*	*C*	*D*	*E*	*F*	*Total*
Anton	M	62	101	Haemorrhagic stroke	MCA left hemisphere	2	5	5	2	4	3	21
Arthur	M	47	79	Ischemic stroke (*recurrent*)	MCA left hemisphere	3	4	5	5	4	1	22
Barend	M	57	30	Haemorrhagic stroke	Not available	4	4	5	4	4	4	25
Bram	M	37	83	Haemorrhagic stroke	Left hemisphere	4	5	5	5	5	3	27
Bren	M	67	7	Ischemic stroke (*recurrent*)	MCA left hemisphere	1	3	2	0	0	0	6
Daan	M	22	31	Traumatic brain injury	Basal ganglia (left)	2	2	4	4	4	3	19
Ersel	M	39	34	Haemorrhagic stroke	Intracerebral left hemisphere	3	4	5	5	3	2	22
Gerrit	M	53	57	Haemorrhagic stroke	Basal ganglia	4	5	5	4	4	4	26
Hugo	M	69	119	Haemorrhagic stroke	Not available	2	3	4	3	4	2	18
Jasper	M	55	68	Ischemic stroke	MCA left hemisphere	3	4	4	4	5	2	22
Jens	M	66	21	Ischemic stroke	Not available	3	4	5	4	4	3	23
Lars	M	61	56	Ischemic stroke	Left hemisphere	3	5	4	5	2	1	20
Laura	F	75	50	Ischemic stroke	MCA left hemisphere	3	5	5	4	5	4	26
Madar	M	30	12	Haemorrhagic stroke	Intracerebral left hemisphere	3	5	4	4	4	1	21
Niels	M	63	137	Ischemic stroke	Intracerebral left hemisphere	3	4	5	4	4	2	22
Olaf	M	53	26	Haemorrhagic stroke	Basal ganglia	4	3	5	5	2	5	24
Tessa	F	67	48	Ischemic stroke	MCA left hemisphere	3	5	3	3	5	2	21
Tobias	M	35	54	Traumatic brain injury	Not available	3	4	5	4	5	2	23
Valerie	F	27	64	Ischemic stroke	MCA (total) left hemisphere	3	5	4	4	4	2	22

[a]All names are fictitious; [b] Age in years (rounded); [c] TPO: time post-onset in months; [d] Localisation MCA = middle cerebral artery; [e] AAT rating of spontaneous speech for communicative behaviour (A), articulation and prosody (B), automatised language (C), semantic structure (D), phonemic structure (E), syntactic structure (F), each on a 6-point scale, ranging from 0 (severely impaired) to 5 (not/only mildly impaired), with a total of 30.

Table 3. Language background of the participants.

Code name[a]	Languages[b]	Age of acquisition[c]	Manner of acquisition[d]	Language context[e]	Current language mode[f]	Language in therapy
Anton	L1: Dutch, L2: English, L3: German	Late (L2, L3)	Both (L2, L3)	**L1**	Monolingual	L1
Arthur	L1: Dialect of Dutch, L2: Dutch, L3: German, L4: English	Early (L2, L3) Late (L4)	Both (L2, L3, L4)	L1, **L2**, L3	Multilingual	L2
Barend	L1: Dutch, L2: English, L3: German, L4: Portuguese, L5: French	Late (L2, L3, L4, L5)	Both (L2, L3, L4, L5)	**L1**	Monolingual	L1
Bram	L1: Dutch, L2: English, L3: German	Early (L2) Late (L3)	Both (L2) Instruction (L3)	**L1**	Monolingual	L1
Bren	L1: German, L2: English, L3: Dutch	Late (L2, L3)	Both (L2, L3)	L1, L2, **L3**	Multilingual	L3
Daan	L1: Dutch, L2: English, L3: German	Late (L2, L3)	Both (L2) Instruction (L3)	**L1**	Monolingual	L1
Ersel	L1: Turkish, L2: Dutch, L3: English, L4: German, L5: French	Early (L2) Late (L3, L4, L5)	Immersion (L2) Both (L3) Instruction (L4, L5)	L1, **L2**	Multilingual	L2
Gerrit	L1: Dutch, L2: English, L3: French	Late (L2, L3)	Both (L2, L3)	**L1**	Monolingual	L1
Hugo	L1: Dutch, L2: German, L3: English	Late (L2, L3)	Immersion (L2, L3)	**L1**	Monolingual	L1
Jasper	L1: Dialect of Dutch, L2: Dutch, L3: English	Early (L2) Late (L3)	Immersion (L2) Both (L3)	L1, **L2**	Multilingual	L2
Jens	L1: Dutch, L2: English, L3: French	Late (L2, L3)	Both (L2, L3)	**L1**	Monolingual	L1
Lars	L1: Dutch, L2: English, L3: Swedish	Late (L2, L3)	Both (L2, L3)	**L1**, L2, L3	Multilingual	L1 and L3
Laura	L1: English, L2: Dutch	Late (L2)	Immersion (L2)	L1, **L2**	Multilingual	L2
Madar	L1: Somali, L2: Dutch, L3: English, L4: German	Early (L2) Late (L3, L4)	Immersion (L2) Both (L3) Instruction (L4)	L1, **L2**, L3	Multilingual	L2
Niels	L1: Dutch, L2: English, L3: French	Late (L2, L3)	Both (L2, L3)	**L1**, L2	Multilingual	L1
Olaf	L1: Dutch, L2: English, L3: German, L4: French, L5: Cantonese	Late (L2, L3, L4, L5)	Both (L2, L5) Instruction (L3, L4)	**L1**	Monolingual	L1
Tessa	L1: Papiamento, L2: Spanish, L3: English, L4: Dutch	Early (L2, L3, L4, L5)	Immersion (L2, L3, L4)	L1, L2, L3, **L4**	Multilingual	L4
Tobias	L1: Dutch, L2: German	Early (L2)	Immersion (L2)	**L1**, L2	Multilingual	L1
Valerie	L1: Dutch, L2: English, L3: French	Late (L2, L3)	Instruction (L2, L3)	**L1**	Monolingual	L1

[a]All names are fictitious; [b] Languages spoken by the participant based on order of acquisition, definition of dialects was based on the participant's self-evaluation; [c] Early age of acquisition: ≤7 years old, late age of acquisition: >7 years old; [d] Manner of instruction: immersion, formal instruction, or both; [e] Language of the interview in bold; [f] Information about the current language mode: "multilingual" indicates that the participant frequently interacts in contexts where multiple languages can be used interchangeably.

acquisition context, manner of acquisition, and current frequency and context of language use varied across participants and are summarised in Table 3.

Two participants (Niels and Olaf), who reported opposing experiences regarding their bilingual language control abilities, were selected as case studies to evaluate associations between abilities related to bilingual language control and conversational repair initiation.

All participants gave their informed consent prior to participation. The institutional ethics assessment committee approved the study (case number 2019–5035).

Materials

We conducted semi-structured interviews, consisting of general questions based on the Dutch version of the AAT (Graetz et al., 1992), and additional questions concerning the

interviewee's language background, use, and experiences (Appendix B). These questions were used as a starting point for the interview, but we allowed the conversation to flow naturally, meaning that the participants' answers determined the topic of the conversation and not all questions were asked to each participant. To avoid a clinician-patient style of interaction, we used the Social Conversation Collection Protocol (Leaman & Edmonds, 2021) as inspiration.

Procedure

Due to the COVID-19 pandemic, the study was conducted remotely in a web-based setting. We recruited participants through online communities, aphasia centres, and speech-language therapists. After participants expressed their interest through email or telephone, we contacted them and provided information about the study. Eligible participants completed a written informed consent form on a secure web-based platform (Qualtrics, 2005).

The first author conducted the interviews in a secure peer-to-peer video call in Zoom (Zoom Video Communications Inc, 2012).[2] Participants could use their smartphone, tablet, or computer. Recordings were made to enable transcription. We conducted the interviews exclusively in Dutch (the interviewer's native language) and did not explicitly address the interviewer's knowledge of other languages. In six interviews, partners, family members, or speech and language therapists were present to provide help when needed. Their assistance could concern the technical set-up or the content of the conversation, and resulted in a contribution ranging from 1% to 14% of the interview (expressed in time). Each interview lasted no longer than 45 minutes.

Analysis

Transcription

We transcribed the interviews orthographically to enable a qualitative analysis of the bilingual experiences. Transcriptions were made in the Computerized Language ANalysis platform (CLAN; MacWhinney, 2000), using the Codes for the Human Analysis of Transcripts (CHAT-format, MacWhinney & Wagner, 2010). The Whisper model (Radford et al., 2022) initially automatically transcribed seven interviews. We subsequently reviewed, corrected, and converted these transcripts into CHAT-format where necessary.

In the results section, we provide examples using simplified transcriptions and corresponding translations. Errors are underlined with a dotted line and may concern phonology [p], grammar [g], or semantics [s], or neologisms [n]. Gestures are presented in [square brackets]. Switched material is provided in **bold** in the original transcript and in SMALL CAPITALS in the translation. Pauses are indicated with (.) and unintelligible words with xxx. To increase readability, filled pauses and retraces of the interviewer are omitted in the excerpts.

Coding

Through a data-driven and iterative process, the relevant variables regarding the reported experiences, mixing behaviour and repair initiation (in the two selected cases) were identified. The first author initially marked the variables, after which these were discussed within the research team, resulting in the final framework (Appendix A). We first marked the reported experiences regarding compensatory use of language mixing for word-retrieval difficulties and language control abilities, using qualitative data analysis software ATLAS.ti (ATLAS.ti Scientific Software Development GmbH, 2023).

Next, we identified all instances of mixing during the interview, by marking all other-language material inserted within utterances or produced between utterances. Words that were part of a name (e.g., "Now in Sverige [Sweden] for ten years".) were not considered switches, nor were loanwords, defined here as other-language words that are listed in the Dutch dictionary (e.g., "gaming"). Mixing could comprise a word or a string of words.

In addition, to assess whether the language mixing in the interviews aligned with mixing patterns typically observed for speakers without aphasia, we marked several aspects of the switches. We identified the *position* (intra-sententially or inter-sententially), *linguistic unit* (content words, function words, or phrases), and the *function* (psycholinguistic, sociolinguistic, pragmatic, or metalinguistic) of the switches (Appendix A). The coding of the functions was based on our interpretation of the observed behaviour.

Subsequently, to further examine the realisation of the switches, we coded whether switches were preceded by *hesitations* or followed by attempts to *correct* to the target language. Hesitations and correction attempts were marked because they are informative in establishing the reason to switch (e.g., hesitations preceding a switch can indicate a word-finding difficulty: "Uh uhm uh nip- nifty$_{[\text{switch to English}]}$".) or the level of control or awareness of the switch (e.g., corrections to the target language indicate being aware of switching: "My Klarheit$_{[\text{switch to German}]}$ . . . eh, I understood[$_{\text{correction}}$] more".).

To establish the relative frequency of switches, we compared the occurrence of other-language to the total number of words produced by the participant during the interview (see Appendix C for our definition of a word). As a result, the instances of mixing (comprising of words or strings of words) might differ from our relative measure of switches (based on the number of words in the other language).

Finally, we identified instances of repair initiation in the transcripts of the two selected cases. We marked instances of repair initiation regardless of the successfulness of that behaviour, and interpreted them as an index of monitoring and shifting abilities. We included three forms of repair initiation: explicit behaviours to signal communicative difficulties, descriptions to replace a word (focusing on the initiation of the description, disregarding the effectiveness), and meaningful gestures (iconic or deictic) before a word or replacing a word. These three types of repair initiation were included because the participants were expected to employ these strategies to initiate repair during the interviews, and because these were relatively straightforward to objectively identify and mark.

All instances of mixing and repair initiation were re-coded by second raters to assess the reliability of the initial coding. We analysed the inter-rater reliability using κ_n, an adjusted version of Cohen's kappa for free marginals (Brennan & Prediger, 1981). The inter-rater reliability for the *position* and the *linguistic unit* of the switches was strong (κ_n =

0.87 and $\kappa_n = 0.88$, respectively). There was substantial agreement between coders for the *functions* of the switches ($\kappa_n = 0.80$), but only moderate agreement for the coding of the *hesitations* ($\kappa_n = 0.53$), *corrections* ($\kappa_n = 0.55$), and the *repair initiation* of the first case study ($\kappa_n = 0.56$) and the second case study ($\kappa_n = 0.44$). Because of these relatively low inter-rater reliabilities, the two raters discussed each discrepancy in the ratings until they reached consensus, which improved the final coding. Therefore, the reliability estimates are an underestimation of the actual reliabilities. Reliability is taken into account when discussing the findings.

Results

Self-reports

Compensation for word-retrieval impairments

The potential advantages of bilingualism to mitigate word-retrieval impairments were discussed in eleven of the nineteen interviews (58%). Among these, eight participants (73%) confirmed that their knowledge of two languages could aid word-retrieval in the target language, for example when switches served as substitutes for words in the target language, or when mixing could facilitate word-retrieval in the target language. Tobias illustrated this process in Excerpt 1.

(1) INV[3]: Ja precies. Dus af en toe is er een woord dat komt dan in het Duits omhoog en dan via het Duitse woord kun je dan bij de Nederlandse vertaling komen? Werkt dat zo?
Yes exactly. So occasionally there's a word that comes up in German, and then through the German word, you can arrive at the Dutch translation? Does it work like that?

Tobias: Ja ja. **Verwendung** eh **verwendung** ehm gebruiken.
Yes yes. USAGE *eh* USAGE *ehm using.*

The extent to which this was perceived as a conscious strategy differed between participants. Arthur explained that there are instances where a word in Dutch does not come to mind, but its translation equivalent in his early-acquired L3 does. He clarified that it is not a conscious trick but rather an automatic process. For Arthur, language mixing does not help in retrieving the Dutch target word, it merely replaces it. Other participants indicated that their knowledge of other languages cannot be harnessed to increase their verbal effectiveness. Bren, for instance, described having the correct concepts in mind but not being able to retrieve the correct word regardless of the language. Similarly, Laura explained that she cannot employ her first language (L1) to compensate for word-finding difficulties in her second language (L2; Excerpt 2).

(2) INV: Dus als u één woord in het Nederlands niet weet, dat u het dan in het Engels kunt zeggen.
So, if you don't know one word in Dutch, you can then say it in English.

Laura: Nee **because then I don't have a a a** woord **I can't take**.
No BECAUSE THEN I DON'T HAVE A A A *word* I CAN'T TAKE *[it].*

Nee [shakes head] **doesn't matter**.
No DOESN'T MATTER.

Language control

In thirteen interviews (68%), participants shared their experiences with controlling multiple languages. In these interviews, four participants (31%) explicitly recounted positive experiences. For instance, Arthur reported that he does not experience difficulties separating his languages and that he deliberately switches to his stronger L2 when he is tired. Both Hugo and Bren reported it to be easy to switch between their languages. For Niels, unintended mixing occasionally happens but he asserted that he is able to separate his languages.

More prominent control difficulties were reported in eleven interviews (85%), as some interviewees mentioned both negative and positive consequences of aphasia for language control. For some participants, words in a non-target language sometimes automatically surface, resulting in somewhat of a "jumble". Relatedly, participants may encounter difficulties separating languages: Bren reported that it is challenging to separate his three languages, although this improved over time. In line with this, Ersel reported difficulties with language comprehension in contexts with a high frequency of Turkish-Dutch language mixing.

Finally, participants mentioned that the non-target language may be more active, requiring conscious suppression of that language and a deliberate language choice. Lars, for instance, pointed out that his languages sometimes start to mingle, and that he prefers to focus on one language in a conversation. Olaf experiences pronounced difficulties controlling his languages because his L2 surfaces automatically and before his L1. Laura explained that she unconsciously switches to her L1, which she only notices by observing the reaction of her interlocutors (Excerpt 3).

(3) INV: En heeft u het zelf eigenlijk altijd door dat u in het …
And do you actually always realise that you're in the …

Laura: **No** [shakes head].
No.

INV: Nee precies. Ja.
No exactly. Yes.

Laura: **No** [shakes head]. Nee **I I don't have uh** het door.
No. No I don't uh notice it.

Language mixing

The results of the language mixing analysis showed that there was variability among participants in their use of other-language material during the interviews (Table 4). For instance, Laura produced 49% of her words in the non-target language English, while three participants only used Dutch words during the interview. Crucially, most participants produced only a limited number of words in the non-target language throughout the interview.

Table 5 presents the instances of mixing observed in the dataset, with information about the position of the switch, the switched linguistic units, and the realisation of the switch. After excluding the names and loanwords, 244 instances of mixing remained. There were more intra-sentential switches ($N = 183$) than inter-sentential switches ($N = 61$).

Table 4. Occurrences of switched words per participant.

Participant	Words produced in non-target language	Total words	% words produced in non-target language
Anton	1	1349	0.1%
Arthur	1	2140	0.0%
Barend	1	1534	0.1%
Bram	15	7790	0.2%
Bren	51	978	5.2%
Daan	4	479	0.8%
Ersel	4	1900	0.2%
Gerrit	12	3788	0.3%
Hugo	48	1605	3.0%
Jasper	3	1344	0.2%
Jens	0	1311	0.0%
Lars	26	1815	1.4%
Laura	450	917	49.1%
Madar	0	1245	0.0%
Niels	29	1799	1.6%
Olaf	21	867	2.4%
Tessa	2	1538	0.1%
Tobias	14	1342	1.0%
Valerie	0	1455	0.0%

Table 5. Counts and percentages of the switches, including information about position, material, and realisation.

Position	Linguistic unit (% within column)		Realisation (% within row)	
			Preceded by hesitation	Followed by correction attempt
Inter-sentential	Content word	3 (5%)	0 (0%)	0 (0%)
	Function word	4 (7%)	0 (0%)	0 (0%)
	Phrase	54 (89%)	12 (22%)	7 (13%)
	Uncategorised	0 (0%)	0 (0%)	0 (0%)
	Total	61 (100%)	12 (20%)	7 (11%)
Intra-sentential	Content word	79 (43%)	33 (42%)	20 (25%)
	Function word	54 (30%)	10 (19%)	12 (22%)
	Phrase	49 (27%)	19 (39%)	6 (12%)
	Uncategorised	1 (1%)	0 (0%)	0 (0%)
	Total	183 (100%)	62 (34%)	38 (21%)
Total	Content word	82 (34%)	33 (40%)	20 (24%)
	Function word	58 (24%)	10 (17%)	12 (21%)
	Phrase	103 (42%)	31 (30%)	13 (13%)
	Uncategorised	1 (0%)	0 (0%)	0 (0%)
	Total	244 (100%)	74 (30%)	45 (18%)

Inter-sentential language mixing

We found 61 inter-sentential switches in the dataset. Naturally, most of these switches were on entire phrases (54 instances). Regarding the realisation of the switches, a minority of the inter-sentential switches was preceded by a hesitation (20%) or followed by a correction attempt (11%). Of these switches, one was interpreted as serving a sociolinguistic function and six appeared to have a metalinguistic function (Table 5). In switches with a metalinguistic function, participants switched to the other language to comment on their abilities in that language (Excerpt 4).

(4) INV: Dat u toch makkelijk wisselt naar het Duits.
That you easily switch to German.

Hugo: Ja **das ist kein Problem**.
Yes, THAT'S NOT A PROBLEM.

The majority of inter-sentential mixing was classified as having a psycholinguistic function (85%). In these cases, we assumed that the switch was the result of a difference in lexical accessibility, where the intended word was easier or faster to retrieve in the non-target language. Importantly, most of the inter-sentential switches were produced by one participant: Laura showed a substantial number of such switches (45 instances, contributing 74% of the total inter-sentential switches). These switches often concerned a shift from her L2 Dutch to her L1 English (Excerpt 5).

(5) INV: Dat is omdat u al zoveel van de wereld heeft gezien, bedoelt u?
That is because you have already seen so much of the world you mean?

Laura: Ja **because uh otherwise uh you think.**
Oh I wanted to do this and I want to do that
And I had it.

Importantly, Laura mentioned that she unconsciously switches to her L1 English when trying to speak in Dutch. Furthermore, only seven (16%) of her inter-sentential switches were followed by an attempt to provide a correction to the target language. Her language mixing pattern in combination with the self-reports lead us to suggest that while many of Laura's switches are the result of a difference in lexical accessibility (i.e., a psycholinguistic function), she is unable to consciously monitor or suppress the more active non-target language. As such, her switches may in fact be the result of a control deficit.

Intra-sentential language mixing

Most of the instances of mixing were intra-sentential (183 out of 244 switches, 75%). Intra-sentential mixing mostly concerned content words (43%), followed by function words (30%) and phrases (27%, Table 5). Compared to the inter-sentential switches, more intra-sentential switches were preceded by hesitations (34%) and followed by attempts to correct to the target language (21%, Table 5), but this should be interpreted with some caution given that the initial inter-rater reliability of these variables was initially only moderate. Of the intra-sentential switches, 21 (11%) were used as examples and their function can thus be interpreted as metalinguistic (Table 6). In these cases, participants seemed to switch to illustrate their language knowledge (Excerpt 6), explain how the languages they know differ (Excerpt 7), or provide an example of how their knowledge of multiple languages helped them (Excerpt 8).

Table 6. The postulated functions of inter-sentential and intra-sentential language mixing, counts and percentages per position.

	Function			
Position	Metalinguistic	Psycholinguistic	Sociolinguistic	Uncategorised
Inter-sentential	6 (10%)	52 (85%)	1 (2%)	2 (3%)
Intra-sentential	21 (11%)	152 (83%)	8 (4%)	2 (1%)
Total	27 (11%)	204 (84%)	9 (4%)	4 (2%)

(6) Tobias: Wel ehm eerste woord van eh op Frans **fromage**. Kaas!
Well ehm first word of eh on [g] French CHEESE*. Cheese!*

(7) Lars: Want ook een [gesture hand] andere uh **trött** bijvoorbeeld trit.
Because also another uh TIRED*, for example, tired [p].*

i(n) Holland is uh **trött** uh moe moe.
in Holland [s] is uh TIRED *uh tired tired.*

(8) Jasper: Ehm (.) ehm (.) ehm (.) heel vroeger, maar ja, vijf jaar geleden, dan eh logopedie geweest.
Ehm ehm ehm a long time ago, but yeah, five years ago, then eh speech therapy had [g].

Maar dan plaatje huis, maar dan eh **home home** maar dan ja.
But then picture house, but then eh HOME HOME*, but then yeah.*

Eh eh verst- ja begrijpen **home** maar dan eh huis ja.
Eh eh hea- [s] yes understand HOME *but then eh house yes.*

Language mixing that could be marked as serving a sociolinguistic function was scarce in the dataset. Bram is the only interviewee who showed multiple switches that could be explained in terms of emphasising one's own identity. During the interview, Bram mentioned that he has been part of an international gaming community, where English is the lingua franca (Crystal, 2001). The switches he produced resemble those that have been observed in online writing of young Dutch people (Verheijen & Van Hout, 2022), and often concerned affective language (Excerpts 9 and 10) or discourse markers (Excerpt 11). The finding that most of the switches were not preceded by hesitations nor followed by correction attempts, adds to our interpretation of a sociolinguistic function of these switches. It must be noted, though, that Bram's insertions of English words could also be explained as *lexical borrowings* rather than true language mixes.

(9) Bram: Maar dat is wel **super cute** natuurlijk.
But that's SUPER CUTE*, of course.*

(10) Bram: Dat is dan **annoying** zeg maar.
That's kind of ANNOYING*, you know.*

(11) Bram: Maar ehm ja **anyway** die dus ik ben tot begin van de corona . . .
But, ehm, yeah, ANYWAY*, that so I was until the beginning of the corona . . .*

Consistent with the inter-sentential switches, we argue that most of the intra-sentential switches in the dataset served a psycholinguistic function and were the result of a difference in the ease of lexical access between the languages. Several factors may have contributed to these lexical access differences. First, participants seemed to encounter *word-finding difficulties*, exemplified by filled pauses or hesitations, and this may have prompted a switch to the other language in case the translation equivalent was easier to retrieve (Excerpt 12). Sometimes, such switches were followed by an attempt to correct with a translation to the target language (Excerpt 13). Secondly, the absence of a translation equivalent with the exact same meaning might also explain why words in the non-target language were easier to access (Excerpt 14). Thirdly, we assumed that the

difference in lexical accessibility could have been driven by a more frequent use of specific words in one language than the other (Excerpt 15).

(12) Niels: Uh [four fingers up] vier *m- m-* **months** geleden krijg ik een beroerte [waves hand].
Uh four m- m- MONTHS *ago I have [g] a stroke.*

(13) Tobias: Ja ja ja en ook ehm **hörbucher** (.) hoorspelen.
Yes, yes, yes, and also, ehm, AUDIOBOOKS *(.) radio plays [s].*

(14) Arthur: i- is is niet zo uh uhm (.) uh **nip- nifty** en zo maar het het werkt uh voorlopig dus uh.
i- is is not like uh uhm (.) uh NIP- NIFTY *and all, but it it works uh for now, so uh.*

(15) Laura: And then I got a [points to head] **herse- herseninfarct**.
And then I got a BRAI- BRAIN INFARCTION.

Finally, some words may have been easier to access because they were cued by the preceding context. This was mainly the case for Laura, whose default language during the interview appeared to be English (L1). In some utterances, she inserted Dutch nouns that were included in the question (Excerpt 16). A likely explanation for these intra-sentential switches is that certain salient words in the immediately preceding context received an activation boost, making this specific word temporarily more accessible in Dutch than English. Importantly, as noted before, Laura indicated to have difficulties controlling her language choice. As such, these intra-sentential switches may be involuntary, and result from priming effects that reflect an activation process rather than an intentional switch to the target language.

(16) INV: Heeft u ook geen duidelijke herinneringen aan die eerste periode? Of?
You also don't have clear memories of that first period? Or?

Laura: **Uhm (.) i- uhm I know what uhm I was doing.**

INV: Hmm.

Laura: **But I I don't have any** herinnering **that uh doing wrong** [g].
but I DON'T HAVE ANY *memory that uh doing wrong [g].*

More evidence for intra-sentential language mixing that could be the result of control deficits were switches on function words (e.g., Muysken, 2000). Two participants switched frequently on function words: Olaf (13 instances) and Bren (29 instances). For Bren, the interview was conducted in his L3. His switches predominantly concerned insertions of function words, most notably "und" (*and*) in his L1 German (Excerpt 17). In only a few cases, his switches were corrected to Dutch (Excerpt 18). In line with this more marked language mixing pattern, Bren described that he cannot use his multiple languages to compensate for word-retrieval deficits, and that he experiences difficulties separating his languages, although this slowly improves over time. Olaf reported similar experiences and also showed intra-sentential mixing of function words to his L2 English.

(17) Bren: **Und** Engels **und** ja zie die uh ja dat di- di-. . .
AND *English* AND *ja see that uh yes that di- di. . .*

(18) Bren: En dat s- uh het het uhm uhm uh ik w- weet niet **wo** waar w- w- wat we uh. . .
And that s- uh it it uhm uhm uh I d- don't know WHERE *where w- w- what we uh. . .*

In summary, the results for the language mixing patterns show that most of the participants produced few instances of mixing and adhered to the pragmatic context of the interview. Moreover, the majority of participants switched by inserting content words into the structure of Dutch sentence, which aligns with the literature on neurologically healthy bilingual speakers (e.g., Muysken, 2000). Finally, we saw that many switches appeared to be the result of differences in lexical access between languages (i.e., psycholinguistic function), and that there were some instances of metalinguistic or sociolinguistic reasons to switch.

Two case studies

The previous sections revealed variability in the participants' experiences and language mixing patterns. To further explore language control mechanisms in bilingual individuals with aphasia, we focused on two interviewees with diverging experiences: Niels, who reported no control difficulties, and Olaf, who experienced problems suppressing his L2. We address their self-reports, language mixing, and repair initiation observed in the interviews.

Niels: Unimpaired language control?

Niels is a 65-year-old man with chronic aphasia and apraxia of speech due to an ischemic stroke in the left hemisphere eleven years prior to the interview. He is a non-fluent speaker with slightly slowed and staccato speech. His spontaneous language production is characterised by word-finding difficulties and simplified syntactic structure. His spontaneous speech was rated 22/30 on the AAT assessment scale (Graetz et al., 1992). Niels is a native speaker of Dutch and a late learner of English (L2) and French (L3). He acquired his L2 and L3 through formal instruction and immersion. Pre-morbidly, he was a highly proficient, balanced Dutch-English bilingual with frequent use of both languages. He currently still uses both languages daily.

Interview

Niels exclusively reported positive experiences regarding compensation and control during the interview. He said that he sometimes uses his other language to retrieve a word, and answered "of course!" to the question whether this should be viewed as a strategy. Consequently, he indicated that he considers his knowledge of multiple languages beneficial. In similar vein, Niels reported that he does not mix his languages unconsciously and although mixing occasionally happens, he explains that he "knows the languages".

Language mixing

Niels produced 29 words (1.6%) in the non-target language. These words were part of 12 switches, one produced inter-sententially and 11 intra-sententially. Niels provided corrections to the target language for three of his switches, and nine switches were preceded by hesitations or filled pauses. The switches concerned, for example, interjections (*"whatever", "oh wait"*) or idiomatic expressions (Excerpt 19). Moreover, Niels showed multiple switches that can be interpreted as self-cueing via his L2. In Excerpt 20, the switch is

preceded by a filled pause and an explicit signal of a word-finding difficulty (*"What do you call that?"*), and is followed by the Dutch target word. Finally, there were examples of switches that were likely to have been primed by the preceding context. In Excerpt 21, the English title of the movie may have primed the switch to English on the word "speech".

(19) Niels: Nou niet uh mijn mijn **cup of tea** nee en uh Hazes ook niet maar . . .
Well, not uh my my CUP OF TEA, *no, and uh, Hazes neither, but. . .*

(20) Niels: Ik vind het uh i- i- i- i- i- ik uh mijn uh familie uit Frankrijk uh ja d- die uh schoonfamilie is uh . . .
I find it, uh, i- i- i- i- i- I, uh, my, uh, family from France, uh, yes, my i- uh in-laws are, uh. . .

Hoe noem je dat?
What do you call that?

Dead uh overleden.
DEAD, *uh, deceased.*

(21) Niels: Maar de eerste keer dat ik film zien uh na de beroerte was the King's Speech.
But the first time I see [g] a movie after the stroke was "The King's Speech".

INV: Oh oké!
Oh okay!

Niels: Geweldige film.
Great movie.

INV: Ja is een prachtige film.
Yes, is a wonderful film.

Niels: Dat gaat over de koning in Engeland die die uh stottert en dat is geweldig.
It's about the king in England who who uh stutters and that is fantastic.

INV: Ja.
Yes.

Niels: En de eerste keer dat ik- gaat over uh **speech** [points to mouth].
And the first time that I- it's about uh SPEECH.

Repair

Niels showed 73 instances of repair initiation during the interview, indicating that the percentage of repair behaviour over total number of words during the interview was 4%. There were seven occurrences of signalling (Excerpt 20), two descriptions, and 64 gestures. Excerpt 22 illustrates how Niels used gestures to support the target word "think". In the same example, he gave a description of how he can use his knowledge of English to communicate a message.

(22) Niels: Ja tuurlijk want uh ja i- ik ik denk oh ja is beter [points to head].
Yes of course because, uh yes, I- I think, oh yes is better.

Ja uh wat is een l- l- uh misdaad dingen uh **crime crime** nee ja uh ja dan ga je [points to head]. . .
Yes uh what is a l- l- uh crime things, uh, CRIME, CRIME, *no yes uh yes, then you go. . .*

Olaf: Impaired language control?

Olaf, a 54-year-old man had a haemorrhagic stroke in his basal ganglia three years prior to the interview. Olaf is a non-fluent speaker whose speech is mostly characterised by articulatory and phonemic difficulties, as he has concomitant apraxia of speech. He exhibits no clear syntactic impairment and his word-finding problems are not prominent in spontaneous speech, which was rated 24/30 on the AAT assessment scale (Graetz et al., 1992). Dutch is his mother tongue, and he is a late learner of English (L2), which he acquired through formal instruction and immersion since he lived and worked abroad. He also learned German, French, and Cantonese, albeit to more limited levels of proficiency. Prior to his stroke, he was a highly proficient speaker of English and a balanced bilingual, who used his L2 reportedly 90% of the time. After his stroke, Olaf indicated that he wanted to focus on improving his Dutch.

Interview

Olaf solely reported negative experiences with language control during the interview. He explained that his knowledge of English is no longer beneficial but interferes with speaking Dutch. When he intends to communicate a message in Dutch, the non-target English is automatically activated, and Olaf needs to deliberately translate each word before speaking (Excerpt 23).

(23) INV: Bedoelt u dat u dat nu nog steeds makkelijk spreekt? Makkelijker?
Do you mean that you still find it easy to speak now? Easier?

Olaf: [shakes head] Ja makkelijker **but** want het komt als de eerste taal in mijn hoofd op.
Yes, easier, BUT *because it comes up as the first language in my head.*

INV: Echt waar?
Really?

Olaf: Dan dan Engels dan **to** Nederlands dan **to** paar- praten.
Then, then English, then TO *Dutch, then* TO *a spe- speaking.*

Language mixing

Olaf used 21 words (2.4%) in the non-target language, and these were part of 18 switches that were all produced intra-sententially. His switches comprised four content words, thirteen function words, and one phrase. There were correction attempts in five switches and four were preceded by a hesitation or filled pause. Excerpt 24 illustrates a switch on a noun that is preceded by false starts and followed by a correction to Dutch. In Excerpt 25, Olaf switched on pronoun "everything", which is subsequently corrected to Dutch. The most striking pattern is the switching on short function words (Excerpt 26). In line with his own reports, our interpretation is that these switches are caused by difficulties suppressing his L2.

(24) Olaf: En (.) wonen in een vreemd **kl**- **l- kanty** wonen in een vreemd gebied ook leuk.
And (.) living in a foreign c- c- COUNTRY *[P], living in a foreign area, also fun.*

(25) Olaf: i- parijt en de opelheid en de [waves hand] **everything** al- al- (.) alles.
i- parijt [n] and the opelheid [n] and the EVERYTHING *ev- ev- everything.*

(26) Olaf: Ja **it** gaat beter.
Yes IT *gets better.*

INV: Hmhm.

Olaf: Maar **still** maar st- **it** gaat stap voor stap.
But STILL, *but st-* IT *goes step by step.*

Repair

Olaf showed a total of 25 instances of repair, and the percentage of repair behaviour over total number of words produced during the interview was 2.9%. His repair behaviour included nine occurrences of signalling and sixteen gestures. One frequently observed repair is a gesture used to signal that he needed more time to verbalise his message (Excerpt 27). After this signal, he was generally able to produce the target answer.

(27) INV: En dus een grote retailer, is dat een kledingwinkel of. . .
And so, a big retailer, is that a clothing store or. . .

Olaf: Nee tis i- **it** o- ehm even wachten [holds up hand].
No, it's i- IT, *ehm, wait a moment.*

INV: Ja.
Yes.

Olaf: Het i- het is een schoenenbedrijf.
It i- it is a shoe company.

Discussion

This study aimed to provide new insight into the question why bilingual individuals with aphasia mix their languages, and whether their mixing behaviour should be considered the result of control deficits or as a strategy to enhance verbal effectiveness. We discuss the self-reported experiences with language control, language mixing patterns observed during the interviews, and elaborate on the two cases who reported diverging experiences with language control. It should be kept in mind that the inter-rater reliability was strong for position and linguistic unit of the switches, and good for their functions, but initially only moderate for the hesitations, corrections, and repair initiations. Therefore, consensus coding was ultimately used.

Self-reports about bilingual experiences

The self-reports indicated that eight out of eleven interviewees (73%) reported to recruit their bilingual language knowledge to compensate for word-retrieval deficits. Differences were described in the intentionality of these switches and whether they served as substitutions or aids in retrieving the target word in the intended language. The issue of language control was addressed in thirteen interviews, and within these, a majority (85%) experienced difficulties controlling their languages, which was often considered disruptive for their daily communication. The reported control difficulties primarily concerned the automatic and involuntary co-activation of both languages, leading to

problems separating and suppressing the languages. The stage at which the control difficulties arise, varied across participants. For some, the non-target language could not always be inhibited proactively but they were able to monitor their output. For one interviewee, inhibition could not be selectively applied to the non-target language, nor was it possible to monitor the language of the output.

Our results thus reveal variability in the self-reported experiences regarding compensatory use of two languages and the presence of control difficulties. Previous research also reported variability in the presence and extent of control impairments in bilingual individuals with aphasia (e.g., Dash & Kar, 2014; Grunden et al., 2020). However, to our knowledge, this study is the first that corroborates these findings with self-reports of bilingual speakers with aphasia. From these results, we can conclude that persons with aphasia are often aware of their (language) control abilities and are able to reflect on these competences. Furthermore, our results indicate that self-reported bilingual language control difficulties appear to occur in the majority of individuals with aphasia, although future research should explicate whether the prevalence of such impairments is impacted by the bilingual background of individuals.

Typical language-mixing patterns

The language mixing analysis revealed that most participants showed no or very few instances of mixing. Instead, they answered almost exclusively in the target language. Notably, when mixing did occur, it primarily involved switches to English, despite the participants having diverse language backgrounds encompassing various languages. It is possible that participants made assumptions about the interviewer's language knowledge, as English use and proficiency is widespread in academia and in the Netherlands in general (Edwards, 2016). Consequently, most participants seemed to only switch to languages assumed to be shared between interviewer and interviewee, and thus adhered to the pragmatic context of the interview. These results corroborate earlier research that found no evidence for pragmatically inappropriate language mixing in bilingual individuals with aphasia (Chengappa et al., 2004; Goral et al., 2019; Paplikar, 2016; Riccardi, 2004). The participants' sensitivity to the pragmatic contexts has likely prevented them from mixing their languages in the monolingual setting of the interviews. To explore the mixing patterns of individuals with aphasia more extensively, future studies could include bilingual interviewers who use both their languages to stimulate an environment to mix languages.

Furthermore, the language mixing patterns generally aligned with those observed in neurologically healthy bilingual speakers, both in terms of switched elements and their functions. In most cases, switches involved intra-sentential insertions of single content words, serving metalinguistic, sociolinguistic, or psycholinguistic functions (e.g., Muysken, 2000; Poplack, 1980). These findings are in line with earlier studies that reported few qualitative differences between individuals with and without aphasia (Chengappa et al., 2004; Grosjean, 1985; Muñoz et al., 1999), although it is important to point out that our study did not include a direct comparison between speakers with and without aphasia within the same setting. The specific functions of language mixing in persons with aphasia had not been extensively studied, as previous research administered more constrained narrative elicitation tasks (Bihovsky et al., 2023; Goral et al., 2019; Lerman et al., 2019;

Neumann et al., 2017), or focused on the structural properties of switches (Muñoz et al., 1999; Paplikar, 2016). Admittedly, our results of the functions of the switches are based on interpretations of the observed behaviour. Future research could further investigate the functions of switches by bilingual individuals with aphasia in a more controlled setting. Although the inter-rater reliability was strong for position and linguistic unit of the switches, and good for their functions, it was initially only moderate for hesitations, corrections, and repair initiations. To improve reliability, we have solidified our results by using a consensus coding.

Language mixing that served a metalinguistic function suggests that participants were able to intentionally access their other languages to convey a message. In addition, the participant who produced switches that appeared to be driven by sociolinguistic factors, showed switching patterns that resembled those seen in neurologically healthy bilingual speakers (Verheijen & Van Hout, 2022). Additionally, many switches were likely the result of differences in ease of lexical access, a key factor in language mixing among healthy bilingual speakers (Heredia & Altarriba, 2001). Individuals with aphasia may experience more pronounced lexical accessibility difficulties due to their language impairment, potentially resulting in increased mixing frequency (Bihovsky et al., 2023; Chen, 2018; Goral et al., 2019; Lerman et al., 2019; Muñoz et al., 1999; Paplikar, 2016).

Furthermore, our results showed instances of explicit self-cueing via the other language. In such cases, participants encountered word-retrieval problems, often accompanied by (filled) pauses, hesitations, or explicit signals. This was followed by a switch and, in some cases, by corrections to the translation equivalent in the target language. Notably, this realisation of mixing contradicts a control deficit interpretation (Abutalebi et al., 2000). Self-cueing is known to be an effective communicative strategy for individuals with aphasia in general (e.g., Berman & Peelle, 1967; Tompkins et al., 2006), and has also been used in an intervention to train switching back to the target language for a bilingual with aphasia who involuntarily switched to the non-target language (Ansaldo et al., 2010). Our results indicate that language mixing may be used as a self-cueing strategy and should therefore not always be discouraged in clinical practice (see also Hameau et al., 2022). Additional research into the effectiveness of self-cueing via the other language is an important direction for future studies.

Marked language-mixing patterns

The results of the current study demonstrate that the majority of our participants exhibited typical mixing patterns that were often driven by differences in lexical accessibility. However, three participants displayed more marked language mixing: Laura, Bren, and Olaf. Their switches may be attributed to language control impairments. This interpretation was based on several factors, including the participants' self-reported difficulties with language control, the characteristics of the switched elements, or the absence of corrections for switches.

Laura, who reported limited control over her languages, tended to switch from her late-acquired L2 (Dutch, the target language of the interview) to her L1 (English) upon answering questions. These inter-sentential switches have been associated with language control impairments (Fabbro, 2000; Perecman, 1984). Moreover, the observed intra-

sentential switches to the target language were argued to result from automatic bottom-up activation of lexical items in the preceding context, rather than intentional switches. This pattern aligns with observations from neurologically healthy bilingual speakers, where language mixing can be *triggered* by priming from words in the context (Broersma & de Bot, 2006; Clyne, 2003; Wintner et al., 2023). Investigating whether bilingual individuals with aphasia are more susceptible to triggered mixing than neurologically healthy bilingual speakers, is a direction for future research.

For Bren, the interview also took place in his late-acquired L3. His language background and the severity of his language impairment might have contributed to his frequent and marked language mixing, often involving short function words – an uncommon pattern among healthy bilingual speakers (Muysken, 2000). Switching on function words has previously been attested in bilingual individuals with aphasia, and has been explained as an attempt to enhance fluency (Bihovsky et al., 2023). Bren reported difficulties in separating his languages. These observations together lead us to suggest that his mixing patterns were, at least partially, caused by a problem with language control.

Olaf also switched frequently on short function words. Because he is a native speaker of Dutch residing in the Netherlands, it appeared unlikely that he switched to his L2 to compensate for language deficits, making a control deficit more plausible. This interpretation aligns with his self-reports and localisation of his lesion in the basal ganglia, a subcortical brain structure that is part of a wider network hypothesised to be crucial for bilingual language control (Abutalebi et al., 2000; Aglioti et al., 1996; Ansaldo et al., 2010; Calabria et al., 2018; Green & Abutalebi, 2008; Van der Linden et al., 2018).

In sum, it seems that post-morbid patterns of language switching may depend on severity of the word-finding difficulties, pre-morbid language proficiency or language use, and age of acquisition of the second language. The participants in our study varied considerably regarding these variables, but our modest sample size rendered a systematic investigation of these factors difficult. Future studies could examine the potential influence of bilingual background on language switching in a larger group (see also Bihovsky et al., 2023), and could include a more thorough examination of the severity of the language disorder.

Highlighting variability in two cases

We further examined the experiences and language mixing behaviour of Olaf and Niels, two cases who illustrated the diversity within our participant group. Despite their similar language backgrounds, these two cases reported diverging experiences with bilingual language control. Their self-reports during the interviews were consistent with the mixing patterns. Both participants proved to be able to initiate conversational repair during the interview, taken as index of language control abilities in functional communication (Frankel et al., 2007; Penn et al., 2010; Spitzer et al., 2020), although Niels showed a higher occurrence of repair initiation as compared to Olaf.

This difference between Niels and Olaf could imply that the bilingual language control difficulties experienced by Olaf that result in problems suppressing his L2, are part of a more general language control problem that may sometimes prevent him from

initiating repair upon encountering communicative difficulties. However, these results should be regarded as exploratory, because the observed differences were small and repair initiation was analysed in a relatively uncontrolled setting. Moreover, repair was initially assessed with only moderate inter-rater reliability. Importantly, Olaf was able to limit his language mixing to only 2% of the words produced during his interview, suggesting that he was often able to suppress the interference he experienced from his bilingual language knowledge. In addition to this, Olaf appeared to be able to initiate communicative repair in many cases. This finding could suggest that bilingual language control difficulties are, to a certain extent, distinguishable from language control problems expressed in the ability to initiate repair. Further research including a larger group is needed to elucidate this question. Future studies could also elaborate on the various forms of (non)verbal compensatory strategies that persons with aphasia use.

Conclusion

This study showed that although many bilingual individuals with aphasia report to experience difficulties controlling their languages, they also report their knowledge of multiple languages to be beneficial in word retrieval. A similar variability exists regarding their language mixing patterns but importantly, most participants adhered to the pragmatic context of the interview and rarely switched. Furthermore, the observed switches often resembled those of healthy bilingual speakers in terms of realisation and function. Three participants exhibited atypical mixing patterns, both quantitatively and qualitatively. We argued that their mixing was likely, at least partially, the result of difficulties with language control. Importantly, all three participants were able to accurately reflect on their abilities. A more detailed exploration of two participants with diverging control experiences further illustrated the variability in this population, and indicated that diverging reported bilingual language control experiences did not coincide with clear differences in the ability to initiate conversational repair. This study highlights that, despite variability, the majority of bilingual individuals with aphasia effectively manage their two languages. Control deficits appear to exist in a small number of bilingual individuals with aphasia, and may result in marked language mixing behaviour.

Notes

1. Different terminologies and definitions of language mixing have been proposed, but we use "language mixing" to encompass all forms of language alternation in a conversation. Consequently, we will use the terms "mixing", "switching" and "alternation" interchangeably.
2. For one participant, the BigBlueButton software was used for the interview. BigBlueButton is a secure platform that was made available to us by the Max Planck Institute for Psycholinguistics.
3. INV refers to the interviewer.

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Appendices

Appendix A. Framework for coding behaviour observed in interviews

Behaviour	Definition
Self-reports: Compensation through bilingual knowledge	Self-reports about whether the knowledge of other languages can be used to compensate for language difficulties. Could be coded as negative or positive. *Example negative valence: "I cannot use English as a trick to find a word".* *Example positive valence: "I use my Turkish when I can't find a word".*
Self-reports: Control abilities	Self-reported bilingual language control abilities (e.g., switching, interference suppression). Could be neutral, negative, or positive. *Example neutral valence: "It is difficult to say if languages interfere".* *Example negative valence: "Sometimes, my languages interfere".* *Example positive valence: "It costs me no time to switch between languages".*
Language mixing	All other-language material produced by the interviewee.
Position	
Inter-sentential	A switch between languages that happens at clause boundaries, between turns, or between utterances. *Example: "Wat is er? **What is wrong?**"*
Intra-sentential	Insertion of lexical items or constituents from one language into structure of other language. *Example: "I can't walk outside **alleen** [DUTCH]".*
Material	
Content	Switching on content words (nouns, main verbs, adjectives, adverbs). *Example: "I filled out that **beurs** [DUTCH]".*
Function	Switching on function words (prepositions, determiners, auxiliary verbs, conjunctions, pronouns, interrogatives, interjections). *Example: "Yes easier, **maar** [DUTCH] it comes up first".*
Phrase	Switching on a string of words. *Example: "My **man zegt** [DUTCH] something is wrong".*
Realisation	
Preceded hesitation	Switch is preceded by a hesitation (repetition of target phonemes) or a filled pause ("uh"). *Example: "Uh uhm uh nip- nifty".*
Correction attempt	Switch is followed by an attempt to correct to target language. *Example: "My **Klarheit** [GERMAN], **eh, I understood more".***
Function (following e.g., Appel & Muysken, 1987; Heredia & Altarriba, 2001; Myers-Scotton, 1979 ; Poplack, 1980)	
Metalinguistic	Switching to comment directly or indirectly on languages involved. *Example: "The only thing I know in French is **sortie** [FRENCH]".*
Sociolinguistic	Switching to align with or differentiate from a social group, express or emphasize own identity. *Example: "I think that really **super cute** [ENGLISH]".*
Pragmatic	Switching to involve hearer directly, to include or exclude persons from conversation. *Example: "**Hola hermana** [SPANISH], how are you?"*
Psycholinguistic	Switching when the non-target language is (momentarily) easier to retrieve. *Example: "And also uhm **hörbucher** [GERMAN] . . . radio plays".*
Repair initiation	Communicative behaviour signalling language control impairments or abilities, defined as the presence of repair initiation (regardless of success).
Signal	Communicative behaviour with which the interviewee signals (s)he encounters difficulties (and potentially asks for help). *Example: "What do you call that?"*
Description	Interviewee provides a description of the target word. Description should not be a synonym and should contain > 2 words. *Example: "Yes, it's a thing to put flowers in". (for vase)*
Gestures	Interviewee provides a gesture to substitute or help retrieve a target word. Can be iconic (form a meaning related to the meaning articulated in speech) or deictic (pointing, showing, giving, and reaching). *Example: "A big book [gesture size] Dick Swaab about the [points to head] uh **the brain**".*

Appendix B. Interview questions

Interview questions taken from the Dutch AAT (Graetz et al., 1992)

(1) Can you tell me what happened to you?
  (a) How are you doing now?
  (b) How is your speech now?
  (c) What speech problems were there in the beginning?
(2) What is/was your profession?
  (a) Where did you last work?
  (b) What exactly did you have to do there?
  (c) Can you tell me more about that?
  (d) How did you come to that choice?
(3) Where do you live? Can you tell me something about your family?
(4) What do you like to do in your free time? Do you have any hobbies?

Questions about bilingualism:

(1) Can you tell me about the languages you speak?
  (a) What is your native language?
  (b) Which other languages do you speak?
(2) Where did you learn these languages?
(3) When did you learn these languages?
(4) How well do you speak these languages?
(5) How often and where do you speak these languages?
(6) Do you notice a difference between the two languages before and after your brain injury? If so, in what way?
(7) What does being bilingual mean to you?
(8) In which situations do/did you speak these languages?
(9) How important is it for you to speak both languages?
(10) Does your bilingualism have only advantages, or do you also encounter difficulties? Can you explain how that works?
(11) Does knowing another language help you with speaking Dutch? If so, in what way?
(12) Do you ever have trouble keeping your two languages apart? If so, in what way?
(13) Do you feel that others understand you well when you mix two languages?
(14) Did you practice both languages after your brain injury? If not, why not? If yes, how was that?

Appendix C. Definition of words used for the word count

The definition of words was based on Nicholas and Brookshire (1993) and Bihovsky et al. (2023). We counted all words or partial words that were intelligible in context. Words did not have to be accurate, relevant, or informative.

Included:

- All words or partial words that were intelligible in context, also if they were repeated, retraced, or revised.
- Words that contain sound substitutions, omissions, distortions, or additions if the word is intelligible in context, also if they result in a real word that was not the target.
- Sound combinations denoting a specific object or action.
- Filler words, phrases, interjections, and informal terms.
- Common contractions or simplifications of words.
- Each word in numbers.

- Compound words were counted as one word.
- Each word in proper names.
- Acronyms were counted as one word.

Excluded:

- Words or partial words that are not intelligible in context:
    - Neologisms
    - False starts
    - Vocalisations
    - Non-word fillers