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LANGUAGE PRODUCTION IN PTSD: EVIDENCE FOR FEATURES ASSOCIATED WITH BROCA'S APHASIA IN TWO CASE STUDIES

This pilot study investigates whether individuals with PTSD (IWPs), in general and during flashbacks, exhibit linguistic deficits reminiscent of Broca's aphasia. The study is motivated by two things: 1) research documenting Working Memory (WM) deficits in IWPs as well as lower activity in Broca's area (BA 44-45) during flashbacks specifically; 2) a theory suggesting that Broca's aphasia arises from general resource reductions, likely in working memory capacity (WMC), prompting more economical language production. If this theory is correct, it predicts a similar response in other groups experiencing resource reductions, including IWPs. In the present study, we analyzed the language of two IWPs and two matched controls across three comparisons: (1) IWPs in flashback vs. not in flashback, (2) IWPs not in flashback vs. control, and (3) IWPs in flashback vs. control. We found significant deficits in terms of variables associated with Broca's aphasia when IWPs were compared to controls as well as when compared to themselves while not experiencing flashback. The results support the idea of transient non-fluency during flashback as well as a degree of non-fluency in IWPs in general.

Keywords: post-traumatic stress disorder, non-fluency, Broca's aphasia, cognitive linguistics, compensatory response, cognitive resource reduction, working memory

1. INTRODUCTION

A notable minority of people who experience an event of "extremely threatening or horrific nature" (Koenen et al., 2017) will develop post-traumatic stress disorder (PTSD) (World Health Organization, 2019). Individuals with PTSD (IWPs; sg. IWP) exhibit avoidance behavior, heightened vigilance, and involuntary re-experiencing of the traumatic event (Koenen et al., 2017).

Involuntary re-experiencing, commonly referred to as *flashbacks*, is a dissociative state in which the affected individual feels as if she is reliving the traumatic event in the present (e.g., Brewin, 2003; Ehlers & Clark, 2000; Herman, 2015). Flashbacks are typically triggered by an essentially harmless stimulus that the sufferer associates with the traumatic event (Lanius, 2015), e.g., the smell of gasoline in a car crash survivor. Flashbacks can last anywhere from seconds to, in extreme cases, days (American Psychiatric Association, 2013).

Flashbacks are thought to mirror how the body responds to genuinely life-threatening situations (e.g., Payne et al., 2015; Rainnie & Ressler, 2009). This involves reallocating resources away from slow and resource-intensive higher cognitive processes to prioritize quick threat processing and alertness (e.g., LeDoux, 2012; Pavlícková et al., 2024; Rainnie & Ressler, 2009). If we understand language production as a complex cognitive ability, experiencing a flashback might affect its

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functionality due to competing cognitive demands. In the case of a genuinely dangerous situation of a limited duration, this response is adaptive (McEwen, 2007). However, when overgeneralized, it becomes more harmful than helpful.

The idea that flashback-related reallocation might have linguistic consequences is supported by brain-imaging studies showing Broca's area (BA 44-45) to receive less blood flow during flashback (e.g., Pitman et al., 2001; Rauch et al., 1996; Shin et al., 1997). Although its particular contribution is controversial, Broca's area remains famous for its role in language production (Rogalsky et al., 2008), as evidenced by the fact that linguistic symptoms known as *Broca's aphasia* have been linked to the area (e.g., Carey, 2017). The link between Broca's area and Broca's aphasia has been called into question by findings showing that individuals with damage to BA 44-45 do not necessarily exhibit Broca's aphasia, and conversely, that those with Broca's aphasia do not always have damage to the area (Andrews et al., 2022; Davis et al., 2008). However, the association between Broca's aphasia and BA 44-45 persists in popular scientific literature. This is evident in how the observation that reduced activity in Broca's area is associated with both PTSD-flashbacks and Broca's aphasia has led to the hypothesis that IWPs during flashback may exhibit a form of "transient aphasia" (Cozolino, 2020, p. 168) or "effects [similar to those] of physical lesions like strokes" (van der Kolk, 2014, p. 43). In further support of this hypothesis, the presence of "unclear speech" (Chessell et al., 2019, p. 11) is used clinically as a marker of a flashback occurring. Thus, reduced blood flow to the region could be interpreted as a manifestation of resources being moved away from mechanisms involved in higher cognitive functions, e.g., language.

Beyond possible linguistic deficits during flashbacks, there is reason to suspect deficits in IWPs outside flashbacks. Some researchers argue that Broca's aphasia is the result of general resource reductions (e.g., Boye et al., 2023; Fedorenko et al., 2023; Kolk, 1995)[5] with some specifically suggesting that it is the result of a reduction in working memory capacity (WMC) (e.g., Blackwell & Bates, 1995, cf. Boye et al., 2023). WMC reductions are also common in the PTSD population (Norte et al., 2024). The idea that WMC reductions could lead to language production issues is in line with the theory that working memory (WM) contributes to our capacity for producing language (e.g., Badecker & Kuminiak, 2007; Deldar et al., 2020). Due to these shared symptoms, the features seen in Broca's aphasia could be a meaningful point of comparison for an investigation of the linguistic patterns in IWPs.

[5] This theory contrasts with the interpretation of Broca's aphasia as the result of a specific deficit in syntax (e.g., Friedmann, 2006; Friedmann & Grodzinsky, 1997).

A growing body of research has already examined the patterns of language production in PTSD from a variety of perspectives. Hellawell and Brewin (2004) investigated how language use differs in the retelling of traumatic versus non-traumatic memories. Their findings supported Brewin's (2001, 2003) theory that traumatic memories are processed and stored differently from ordinary memories. Likewise, other studies have explored whether the linguistic structure and content of the retellings of traumatic memories reflect their distinct nature (e.g., Miragoli et al., 2019; Römisch et al., 2014; van der Kolk & Fisler, 1995). Still others have investigated whether language content or structure correlates with the presence or severity of PTSD, including potential diagnostic implications (e.g., Gayraud & Auxéméry, 2022; Kleim et al., 2018; Papini et al., 2015). While most focus on content and structure, some studies have investigated articulation specifically (Hu et al., 2024; Marmar et al., 2019), finding a tendency towards slower and more monotonous speech.

However, little attention has been paid specifically to how flashbacks and PTSD in general might impair language production. This is both a disservice to IWPs who might be suffering from unaddressed linguistic difficulties and a loss for the field of linguistic impairment research. The specific hypothesis that linguistic features resembling Broca's aphasia are present in IWPs has been tested only once previously: As part of her MA thesis, Caglar (2012) completed an investigation which yielded no significant results, possibly due to an insufficient selection of variables. Our study[6] seeks to close that gap in the research by investigating the language production of IWPs in two case studies. It seeks to test the hypothesis that IWP speech shows similarities to the speech characteristic of Broca's aphasia, and that it does so both for speech produced by IWPs in flashback and for speech produced by IWPs outside flashback. Our use of Broca's aphasia specifically as a point of comparison is theoretically motivated by the parallels in symptoms, as described above. We supplement the results of the linguistic analysis with the results of a brief qualitative survey in which we ask participants about their experience with language during flashback. The purpose of this is to evaluate whether the linguistic results reflect subjectively felt language difficulties in sufferers. The study at hand is the pilot of a larger project on language production in IWPs named *Language in PTSD* (LIP).

Section 2 outlines our understanding of Broca's aphasia. On this background, it subsequently elaborates on the link between aphasia and PTSD. Section 3 presents our specific hypotheses, and Section 4 the cases. Section 5 deals with methodological issues, Section 6 presents the results, and Section 7 discusses the results. The conclusion is found in Section 8.

[6] Note that this study builds on the work conducted for Isen's unpublished MA thesis (2025).

2. BROCA'S APHASIA AS A RESPONSE TO RESOURCE REDUCTION

While consensus is lacking on the exact mechanisms underlying Broca's aphasia, it is widely recognized as a language disorder linked to acquired brain damage (Carey, 2017; see Section 1). The disorder is a type of non-fluent aphasia and is characterized by slower speech rate and shorter average utterance length (Menn et al., 1990; for a recent review, see Hasan et al., 2024). Additional features are subject to significant individual and cross-linguistic variation, but may include agrammatism,[7] i.e., a decrease in the conventional use of grammatical elements (including morphemes, words, constructions), and an overall reduced syntactic complexity (e.g., Kolk, 1995; Maher, 2018; Thy et al., 2024). Although traditionally associated with Wernicke's aphasia, reduced lexical diversity has also been observed in people with Broca's aphasia (Arslan et al., 2016; Sang, 2015).

At first glance, it may not seem intuitive to compare disorders as different as PTSD and Broca's aphasia. However, as mentioned in the introduction, both can be understood to involve a reduction in the availability of cognitive resources. According to a theory developed by Boye et al. (2023), some of the linguistic characteristics of Broca's aphasia must, in fact, be understood in part as a compensatory response to a cognitive resource reduction, possibly a reduced WMC.[8]

Specifically, Boye et al. proposed that the sparsity of grammatical elements sometimes seen in Broca's aphasia is an extreme example of what is known as *good-enough production* (Goldberg & Ferreira, 2022). *Good-enough production* refers to the phenomenon of speakers producing utterances that are incomplete, less complex, or generally suboptimal in order to preserve cognitive resources. Despite imperfections, *good-enough utterances* are typically sufficient for successful communication due to listeners being cooperative (Grice, 2002 [1975]) and able to infer meaning from context (Tanenhaus et al., 1995). The view that lower resource availability might lead to aphasia-like language production is further supported by the finding that neurotypical individuals can be induced to produce agrammatic language if put under stress (e.g., Blackwell & Bates, 1995; Ishkhanyan et al., 2019). In this view, Broca's aphasia is not unique in kind but in degree: it represents an extreme utilization of compensatory strategies that all speakers might employ when experiencing excessive cognitive load.

The theory mentioned above provides a theoretical link between possible linguistic features characteristic of PTSD and features characteristic of Broca's aphasia, as it allows us to see them as resulting from the same basic phenomenon, viz. resource reduction. In the case of Broca's aphasia, the

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[7] While this feature of aphasic speech has received ample attention in the literature, not all individuals with Broca's aphasia display agrammatism (see e.g., Berndt, 1987). Additionally, omission of grammatical elements might not be a feature of Broca's aphasia at all in speakers of certain languages, e.g., Bengali (Bose, 2025) and Kalaallisut (Nedegaard et al., 2020).

[8] Multiple studies have found reduced WMC in individuals with aphasia (e.g., Caspari et al., 1998; Mayer & Murray, 2012). Therefore, WMC is a plausible candidate for the particular resource in deficit.

resource reduction is due to brain damage. In the case of PTSD flashbacks, we hypothesize that the reduction is due to a reallocation of cognitive resources to better accommodate perceived acute survival needs. The WMC reduction found in IWPs more broadly might likewise result in linguistic difficulties even outside of flashbacks, although possibly to a lesser extent. In short, if Broca's aphasia is due to resource reductions, we would expect to see features in the language of IWPs which are parallel to those found in Broca's aphasia.

2.1 Specific features of Broca's aphasia as compensatory responses

If a speaker has fewer resources available than what typical language production requires, she must adjust her language production to accommodate it. The basic compensatory response gives priority to those elements that convey the communicatively essential points. As a result of this prioritization, less essential elements may be left out entirely, reduced, or substituted with others. The utterance in (1) is an example of language from an individual with aphasia (IWA).[9] Assuming that the utterance represents an alternative to the utterance *the stepmother is really ugly*, we might interpret the lack of both copula and article as the result of a prioritization in response to resource limitations:

(1) "Stepmother … really ugly" (Thompson & Bastiaanse, 2012)

Now, what governs which elements are retained, and which ones are 'left out'? According to Boye et al. (2023), attentionally foregrounded parts of messages tend to be retained, while backgrounded parts tend to be omitted, reduced, or substituted. In light of the theory developed in Boye and Harder (2012), this explains why grammatical elements tend to be omitted, reduced or substituted. In this theory, grammatical elements – e.g., *the* and *is* – are defined as being attentionally backgrounded (or, discourse secondary) and thus as dependent on combination with other words, while lexical words – e.g., *stepmother* and *ugly* – are defined as having the potential to be foregrounded (discourse primary). In a speaker with a reduction in available cognitive resources – e.g., IWA – it therefore makes sense that we specifically see a reduction of grammatical words as opposed to lexical ones, since the information loss resulting from 'omitting' grammatical words is relatively benign and thus a more effective use of resources. Note now that if the speaker who produced (1) 'left out' *stepmother* and *ugly* instead of the grammatical words – leaving only *the is really* – the main point of the utterance is lost. A similar point was made by Fedorenko et al. (2023), who went as far as calling agrammatism a rational strategy in the face of resource deficits.

[9] While this abbreviation can be used for individuals with other types of aphasia, we will exclusively use it for references to individuals with Broca's aphasia in this paper.

Leaving out elements inherently leads to shorter utterances, and shorter average utterance length is an indicator of lower complexity (Szmrecsányi, 2008). Shorter average utterance length is also a defining feature of Broca's aphasia (Menn et al., 1990). In addition, grammatical elements are often obligatory, for which reason their omission can be described as a type of error, i.e., a deviation from conventions. Thus, lowering complexity may be associated with higher error rates.

This brings us to another possible means of adjusting resource expenditure: speech rate. Coupé et al. (2019) measured the information rate (bits/s) in language production and found that while speech rate varies, bits/s remains stable across languages (~39 bits/s). Based on this, they argued that the typical speech rate of a given language is determined by the typical information processing speed of the human brain. If this assertion is correct, a slower speech rate could be a way of lowering the bits/s, thus distributing production costs over a larger span of time. This might manifest as individual words being pronounced more slowly or as a higher production rate of disfluencies. Both of these responses create more time between information-carrying units, as exemplified in (2).

(2) "(uhm) (well) (uhm) worked (uhm) autodesk (uhm) [/] sales <sales> (uhm) worldwide" (tactustherapy, 2017)

Finally, lowering lexical diversity might represent a way of preserving resources by relying on more entrenched vocabulary, thus possibly reducing retrieval costs (e.g., Steinkrauss & Schmid, 2016; Hatchard, 2015).

3. HYPOTHESES

The previous section introduced the features we are looking for in our two cases. We will be investigating whether these features can be found in our two cases (see Section 4). This brings us to the specific hypotheses we are testing. These are seen in Table 1.

Table 1. Hypotheses.

H1	The language of an IWP experiencing flashback shows features associated with Broca's aphasia when compared to the language of an IWP not experiencing a flashback.
H2	The language of an IWP not experiencing a flashback shows features associated with Broca's aphasia when compared to the language of a neurotypical control.
H3	The language of an IWP experiencing flashback shows features associated with Broca's aphasia when compared to the language of a neurotypical control.

As summarized in Table 2, the hypotheses concern relative differences between individual IWPs and either themselves in a non-flashback state (H1) or neurotypical matched controls (H2, H3).

Testing H1 will shed light on the linguistic consequences of the presence of a flashback, flashback being the independent variable, while H2 concerns the effect of PTSD without flashback, PTSD being the independent variable. Finally, H3 compares the flashback condition directly with the neurotypical control condition. It needs to be emphasized that all hypotheses concern *relative similarity to Broca's aphasia*: flashback relative to non-flashback, non-flashback PTSD relative to neurotypicality, and flashback relative to neurotypicality.

Table 2. Conditions.

	Focal condition	Control
H1	IWPs during a flashback (+flashback/+PTSD)	IWPs in non-flashback state (–flashback/+PTSD)
H2	IWPs in non-flashback state (–flashback/+PTSD)	Control without PTSD (–flashback/–PTSD)
H3	IWPs in flashback (+flashback/+PTSD)	Control without PTSD (–flashback/–PTSD)

As an example of how these hypotheses would be supported, consider H1. Support for H1 is found if, for instance, the median utterance length or median speech rate is lower in IWPs' speech during a flashback than in IWPs outside a flashback.

4. DATA

In the following section, the data collection procedure as well as the collected data is described. The procedure received IRB approval from *The Research Ethics Committee of the Faculty of Humanities and the Faculty of Law at University of Copenhagen* and all participants provided informed consent.*4.1 Data collection, IWPs*

IWPs were recruited both via Danish NGOs supporting the population specifically[10] and those serving populations with a high incidence rate of PTSD.[11] Inclusion criteria for IWPs were (a) being a native speaker of Danish, and (b) having received a formal PTSD diagnosis.

The data collection method was developed specifically for this study. In the design, we prioritized participants' mental safety over data quality when the two were at odds. IWPs were provided with a definition of flashbacks and then had to record themselves during flashbacks up to three times over the span of one month (used as the focus condition for H1 and H3). Additionally, the IWPs had to record themselves up to three times while in a neutral or positive mood (used as the control for H1 and the focus for H2).

[10] *Landsforeningen for PTSD-ramte og pårørende* (IWPs and their loved ones) and *Angst & StressForeningen* (individuals suffering from anxiety and/or stress).

[11] *Landsforeningen Spor* (adult victims of childhood sexual abuse), *Søstre mod vold og kontrol* (victims of gendered violence), and *Voldtægtsofres Vilkår* (victims of rape).

We decided against on-site recording by the researchers, as this would have necessitated the ethically dubious task of having to trigger flashbacks in the participants (cf. Pitman et al., 2001; Rauch et al., 1996; Shin et al., 1997). Having the participants record themselves instead allowed us to capture flashbacks they would have experienced regardless of their participation in the study.

Each recording had to be between 2 and 5 minutes as we estimated that this would provide us with a sample of at least 300 words per participant per condition (see Prins & Bastiaanse, 2004) without overwhelming the participants with the scale of the task, thus possibly increasing the risk of participant dropout.

In the recordings, participants describe the current day in detail without discussing the traumatic memory itself. This topic was chosen because it closely resembles grounding exercises used in PTSD treatment (e.g., Rothschild, 2021), thus being judged safer for participants. In addition, due to the transient nature of flashbacks, asking the participants to perform a more structured task, e.g., picture description, was judged impractical: by the time a participant had located the elicitation material, their flashback state might have passed.

After the collection of language samples, IWPs had to fill out a questionnaire on demographic information, details about PTSD diagnosis and treatment history, and their subjective experience of linguistic difficulty.

4.2 Data collection, controls

The controls (non-IWPs) were recruited subsequent to IWP-recruitment for the sake of matching gender and age. Inclusion was additionally based on (a) being a native speaker of Danish, and (b) not being diagnosed with PTSD. Non-IWPs were asked to complete the same task as the IWPs, but only once for 3-5 minutes while in a neutral or positive mood (used as controls for H2 and H3). This was decided to approximate the lengths of recordings provided by IWPs. Non-IWPs were additionally asked to report their gender, age, and PTSD status.

4.3 Data description

Two IWPs (M35-39, F60-64) completed data collection. M35-39 will henceforth be referred to as Peter, F60-64 as Pia. Pia’s control will be referred to as Carla, Peter’s control as Chris. The details of the data collected can be seen in Table 3.

Table 3. Data.

	+flashback/+PTSD		−flashback/+PTSD		−flashback/−PTSD	
	Peter[12]	Pia	Peter	Pia	Chris	Carla
Duration	00:02:17	00:03:57	00:01:59	00:03:16	00:03:43	00:03:55
Length	150	354	193	480	298	554

5. METHOD OF ANALYSIS

Our method of analysis is pairwise comparison. For non-categorical variables, the Mann-Whitney U-test (Mann & Whitney, 1947) is applied; for categorical variables, Fisher's Exact Test (Fisher, 1922). The specific tests were chosen for their reliability in the case of small sample sizes (Morgan, 2017), e.g., in case studies. We selected our dependent variables based on literature describing Broca's aphasia (see Section 1.2). The variables are introduced in the following subsection.

5.1 Dependent variables and their relation to Broca's aphasia

Utterance length is measured by median length of utterance (MdLU).[13] In our definition, an utterance can either consist of a main clause (including 0 or more subordinate clauses), or a stand-alone phrase, e.g., NP or VP. In order to relatively resemble Broca's aphasia, utterances must be shorter on average.

We measure speech rate in both words per minute (WPM) and the rate of disfluencies. In order to relatively resemble Broca's aphasia, production must contain a higher rate of disfluencies and lower WPM.

Grammatical error rate is measured firstly by frequency of errors (insertion, deletion, and substitution) (Dulay et al., 1982) and secondly by frequency of topic drop (e.g., Nygard, 2018). Topic drop is a type of deviation from convention in Danish. However, we distinguish between this type of deviation and genuine errors as topic drop is relatively common in informal registers (Jensen, 2015). Proportion of definite articles (DEF) (rel. to nouns) is included as a third measurement of error rate.

Complexity is measured by comparing proportions of parts of speech where one category is more discourse prominent in Danish. These include proportion of subordinate clauses (SUBR) (rel. to main clauses, MAIN), transitive verbs (TR) (rel. to intransitive verbs, INTR), and auxiliary verbs (AUX) (rel. to main verbs, MV). Complexity is additionally measured by contrasting the frequency of

[12] Note that Peter only managed to make one recording per condition, meaning that in his number of words per condition did not reach 300.

[13] Mean length of utterance (MLU) is more commonly used for this purpose. However, we decided to use MdLU because medians are less sensitive to extreme outliers – a common issue with smaller samples.

nouns (N) with verbs (V), articles (ART), and anaphoric pronouns (ANA), given that nouns are typically discourse primary.

Finally, lexical diversity is measured by Type–Token Ratio (TTR). Both lexical and grammatical words are included in this count, while disfluencies are excluded. An overview of all variables can be found in Table 4.

Table 4. Linguistic features associated with Broca's aphasia and the variables representing them.

Linguistic feature	Variable
Shorter average utterance length	• Median length of utterance (MLU)
Slower speech rate	• Words per minute (WPM) • Ratio of disfluencies to words
Higher grammatical error rate	• Ratio of grammatical errors to words • Ratio of topic drops to words • Ratio of DEF to N
Lower complexity	• Prop. of SUBR • Prop. of TR • Prop. of AUX • Ratio of V to N • Ratio of ART to N • Ratio of ANA to N
Lower lexical variety	• Ratio of types to tokens

6. RESULTS

When results are presented in terms of p-values (Table 5 and Table 7), red denotes a non-significant result, darker green a result significant at the Bonferroni-corrected significance level ($\alpha_{corrected} = \alpha/13 = 0.003846154$), and lighter green a result significant at the nominal significance level ($\alpha = 0.05$).[14] For tables displaying results in terms of medians and proportions (Table 6 and Table 8), light blue denotes that the +flashback condition is significantly different from the −PTSD condition but not from the −flashback/+PTSD condition, dark blue that it is both significantly different from −PTSD and from +flashback/−PTSD. Purple denotes that the −flashback/+PTSD condition differs significantly from −PTSD.

6.1 Peter

With vs. without PTSD

[14] See e.g., VanderWeele and Mathur (2019) for a discussion of when Bonferroni-correction might be too conservative as well as benefits of including both Bonferroni-corrected and nominal significance level.

WPM (U = 0, z = -2.51, p = 0.0060), rate of topic drop (p = 0.0174), and TTR (p = 0.0424)[15] are significantly different from the neurotypical control at the nominal level. Disfluency rate is significantly different at the corrected level (p = 0.0007). This suggests Peter speaks more slowly than Chris, both in terms of disfluency rate (26.94 per 100 words) and WPM (Mdn = 93.6). He additionally produces more deviations of the topic drop type (4.15 per 100 words).

In vs. outside of flashback

When the speech of Peter during flashback is compared to his non-flashback speech, only WPM is significantly different (U = 4, z = -1.67, p = 0.0475) and only at the nominal level. This indicates slower production (Mdn = 62.1) during flashback.

In flashback vs. without PTSD

When Peter in flashback is compared to Chris, WPM (U = 0, z = -2.51, p = 0.0060), disfluency rate (p = 0.0039), and TTR (p = 0.0493) are significantly different at the nominal level. MdLU (U = 405, z = 2.84, p = 0.0023) is significantly different at the corrected level. This means that Peter in flashback produces shorter utterances (Mdn = 6.00). This indicates that his utterances are also less complex. In addition, his speech production appears to be slower, both in terms of disfluencies and WPM.

[15] At first glance, Peter's language appears to be less lexically diverse (51.81 types per 100 tokens). However, this is most likely due to a mismatch in sample size lengths, which TTR is highly sensitive too (Wright et al., 2003). In future studies, this could be mitigated either by matching sample sizes or by using Moving-Average Type–Token Ratio (MATTR) (Covington & McFall, 2010) instead of a classic TTR.

Table 5. Results, p-values, Peter and Chris.

	With vs. without PTSD	In vs. outside of flashback	In flashback vs. without PTSD
MdLU	0.0571	0.1314	0.0023
WPM	0.0060	0.0475	0.0060
Disfluency	0.0007	0.8124	0.0039
Errors	0.7590	0.3816	0.1437
Topic drop	0.0174	0.1976	0.6054
DEF	0.7153	0.6416	0.7144
SUBR	0.7767	1.0000	0.5412
TR	0.8515	0.0814	1.0000
VB	0.3843	0.8535	0.7459
ART	0.4906	1.0000	0.4239
ANA	0.2530	1.0000	0.3031
AUX	0.6090	1.0000	0.7801
TTR	0.0424	0.9257	0.0493

Table 6. Results, proportions and medians, Peter and Chris.

	+PTSD/+flashback	+PTSD/−flashback	−PTSD
Median length of utterance	6.0	7.0	8.0
Median WPM	62.1	93.6	147.4
Disfluencies per 100 words	25.3	26.9	12.1
Errors per 100 words	4.7	2.6	2.0
Topic drop per 100 words	1.3	4.1	0.7
DEF per 100 N	14.3	6.7	11.3
SUBR per 100 MAIN	21.1	27.3	34.5
TR per 100 INTR	28.0	73.9	67.2
V per 100 N	152.4	133.3	172.6
ART per 100 N	19.0	23.3	35.5
ANA per 100 N	19.0	20.0	37.1
AUX per 100 MV	18.5	22.9	16.3
Types per 100 tokens	50.7	51.8	70.8

6.2 Pia

With vs. without PTSD

When Pia is compared to Carla, both MdLU (U = 1374.5, z = -1.83, p = 0.0336) and proportion of subordinate clauses (p = 0.0245) are significantly reduced at the nominal level. The proportion of topic drops (p = 0.0005) is significantly different at the corrected level. This suggests that Pia produces shorter and thus less complex utterances (Mdn = 6.5). Additionally, her utterances appear less complex in terms of subordination (17.86 per 100 MAIN) and contain a higher rate of a benign type of deviation from convention (2.71 topic drops per 100 words).

In vs. outside of flashback

Pia's speech rate (U = 2, z = -2.48, p = 0.0066) and error rate (p = 0.0108) both significantly differ from her non-flashback condition at the nominal significance level. MdLU (p = 0.0009) and disfluency rate (p = 0.0004) differ significantly at the corrected level. This suggests Pia speaks more slowly during flashbacks, both in terms of WPM (Mdn = 91.7) and rate of disfluency production (18.08 per 100 words). Additionally, her utterances appear to contain more errors (3.39 per 100 words) and to be shorter (Mdn = 5.0) and thus less complex.

In flashback vs. without PTSD

When Pia in flashback is compared to Carla, she has a significantly higher error rate (p = 0.0112), disfluency rate (p = 0.0113) and proportion of subordinate clauses (p = 0.0216) at the nominal significance level. MdLU (U = 907, z = -4.57, p = 1.00E-5), WPM (U = 0, z = p = 0.0026) and topic drop rate (p = 3.793E-6) are significantly different at the corrected level. This indicates that Pia in flashback produces utterances that are less complex in terms of both subordination and length while containing more deviations from convention, both topic drops and errors of the general type. Additionally, her speech is slower.

Table 7. Results, p-values, Pia and Carla.

	With vs. without PTSD	In vs. outside of flashback	In flashback vs. without PTSD
MdLU	0.0336	0.0009	1.00E-05
WPM	0.3446	0.0066	0.0026
Disfluency	0.2525	0.0004	0.0113
Errors	1.0000	0.0108	0.0112
Topic drop	0.0005	0.1858	3.79E-06
DEF	1.0000	0.7687	0.5930
SUBR	0.0245	1.0000	0.0216
TR	0.1128	0.1564	1.0000
VB	0.4453	0.3626	0.7779
ART	0.3019	0.7078	0.7450
ANA	0.5036	0.4231	0.8841
AUX	0.7909	0.5145	0.3107
TTR	0.9077	0.8969	0.8008

Table 8. Results, proportions and medians, Pia and Carla.

	+PTSD/+flashback	+PTSD/−flashback	−PTSD
Median length of utterance	5.0	6.5	9.0
Median WPM	91.7	154.9	145.0
Disfluencies per 100 words	18.1	8.5	11.0
Errors per 100 words	3.4	0.8	0.9
Topic drops per 100 words	4.5	2.7	0.2
DEF per 100 N	6.3	9.3	9.4
SUBR per 100 MAIN	17.9	19.0	47.4
TR per 100 INTR	27.2	42.2	28.3
V per 100 N	182.8	149.5	171.0
ART per 100 N	25.0	20.6	29.0
ANA per 100 N	37.5	28.9	35.5
AUX per 100 MV	18.2	22.9	25.5
Types per 100 tokens	41.8	40.8	40.3

7. DISCUSSION

This study is only a pilot study and has several major methodological limitations. Before we discuss the possible interpretations of the study, the limitations should be noted. Firstly, the study consists of only two case studies, meaning that the results cannot be generalized. Secondly, the match between IWPs and non-IWP controls is less than ideal. Thirdly, the fact that sample sizes vary might skew the results, especially in the case of variables known to be sensitive to sample size, e.g., TTR (Wright et al., 2003). These factors should be taken into account when interpreting the results and in the design of future studies by LIP and others.

7.1 Interpreting the results

We aimed to test three hypotheses, specifically whether the language produced by our IWPs (Peter and Pia) during flashback and outside flashback showed features associated with Broca's aphasia when compared to respectively the language produced by the IWPs outside flashback (H1) and the language produced by their neurotypical controls (H2; H3).

Our results provide support for all three hypotheses. The support is found in both case studies. It is however found only for some of the variables investigated, and for distinct sets of variables depending on speakers and hypotheses. Specifically, we find a slower speech rate and shorter utterances, i.e., the defining features of Broca's aphasia, but we do not find evidence of agrammatism.

In summary, the speech in IWPs can be said to be relatively non-fluent but not agrammatic, and the parallel to Broca's aphasia is thus only partial.

Consider again H1: *The language of an IWP experiencing flashback shows features associated with Broca's aphasia when compared to the language of an IWP not experiencing a flashback*. The support for H1 might be explained by our theory that flashbacks lead to resource reallocation, which in turn leads to fewer resources available for language production (see Section 1).

Now, consider H2: *The language of an IWP not experiencing a flashback shows features associated with Broca's aphasia when compared to the language of a neurotypical control*. The support for this hypothesis could be interpreted as suggesting that the WMC reductions often seen in PTSD (see Section 1) have negative consequences for language production.

Lastly, consider H3: *The language of an IWP experiencing flashback shows features associated with Broca's aphasia when compared to the language of a neurotypical control*. This hypothesis was naturally supported for more variables than H1 and H2. In accordance with the interpretations suggested for H1 and H2, the support for H3 may be interpreted as being due to an accumulation of the effects of temporary resource allocation and of a general deficit in WMC.

7.2 Subjective experience of IWPs

To learn whether the quantitative analysis might reflect subjectively felt impairments in the IWPs, we asked the IWPs about their self-perceived linguistic difficulties (see Section 3.1). Specifically, we asked: 'Are you yourself aware of having experienced language difficulties during flashbacks?', and: 'If yes, which ones?'.

Peter describes how his 'vocabulary is very small', which possibly reflects a deficit in lexical retrieval, which was not pronounced enough to show up in the quantitative analysis. Additionally, Peter describes how he 'has a hard time putting sentences together'. This could reflect reductions in his resource availability, resulting in subthreshold effects on his grammatical production. Pia also describes experiencing linguistic difficulties during flashbacks. She specifically describes a spectrum where she feels that her language either 'becomes faltering' or 'disappears'. This might reflect the quantitative finding that she produces slower, more disfluent speech in flashback.

Overall, the answers support an interpretation of the quantitative results as possibly reflecting an actual, subjectively felt impairment during flashbacks (World Health Organization, 2001) with negative linguistic consequences, not simply a neutral difference in language production.

7.3 Interpreting the results based on qualitative similarity to Broca's aphasia

Our results suggest that the presence of flashbacks and PTSD respectively appears to influence language production in a way which is in part parallel to the presence of Broca's aphasia. We did not include a control group of IWAs, and quantitative similarity can thus not be determined. However, we can say that the speech of IWPs and IWAs share some qualitative similarities.

Keeping this similarity in mind, we may begin to understand our results in terms of interpretations of Broca's aphasia. As stated in Sections 1–2, researchers have argued that features of Broca's aphasia may be understood as the result of a compensatory response to resource reduction (Boye et al., 2023) or as a rational strategy in the face of resource deficits (Fedorenko et al., 2023). This interpretation entails that features characteristic of Broca's aphasia may also be present in other types of language conditioned by resource reductions, e.g., the language of IWPs. Additionally, some of the features are also seen in speakers with disorders other than Broca's aphasia, including disorders without structural damage to Broca's area, e.g., slower speech and shorter utterances in individuals with frontotemporal dementia (Coppieters et al., 2024) or those with a developmental language disorder (DLD) (Wilder & Redmond, 2022).

As predicted by our theory (see Section 1), several features of Broca's aphasia were found in the language production of our IWPs, including the defining features, i.e., slower speech rate and shorter utterances. This and other evidence (see Section 2) considered, we suggest interpreting the results and the qualitative similarity to Broca's aphasia as the consequence of cognitive resource reductions which are not specific to language. WMC could be the specific resource which is reduced in Broca's aphasia as well as PTSD, given that WMC reductions are often seen in IWPs (Norte et al., 2024) as well as in IWAs (e.g., Caspari et al., 1998; Mayer & Murray, 2012). This is, however, purely speculative as we did not dissociate WMC deficits from other possible cognitive consequences of PTSD in our design.

Other features of Broca's aphasia were not present, chiefly those representing reduced grammatical complexity. For instance, while Pia's language production contains a reduced proportion of subordinate clauses compared to Carla's – one variable representing complexity (see Section 5.1) – it does not display a reduced proportion of auxiliary verbs – a second variable representing complexity. In other words, we did not find convincing evidence of agrammatism. At first glance, this might be taken to speak against our interpretation of Broca's aphasia and PTSD as sharing the underlying cause, e.g., a general resource reduction. An interpretation based on the syntactic deficit theory of Broca's aphasia would be that grammatical knowledge is spared in IWPs while it is damaged in IWAs with agrammatism, implying differences in the underlying processes of the disorders. However, an alternative interpretation based on the compensatory response theory would be that agrammatism is only present in the case of more severe resource deficits, i.e., those seen in IWAs with agrammatism but not in IWPs. This theory might be investigated in controlled experiments in which neurotypical speakers are exposed to varying degrees of cognitive load.

This study was first and foremost motivated by the finding that flashbacks are associated with a decrease in blood flow to Broca's area (e.g., Pitman et al., 2001; Rauch et al., 1996; Shin et al., 1997) and claims that this might cause deficits in linguistic production parallel to Broca's aphasia (e.g., Cozolino, 2020; van der Kolk, 2014). In addition, we argued that a parallel might even be found between the speech of IWAs and IWPs not in flashback, given the shared symptom of reduced WMC.

Our results support, if only partly, the idea that flashbacks might lead to deficits in linguistic production that are qualitatively similar to Broca's aphasia. We hypothesize that this is due to the reduction in blood flow to Broca's area during flashback, which might in turn be a manifestation of temporary resource reallocation. Our results also support, though again only in part, the idea that the presence of PTSD might lead to deficits in linguistic production that are qualitatively similar to Broca's aphasia. We hypothesize that this is due to the WMC deficits associated with PTSD.

However, our study does not allow us to determine the exact chain of causality between the independent variables (PTSD and flashbacks) and the linguistic features of Broca's aphasia, i.e. the dependent variables. In particular, our suggestion that the relative increase in features associated with Broca's aphasia during flashback is due to reduced blood flow to Broca's area is put into question by the incomplete link between damage to the area and Broca's aphasia (see Section 1). Thus, while we argue that the qualitative similarity between the speech of IWAs and IWPs likely has to do with reduced resource availability in both disorders, the role of Broca's area specifically remains unclear.

Moreover, because we only find a partial qualitative parallelism between the linguistic production in IWAs and our IWPs, we cannot entirely reject the possibility that the linguistic deficits seen in the disorders might be caused by fully distinct processes.

Our study cannot establish causality, but if it is in fact the case that flashbacks – and to a lesser extent the long-term resource reductions found in PTSD – cause deficits in language production similar to those seen in Broca's aphasia, then it aligns with our view of Broca's aphasia as a syndrome that must be understood as a compensatory response to resource reduction, and which does not differ qualitatively, but may differ in terms of degree, from other cases of language produced under resource reduction. Thus, our study adds to the list of groups without structural damage to Broca's area (e.g., those with DLD, see above) who display the defining features of Broca's aphasia – slower speech rate and shorter utterances – thus increasing the burden of proof for those who argue that Broca's aphasia represents a distinct, specifically linguistic deficit and that this deficit points towards Broca's area serving specific syntactical functions (e.g., Friedmann, 2006; Friedmann & Grodzinsky, 1997).

8. CONCLUSION

Our hypotheses were based on an understanding of Broca's aphasia as the extreme of a commonplace phenomenon, i.e., linguistic reductions in response to resource reductions (Boye et al., 2023). This understanding entails that aphasia-like language production may also be found in populations experiencing resource reduction without having brain damage, e.g., IWPs. We found partial support for all three hypotheses. Firstly, language produced during flashback shows features associated with Broca's aphasia when compared to the language of an IWP not experiencing a flashback (H1). Secondly, language produced by an IWP not experiencing a flashback shows features associated with Broca's aphasia when compared to the language of a neurotypical control (H2). Thirdly, language produced during flashback shows features associated with Broca's aphasia when compared to the language of a neurotypical control (H3). However, with one exception, features associated specifically with agrammatism were not found. What we did find was mainly those features associated with non-fluency more broadly. On this basis, the idea of IWPs suffering from "transient aphasia" during flashbacks (Cozolino, 2020, p. 168; cf. van der Kolk, 2014) is not unfounded, but its focus on aphasia is misleading. Instead, we might say that IWPs suffer from *transient relative non-fluency* during flashbacks.

In addition, it should be noted that while our study documents relative similarities between the linguistic response in IWPs and IWAs, it does not and cannot establish causality. However, given that both PTSD and Broca's aphasia entail resource reductions, we consider the results to most likely reflect lower resource availability in our focus conditions relative to control conditions. More research is needed to confirm this explanation. However, if this interpretation is correct, what we find in IWPs is not a linguistic impairment per se, but a general cognitive impairment with possible linguistic consequences (see Section 7.3). The findings overall suggest language production as a meaningful lens for understanding cognitive impairments in PTSD.

In addition to evidence of relative non-fluency in IWPs, we also found indications of a subjective experience of linguistic impairment in our cases (see Section 7.2). Given the fundamental role of language in everyday interactions, even slight language difficulties may negatively influence an individual's daily functioning and ability to participate in public life on equal footing with the non-impaired population. This knowledge might inform the design of inclusion measures. Additionally, documentation of negative linguistic consequences of PTSD might inform psychoeducation, supporting the self-understanding of patients. However, further research with a larger, more diverse sample and a more comprehensive survey of IWPs' ability to meet their communicative needs is required to draw firm conclusions about both the nature of language in PTSD and the subjective experience of sufferers.

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