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A dual-case study

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ABSTRACT

The aim of our study was to examine the extent to which linguistic approaches to sentence comprehension deficits in aphasia can account for differential impairment patterns in the comprehension of *wh*-questions in bilingual persons with aphasia (PWA). We investigated the comprehension of subject and object *wh*-questions in both Turkish, a *wh*-in-situ language, and German, a *wh*-fronting language, in two bilingual PWA using a sentence-to-picture matching task. Both PWA showed differential impairment patterns in their two languages. SK, an early bilingual PWA, had particular difficulty comprehending subject *which*-questions in Turkish but performed normal across all conditions in German. CT, a late bilingual PWA, performed more poorly for object *which*-questions in German than in all other conditions, whilst in Turkish his accuracy was at chance level across all conditions. We conclude that the observed patterns of selective cross-linguistic impairments cannot solely be attributed either to difficulty with *wh*-movement or to problems with the integration of discourse-level information. Instead our results suggest that differences between our PWA's individual bilingualism profiles (e.g. onset of bilingualism, premorbid language dominance) considerably affected the nature and extent of their impairments.

Introduction

Language abilities following aphasia can be impaired to different extents in bilingual individuals (see Edmonds & Kiran, 2006; Fabbro, 2001; Goral, Levy, & Obler, 2002; Ijalba, Obler, & Chengappa, 2004; Miozzo, Costa, Hernandez, & Rapp, 2010; Moretti et al., 2001; Muñoz & Marquardt, 2004; Sebastian, Kiran, & Sandberg, 2012; Tschirren et al., 2011). While a language that was acquired later in life (henceforth referred to as an L2) may be more affected than an individual's first language (L1), both the reverse pattern of cross-linguistic dissociation and similar levels of impairments in both languages are also possible outcomes in bilingual aphasia (e.g. Fabbro, 2001; Green, 2008; Levy, Goral, & Obler, 1999; Obler & Albert, 1977; Paradis, 1998, 2004). Meta-analyses by Levy et al. (1999) showed that, although parallel language restitution is the most commonly observed pattern, for a sizeable number of bilingual persons with aphasia (PWA), a dominantly used L2 is more likely to be recovered than their L1.

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Our current understanding of language selectivity in bilingual aphasia is largely based upon clinical assessment studies using the Bilingual Aphasia Test (BAT) (Paradis, 1989) and upon treatment studies (e.g. Altman, Goral, & Levy, 2012; Edmonds & Kiran, 2006; Faroqi-Shah, Frymark, Mullen, & Wang, 2010; Goral, Rosas, Conner, Maul, & Obler, 2012; Knoph, 2013). Despite the growing number of bilingual individuals suffering from aphasia, studies reporting in-depth examination of sentence interpretation difficulties in bilingual aphasia are comparatively scarce, however. Existing studies indicate that sentence comprehension is a challenging task for bilingual PWA speaking, for instance, Swahili–English (Abuom, Shah, & Bastiaanse, 2013), Basque–Spanish (Arantzeta et al., 2017; Munarriz, Ezeizabarrena, & Gutierrez-Mangado, 2016), Greek–English (Alexiadou & Stavrakaki, 2006; Kambanaros & Grohmann, 2011) and Italian–Friulian (Fabbro, 2001). Impairments within and across grammatical systems may be highly selective in bilingual aphasia. While the language-selective nature of grammatical impairments is strongly associated with properties of the language systems (e.g. Paradis, 1988), some have argued that individuals' premorbid language proficiency and age of acquisition also play important roles (Miozzo et al., 2010; Paradis, 2004; Sebastian et al., 2012; Ullman, 2005). It is crucial that our understanding of sentence comprehension impairments in bilingual aphasia is advanced from where it currently stands. This is because linguistically based analyses of bilingual aphasia can both inform theories of language breakdown in bilingual individuals and help provide a thorough documentation of language impairments in bilingual aphasia, supplying clinicians with critical input to develop therapy protocols for rehabilitating bilingual PWA.

This study reports on an auditory sentence comprehension task investigating the interpretation of *wh*-questions in an early and a late bilingual individual with non-fluent aphasia who speak both Turkish, a non-*wh*-movement language, and German, a *wh*-movement language. Our motivation for examining PWA speaking both Turkish and German grew out of the fact that this language combination allows us to test potential between and across-language impairments in bilingual PWA's comprehension abilities in typologically different languages. This is particularly relevant here since we currently know little about whether or not PWA's difficulty comprehending *wh*-questions correlates with the presence of word-order changing *wh*-movement. Our study addresses the issue by investigating comprehension in a *wh*-movement and a non-*wh*-movement language in the same individuals, in order to critically evaluate different theoretical hypotheses regarding impaired comprehension of *wh*-questions.

Aphasiological background

Comprehending wh-questions in aphasia

PWA's interpretation of subject and object *wh*-questions is vulnerable to varying degrees and directions of impairments (e.g. Bos, Dragoy, Avrutin, Iskra, & Bastiaanse, 2014; Garraffa & Grillo, 2008; Hanne, Burchert, & Vasishth, 2016; Nerantzini, Varlokosta, Papadopoulou, & Bastiaanse, 2014; Neuhaus & Penke, 2008; Salis & Edwards, 2008; Thompson, Tait, Ballard, & Fix, 1999). Linguistic hypotheses seeking to account for PWA's comprehension problems include the Trace Deletion Hypothesis (TDH) (Drai & Grodzinsky, 2006; Grodzinsky, 1995, 2000), the Derived Order Problem Hypothesis (DOP-H) (Bastiaanse & Van Zonneveld, 2005, 2006) and the D(iscourse)-linking Hypothesis (Avrutin, 2000, 2006; Hickok & Avrutin, 1995, 1996).

According to the TDH, PWA's failure to comprehend *wh*-questions reflect an inability to build syntactic representations that encode movement dependencies. Unable to link syntactically displaced constituents to their base positions (or 'traces'), PWA resort to a default strategy of taking the left-most noun phrase (NP) in a sentence to be the agent argument, which leads them to perform poorly in comprehending object questions. This is because in *wh*-movement languages (e.g. English and German), the left-most NP in object questions usually refers to a theme argument, resulting in a greater likelihood of misinterpretation of object compared to subject *wh*-questions. Particular difficulty with object questions in *wh*-movement languages is also predicted by the DOP-H, according to which word-order changing syntactic operations incur a processing cost that exceeds the processing resources available to PWA; see for example Bastiaanse, Edwards, Mass, and Rispens (2003), Bastiaanse and Thompson (2003).

Several studies have shown that *wh*-elements referring to a set of specific entities in the preceding discourse add onto PWA's problems comprehending *wh*-questions. This gave rise to the D-linking Hypothesis, which assumes that unlike *wh*-pronouns, *which*-NP questions are referential, and that processing questions containing *which*-NPs requires additional computational capacity that is lacking in aphasia. Furthermore, object *which*-questions in languages such as English or German are expected to challenge PWA more than subject *which*-NP questions due to the combined effects of referentiality and of the presence of word-order changing *wh*-movement. For evidence in support of the D-linking Hypothesis; see, for instance, Hickok and Avrutin (1996), Salis and Edwards (2008) for English, Bos et al. (2014) for Russian, Nerantzini et al. (2014) for Greek, and Neuhaus and Penke (2008) for German.

Note that object questions are not always harder to comprehend in aphasia than subject questions (e.g. Arslan, Gür, & Felser, 2017; Kljajevic & Murasugi, 2010; Thompson et al., 1999). Arslan et al. (2017), for example, found that monolingual German PWA performed more poorly for object *which*-questions compared to subject ones, in line with the D-linking Hypothesis, whereas Turkish PWA had more difficulty comprehending subject *which*-questions compared to object ones in Turkish. The linguistic and/or individual factors determining why some PWA show better performance for object than for subject questions (or the reverse) are as yet not fully understood. Examining two typologically different languages in the same individual ensures that different performance patterns cannot be attributed to individual factors such as aphasia severity.

Sentence comprehension in bilingual aphasia

Language-selective impairments in bilingual aphasia may stem from grammatical differences between the languages involved (for reviews, see Lorenzen & Murray, 2008; Paradis, 1988). Studies of bilingual PWA provide support for the DOP-H by showing that syntactic structures that involve derived word orders are more problematic than those which do not, both across and within PWA's languages (e.g., Abuom et al., 2013; Alexiadou & Stavrakaki, 2006).

Sentence comprehension studies on *wh*-questions in bilingual aphasia are scarce. Martínez-Ferreiro (2010) studied Catalan and Galician–Spanish speaking PWA, assessing them in their most dominant premorbid language. The PWA performed virtually perfectly for both object and subject questions in comprehension despite difficulty in production. Munarriz et al. (2016) examined an early Basque–Spanish bilingual PWA, who performed at ceiling for subject *who*-questions in both Basque and Spanish but performed better for Spanish object *who*-questions than for their Basque counterparts. According to the

authors, the presence of an overt object marking (the preposition *a*) in Spanish provided a cue that the individual relied on.

To the best of our knowledge, no published studies on Turkish–German bilingual aphasia are available as yet. In a conference contribution, Gürel (2005) reports using the BAT (Paradis, 1987) to examine a late bilingual Turkish–German speaking woman with non-fluent aphasia. Gürel's data indicate that the woman's sentence comprehension ability was poor in both Turkish and German. In grammaticality and semantic judgement tasks, she performed very poorly in German (around 10%) but obtained better scores in Turkish (64% and 100%, respectively). It remains unclear to which extent the individual's pre-morbid language profile contributed to these outcomes, however.

Linguistic background

German is a *wh*-movement language whose underlying base order is SOV, but whose unmarked word order in simple main clauses is subject—finite verb—object, due to the verb-second requirement (Bach, 1962). Generating object question in German requires the *wh*-object phrase to be fronted, which is assumed to involve movement of the *wh*-phrase across the subject to (Spec,CP). In subject questions, by contrast, the canonical ordering of subject and object remains unchanged. An example of a subject question is given in (1), where the direct object (*den Mann*) is marked for accusative and the *wh*-pronoun (*wer*) for nominative case.

(1) *Wer   kitzelt   den   Mann?*
   who.$_{NOM}$ tickles   the.$_{ACC}$ man?

   'Who is tickling the man?'

(2) *Wen   kitzelt   der   Mann?*
   who.$_{ACC}$ tickles   the.$_{NOM}$ man?
   'Who is the man tickling?'

Example (2) shows a corresponding object question, in which the accusative marked *wh*-pronoun (*wen*) unambiguously indicates that it refers to the object.

Turkish is a non-*wh*-movement language whose base word order has been established as SOV, but virtually all other variations are also allowed (Erguvanli, 1984). In contrast to German, Turkish uses *wh*-in-situ, which means that in object questions, the object does not need to be repositioned sentence-initially (Akar, 1990; Özsoy, 2009). An example of a subject question is provided in (3). The canonical subject position in Turkish is sentence-initial in simple neutral declarative sentences (Lewis, 1967).

(3) *Kim   adamı   gıdıklıyor?*
   who$_{NOM}$ man.$_{ACC}$ tickle.$_{PRES.PROG.}$
   'Who is tickling the man?'

(4) *Adam   kimi   gıdıklıyor?*

    man.NOM   who.ACC   tickle.PRES.PROG.

    'Who is the man tickling?'

An object question is shown in (4), with the object *wh*-phrase positioned pre-verbally, which is assumed to be the canonical position of theme arguments. Note that theme objects in Turkish are often marked with accusative case, depending on the verb semantics, and due to the lack of case syncretism object phrases are rarely ambiguous.

The current study

We examined the comprehension of *wh*-questions in two Turkish–German bilinguals with non-fluent aphasia. This language combination allows us to compare, in the same individual, how sentence comprehension is affected in two languages that differ (among other things) with regard to the *wh*-movement property. Examining typologically different languages in the same bilingual brain is a promising way for testing theoretical accounts of sentence comprehension breakdown in aphasia. The theoretical hypotheses outlined above were originally developed largely on the basis of data from Germanic languages, and it is unclear whether they are robust enough to also explain language-selective impairments in PWA speaking typologically distant language pairs.

In this study, we ask (i) whether Turkish–German bilingual PWA show selective deficits in their comprehension of different types of *wh*-questions, and (ii) whether bilingual PWA show any cross-linguistic dissociations for this phenomenon. Accounts which link sentence comprehension difficulty in aphasia to problems representing or processing argument-order changing movement (such as the TDH and the DOP-H) predict that in German, object questions should be more difficult to comprehend than subject questions. No such subject/object asymmetry is predicted for Turkish, a non-*wh*-movement language. Possible problems with *wh*-fronted objects apart, the D-linking Hypothesis predicts that comprehending *which*-questions should be more difficult than comprehending *who*-questions in both German and Turkish.

Method

Participants

Two bilingual Turkish–German-speaking PWA participated as our case studies. See Table 1 for our participants' demographic details and Table 2 for information about their premorbid

Table 1. Demographic and bilingualism history details of the bilingual PWA (AoA = Age of Acquisition; MPO = Months post onset).

	SK	CT
Age	42	76
Gender	Female	Male
MPO	114	3
AoA German	4	From birth
AoA Turkish	From birth	29
Etiology	Left cardio-embolic stroke	Left cardio-embolic stroke

Table 2. Percent premorbid language use (daily) as reported by our participants and/or their dependents.

	SK		CT	
	Turkish	German	Turkish	German
Speaking	25%	75%	90%	10%
Listening	40%	60%	90%	10%
Writing	10%	90%	30%	70%
Reading	25%	75%	30%	70%

daily language profile. Demographic information of our participants were obtained via both our demographic and bilingualism background questionnaire and the bilingualism background questionnaire at the beginning of the BAT (Paradis, 1987).

Prior to our experiments, both the PWA were examined using screening versions of Turkish (Örkurt & Paradis, 1987) and German adaptations (Lindner & Paradis, 1987) and the Turkish–German bilingual part (i.e. Part C) (Gürel & Paradis, 1997) of the BAT (Paradis, 1987). Additionally, SK was assessed with the Aachen Aphasia Test in German (Huber, Poeck, Weniger, & Willmes, 1983) and CT was assessed using the Aphasia Assessment Test in Turkish (Maviş & Toğram, 2009). The results from the bilingual and monolingual aphasia tests are shown in Table 3 and Table 4, respectively. Demographic and bilingualism background as well as the language assessment details for each of our PWA are provided below.

In addition, a group of 13 Turkish–German bilingual non-brain-damaged individuals (NBDs), nine living in Germany and four in Turkey, who were matched to the PWA in terms of their social and bilingualism background, served as a reference group. The NBDs' mean age was 44.72 (range: 31–70 years). The participants or their legal proxies signed a consent form allowing us to use their data for research. Participation in our study was remunerated with 8€ per hour.

Table 3. The bilingual PWAs' response accuracy to the Turkish-German Bilingual Aphasia Test (shortened screening version). Raw scores indicate the number of correctly answered items, percentages are given in parentheses. TR = Turkish, DE = German.

	SK		CT	
	TR	DE	TR	DE
Object naming	4/6 (66)	6/6 (100)	3/6 (50)	5/6 (83)
Pointing	5/5 (100)	5/5 (100)	5/5 (100)	5/5 (100)
Simple and complex commands	5/6 (83)	6/6 (100)	4/6 (66)	5/6 (83)
Verbal auditory discrimination	7/7 (100)	7/7 (100)	7/7 (100)	7/7 (100)
Syntactic comprehension	8/10 (80)	7/10 (70)	5/10 (50)	7/10 (70)
Word repetition	12/12 (100)	12/12 (100)	8/12 (66)	10/12 (83)
Sentence repetition	3/3 (100)	3/3 (100)	2/3 (66)	3/3 (100)
Series (days of the week and numbers)	2/2 (100)	2/2 (100)	2/2 (100)	2/2 (100)
Antonyms	3/5 (60)	5/5 (100)	3/5 (60)	4/5 (80)
Word reading	4/5 (80)	5/5 (100)	4/5 (80)	4/5 (80)
Sentence reading	3/4 (75)	4/4 (100)	3/4 (75)	3/4 (75)
Writing	3/5 (60)	5/5 (100)	3/5 (60)	4/5 (80)
Reading comprehension (word)	2/4 (50)	4/4 (100)	4/4 (100)	4/4 (100)
Reading comprehension (sentence)	3/4 (75)	4/4 (100)	2/4 (50)	3/4 (75)
TR-DE word recognition	5/5 (100)		0/5 (0)	
DE-TR word recognition	5/5 (100)		0/5 (0)	
DE-TR word translation	4/10 (40)		0/10 (0)	
TR-DE word translation	4/10 (40)		0/10 (0)	
DE-TR sentence translation	2/6 (33)		0/6 (0)	
TR-DE sentence translation	4/6 (66)		0/6 (0)	
DE grammaticality judgement	4/8 (50)		0/8 (0)	
TR grammaticality judgement	5/7 (71)		0/7 (0)	

Table 4. Additional relevant aphasia evaluation outcomes obtained from our PWAs' clinical assessment using monolingual Turkish or German tests. Raw scores represent point values the PWA obtained out of maximum points in a given task, percentages are given in parentheses.

Variable	SK AAT (German)*	CT ADD (Turkish)**
Grammatical comprehension	67/120 (55.8%)	37/66 (56.1%)
Repetition	56/150 (37%)	16/20 (80.0%)
Naming	54/120 (45.0%)	29/44 (65.9%)

* SK was initially assessed at a speech-language therapy unit using the Aachener Aphasia Test (Huber et al., 1983) which was implemented in May 2010. Her performance in Turkish had not been assessed until our examination.
** CT was assessed in Turkish using the Aphasia Assessment Test AAD (Maviş & Toğram, 2009). Note that grammatical comprehension part in the AAD is based on auditory comprehension.

SK. SK is a 42-year-old woman who suffers from chronic mild-to-moderate non-fluent aphasia acquired following a left hemisphere cardio-embolic stroke. SK was born in Turkey but moved to Germany with her family at the age of four. She learnt German at a young age, and German became her dominant language as it was the language of instruction during her entire schooling. SK's dominant use of German over Turkish was also evident from her responses to the bilingualism background questionnaire, in which she rated her Turkish to be used less often than her German across all four skills (see Table 2). SK studied pedagogy and worked as a teacher and translator until she suffered a stroke in May 2006. Both her parents are Turkish, and she reported that her daily interaction with them occurs mostly in Turkish, while the language she speaks with her partner at home is German.

Outcomes from SK's language assessment using the BAT indicate that in a number of tasks including pointing, verbal auditory discrimination, word repetition, sentence repetition and series discrimination she had preserved ability in both German and Turkish. However, she tended to perform slightly worse in Turkish than in German for object naming, antonyms, word reading, sentence and word reading comprehension and writing tasks (see Table 3). SK was initially assessed using the AAT for German in May 2010, roughly six years before our examination, showing compromised grammatical comprehension, repetition and naming abilities (see Table 4).

CT. CT is 76-year-old man with moderate-to-severe non-fluent aphasia and resident in Istanbul. He was born and raised by German parents in Germany where he studied and lived for 29 years. Shortly before turning 30, he came to Istanbul to work as a medical doctor. He suffered from a left-hemisphere cardio-embolic stroke three months before our examination took place. As reported by CT's wife, a Turkey-born Turkish–German speaker, CT was highly proficient in Turkish before his aphasic symptoms emerged, and Turkish was also the language the couple mostly spoke at home.

CT's daily language use pattern indicates that he used Turkish in spoken contexts much more often than German premorbidly, while his German remained dominant over Turkish in reading and writing skills (see Table 2).

Outcomes from CT's language assessment using the BAT showed that he was good at responding to pointing, in verbal auditory discrimination, series discrimination and word reading comprehension tasks in both languages. His performance on object naming, simple and complex commands, syntactic comprehension, word repetition, writing, sentence reading comprehension, sentence repetition and antonyms tasks seemed to be worse in Turkish than in German (see Table 3). Moreover, CT failed to complete the Turkish–German bilingual part (Part C) of the test.

Materials and procedure

Our experimental stimuli consisted of 24 *wh*-questions in four conditions (Subject *Who*, Subject *Which*, Object *Who* and Object *Which*) in both Turkish and German; see examples (5)–(8) for illustration.

(5) SUBJECT *WHO*

Turkish: *Kim   adamı   itiyor?*
          who.NOM   man.ACC   push.PRES.PROG
German: *Wer   stößt   den   Mann?*
          who.NOM   pushes   the.ACC   man
          'Who is pushing the man?'

(6) SUBJECT *WHICH*

Turkish: *Hangi   kadın   adamı   itiyor?*
          which   woman.NOM   man.ACC   push.PRES.PROG
German: *Welche   Frau   stößt   den   Mann?*
          which.NOM woman   pushes   the.ACC   man
          'Which woman is pushing the man?'

(7) OBJECT *WHO*

Turkish: *Kadın   kimi   itiyor?*
          woman.NOM   who.ACC   push.PRES.PROG
German: *Wen   stößt   die   Frau?*
          who.ACC   pushes   the   woman.NOM
          'Who is woman pushing?'

(8) OBJECT *WHICH*

Turkish: *Kadın   hangi   adamı   itiyor?*
          woman.NOM which   man.ACC   push.PRES.PROG
German: *Welchen   Mann   stößt   die   Frau?*
          which.ACC man   pushes   the   woman.NOM
          'Which man is the woman pushing?'

Our stimulus sentences (taken from Arslan et al., 2017) all contained reversible agents and themes, and were created using 12 transitive verbs (see the Appendix). In half of the

24 experimental stimuli, the agent-theme pairs (*man, woman*) were reversed in order to control for potential effects of gender biases.[1]

The event described by our sentence stimuli was visually depicted in a total of 96 photographs, each of which contained three human referents performing an action (see Figure 1 for illustration). Each action was photographed once with two female actors between whom stood a male actor, and once with two male actors and a female actor standing between them. In half of the pictures, the action direction was reversed.

The participants were tested once in Turkish and once in German, with an interval of one week. SK was first tested in German and then in Turkish, CT was first tested in Turkish and then in German with the sentence-picture matching tasks. Bilingual aphasia assessments using the BAT were conducted prior to our experiments in a cross-balanced manner (i.e. Turkish BAT and German experiment in one meeting, and German BAT and Turkish experiment the following week). The participants saw one photo on each printed page with the sentence-stimuli provided in writing beneath. Participants were instructed, either in Turkish or in German depending on the language of testing, to listen to the experimenter reading aloud each sentence and to point to the person referent in the photograph that matched either the agent (for subject questions) or theme (for object

Figure 1. An example visual stimulus used in the German experiment, depicting an object-*who* question for the verb 'push'. Visual credits: © Seckin Arslan, University of Potsdam.

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[1]Note that in our German materials, only masculine NPs are unambiguously marked for case whereas feminine NPs are formally ambiguous between nominative and accusative. None of our stimuli were globally ambiguous, however. In Turkish, nominative forms are unmarked for case, whilst accusative case was marked by an overt suffix in all our stimulus sentences.

questions) of the sentence. Before the experiment started, three practice items were provided and repeated until the task was understood. Each participant responded to all 96 experimental items. Breaks were provided at any time participants needed to rest. The experiments and bilingual aphasia assessments were administered by a Turkish–German speaking speech therapist. Our study was approved by the ethics committee of the University of Potsdam (application number: 54/2015).

Analysis

An answer was counted as accurate when the participant pointed to the correct referent of the *wh*-phrase. Self-corrections were allowed, which occurred in only very few cases (1.3% of the total data). Each of our PWA's performance was compared with the reference group following the statistical procedures described by Crawford and Howell (1998) for case-controls designs. Our PWA's between-condition differences were tested using the Revised Standardized Difference Test (RSDT) following the criteria for dissociations proposed by Crawford & Garthwaite (2005). The Dissocs_ES.exe package was used for statistical analyses. These statistical procedures are commonly used in neuropsychology research.

Results

As expected, the NBDs performed virtually at ceiling in both language experiments (scoring above 98% correct in all the conditions). Different patterns emerged in the two PWA's responses in our German and Turkish experiments. Table 5 provides an overview of their response accuracy across conditions and languages. Below we report on SK's and CT's performance in turn.

In the Turkish experiment, SK performed significantly worse than the NBDs in all conditions (subject *who: Crawford-Howell, $t(12) = -5.589$, $p < 0.001$*; subject *which: Crawford-Howell, $t(12) = -9.636$, $p < 0.001$*; object *who: Crawford-Howell, $t(12) = -2.313$, $p = 0.019$*; object *which: Crawford-Howell, $t(12) = -3.276$, $p = 0.003$*). She had more difficulty with subject *which*-questions compared to all other conditions (subject *who: RSDT, $t(12) = 2.719$*, $p = 0.018$; object *which: RSDT, $t(12) = -4.238$, $p < 0.001$*; object *who: RSDT, $t(12) = 4.859$*, $p < 0.001$). Her performance was also worse for subject *who* than for object *who*-questions (*RSDT, $t(12) = 2.205$, $p = 0.047$*). No other between-condition differences were significant.

Table 5. Overview of the PWAs' response accuracy. Point values indicate raw scores out of number of items per condition (percentages given in parentheses).

Condition	SK	CT
Turkish		
Subject *Who*	17/24 (71%)	12/24 (50%)
Subject *Which*	12/24 (50%)	12/24 (50%)
Object *Who*	21/24 (87%)	10/24 (42%)
Object *Which*	20/24 (83%)	12/24 (50%)
German		
Subject *Who*	22/24 (92%)	18/24 (75%)
Subject *Which*	21/24 (87%)	18/24 (75%)
Object *Who*	22/24 (92%)	17/24 (71%)
Object *Which*	23/24 (96%)	12/24 (50%)

In the German experiment SK's response accuracy did not significantly differ from the NBDs' in any of the four conditions (subject *who*: Crawford-Howell, $t(12) = -0.749$, $p = 0.234$; subject *which*: Crawford-Howell, $t(12) = -1.178$, $p = 0.130$; object *who*: Crawford-Howell, $t(12) = -0.749$, $p = 0.234$; object *which*: Crawford-Howell, $t(12) = -0.321$, $p = 0.376$). There were no significant between-condition differences in SK's comprehension accuracy, either (all $ps > 0.57$).

An interesting cross-linguistic dissociation emerged in SK's response accuracy data: She comprehended Turkish subject *which*-questions significantly less accurately than German ones (50% vs. 87%, *RSDT* $t(12) = 2.457$, $p = 0.03$) and also performed more poorly on subject *who*-questions in Turkish than in German (71% vs. 92%, *RSDT* $t(12) = 2.908$, $p = 0.013$). No such cross-linguistic difference was observed for object *which* (96% vs. 83%, *RSDT* $t(12) = 0.867$, $p = 0.40$) or object *who* questions (92% vs. 87%, *RSDT* $t(12) = 0.334$, $p = 0.744$), however.

CT's responses to Turkish *wh*-questions were significantly less accurate than the NBDs' in all the four conditions (subject *who*: Crawford-Howell, $t(12) = -9.636$, $p < 0.0001$; subject *which*: Crawford-Howell, $t(12) = -9.636$, $p < 0.0001$; object *who*: Crawford-Howell, $t(12) = -11.178$, $p < 0.0001$; object *which*: Crawford-Howell, $t(12) = -9.636$, $p < 0.0001$). No between-condition differences were found in CT's performance in the Turkish experiment (all $ps > 0.318$).

In the German experiment CT also performed worse than the bilingual NBDs in all conditions (subject *who*: Crawford-Howell, $t(12) = -2.570$, $p = 0.012$; subject *which*: Crawford-Howell, $t(12) = 2.570$, $p = 0.012$; object *who*: Crawford-Howell, $t(12) = -2.998$, $p = 0.005$; object *which*: Crawford-Howell, $t(12) = -5.246$, $p < 0.001$). His performance in the object *which* condition was found to be worse than in all other conditions (subject *which*: RSDT, $t(12) = 4.475$, $p < 0.001$; subject *who*: RSDT, $t(12) = 4.368$, $p < 0.001$; object *who*: RSDT, $t(12) = 4.220$, $p = 0.001$). No other comparisons for CT's response accuracy in the German experiment returned any significant differences (all $ps > 0.77$).

Some cross-linguistic dissociations emerged in CT's comprehension of *wh*-questions. He performed better comprehending German subject *who* (75% vs. 50%, *RSDT* $t(12) = 3.229$, $p = 0.007$), subject *which* (75% vs. 50%, *RSDT* $t(12) = 4.829$, $p < 0.001$) and object *who*-questions (71% vs. 42%, *RSDT* $t(12) = 5.790$, $p < 0.001$) than he did for their Turkish equivalents. However, CT performed equally poorly for object *which*-questions in both languages (50%).

Discussion

Our findings contribute to the understanding of sentence comprehension difficulty and the nature of cross-linguistic impairments in bilingual aphasia. We explored whether an early and a late bilingual PWA showed selective deficits in their comprehension of different types of *wh*-questions in Turkish and German, and whether they showed any cross-linguistic dissociations.

Regarding the first question, our results show that SK, an early Turkish–German bilingual PWA, had selective difficulty interpreting subject *which*-questions in Turkish while showing no particular difficulty in any of the four experimental conditions in German. In contrast, CT (a late German–Turkish bilingual PWA) had a selective difficulty interpreting object *which*-questions in German, whereas in Turkish his response accuracy

was at chance level across all conditions. Concerning our second question, both PWA showed clear cross-linguistic dissociations, with both of them showing between-condition differences in their L1 only. SK's difficulty with Turkish subject *which*-questions and CT's difficulty with German object *which*-questions are broadly in line with Arslan et al.'s (2017) findings from monolingual Turkish and German-speaking PWA. It thus seems that SK's impairments parallel those of monolingual Turkish PWA, and CT's difficulties those of monolingual German PWA. Both our PWA also performed better in German than in the Turkish experiment overall. This may be due to the fact that both of them were German-dominant bilinguals, an issue which we will return to later.

Let us now consider to what extent the neurolinguistic hypotheses mentioned above can account for our data. Following both the TDH and the DOP-H, we expected our PWA to perform poorly for German object questions as these involve a non-canonical ordering of agent and theme arguments. Although CT did indeed show particular difficulty with German object *which*-questions, the fact that his comprehension of object *who*-questions was relatively spared (71% accurate) does not fit well with the assumption that 'traces' are missing from PWA's syntactic representation. Moreover, recall that SK performed completely normal for all types of German *wh*-questions (compared to a group of Turkish–German bilingual NBDs) but showed selective difficulty comprehending subject *which*-questions in Turkish instead. Taken together, our findings thus do not provide support for theoretical accounts that attribute PWA's sentence comprehension problems to difficulty with (canonical order-changing) syntactic movement.

Our results only partially support the D-linking Hypothesis (e.g. Avrutin, 2006; Hickok & Avrutin, 1996), which predicted that *which*-questions should be more problematic than *who*-questions in both German and Turkish, on account of the former question type requiring more complex pragmatic processing. CT's low response accuracy for German object *which*-questions does indeed seem compatible with this prediction in that it might be taken to reflect the combined difficulty of non-canonicity and D-linking. However, CT's overall chance-level performance in the Turkish experiment and his greater response accuracy for German subject *which*-questions than for their Turkish counterparts are not what the D-linking Hypothesis would predict. Moreover, SK's more severe problems with Turkish subject *which* compared to object *which*-questions, combined with the absence of any between-condition differences in the German experiment, does not seem compatible with the D-linking Hypothesis.

In short, none of the above hypotheses are able to fully account for our data. One possible reason for this is that the hypotheses being evaluated here were originally proposed to capture sentence comprehension difficulties in monolingual aphasia. Our PWA's individual language background and bilingualism characteristics might also have contributed to the observed patterns of difficulty, however. Recall, for example, that both SK and CT acquired aphasia in an immigration context, residing in countries where their first languages are not natively spoken. Our PWA also differed with regard to bilingualism onset, with SK an early and CT a late bilingual. Along with dominance and amount of exposure and use, these factors may lead to language imbalance, as noted by Paradis (2004).

Our results indicate that the cross-linguistic impairment patterns seen in our bilingual PWA do not reflect general typological differences between grammars (such as ±*wh*-movement), but instead reveal a more severe language-specific deficit in Turkish. How can the observed cross-linguistic dissociations be explained, then? The most important factor

that seems to predict the differential impairments of our two bilingual PWA is their bilingualism profile. A number of studies have previously reported that bilingualism-related factors (i.e. age of acquisition and premorbid language proficiency) influence both recovery patterns following therapy (e.g. Edmonds & Kiran, 2006; Faroqi-Shah et al., 2010; Goral et al., 2012) and lexical/semantic processing (Miozzo et al., 2010; Sebastian et al., 2012). In line with these studies, we argue that our PWA's performance in both Turkish and German must have been influenced by their different bilingualism profiles. SK is an early bilingual individual whose dominant language was her L2 (German), and her comprehension of *wh*-questions in this language proved to be largely spared. This finding is broadly consistent with Levy et al. (1999); Obler and Albert (1977), who showed that an L2 that is spoken more often at the onset of aphasia may be easier to recover than the L1. SK's intact comprehension of German *wh*-questions is also in line with Martínez-Ferreiro's (2010) finding that Catalan–Spanish and Galician–Spanish bilingual PWA's comprehension of *wh*-questions was unaffected in their premorbid dominant languages. Munarriz et al. (2016) also found selective impairments in a bilingual PWA's comprehension of *wh*-questions in Basque (L1) but ceiling performance in Spanish (L2). The data therefore confirm that a dominant society language may influence language outcomes in bilingual aphasia.

Our second case study (CT), in contrast, is a late bilingual speaker who acquired Turkish much later in life. The fact that CT showed considerably poorer performance in his L2 (Turkish) than in his L1 (German) fails to support the idea that a latter-learned language—even if it is the dominant society language—may be less affected in bilingual aphasia. However, greater impairments in bilingual PWA's L2 is not uncommon (e.g. Lekoubou et al., 2015; Levy et al., 1999; Muñoz & Marquardt, 2004; Tschirren et al., 2011). Nonetheless, an important issue here seems to be the presence of premorbid language imbalance. CT was reported to be an imbalanced bilingual individual, for whom Turkish was dominant only in spoken but not in written language skills (see Table 2). SK, on the other hand, was German-dominant across in all language skills. It thus seems that the different patterns of impairments that we observed in our bilingual PWA are influenced by premorbid language imbalance, as predicted by, for instance, Sebastian et al. (2012) and Paradis (2004).

Conclusion and limitations

We examined the comprehension of *wh*-questions in both Turkish and German in two bilingual PWA. While our PWA patterned differently from each other, they both performed worse in Turkish than in German, as compared to a reference group of bilingual NBDs who performed virtually at ceiling in all conditions. This suggests an important role of premorbid language dominance for language outcomes in bilingual aphasia. We further showed that neither of the linguistic hypotheses under scrutiny (the TDH, the DOP-H and the D-linking Hypothesis) were able to fully account for our data. Our study provides further evidence that bilingualism variables such as premorbid language use, age of acquisition or society language ought to be taken into account when assessing bilingual PWA's language abilities, and may also inform theoretical approaches to bilingual aphasia.

The current study does, of course, have several limitations. One potential confound is that SK acquired aphasia at a rather young age (around 32), and when our assessment was

implemented, about 10 years had passed from the onset of her aphasic syndrome. During this time, she received language treatment mostly in German. Therefore, SK's intact comprehension of German *wh*-questions does not necessarily point to the invulnerability of these questions types in bilingual aphasia, as extensive years of language therapy may well have influenced her performance. Another confound concerns the recency of CT's aphasia onset, which was likely to lead to more severe comprehension difficulties compared to those we observed in SK. Nonetheless, despite his recent onset, CT does not seem to show an alternating antagonism in his impairment patterns. We counter-balanced the language in our experimental tests and general aphasia assessments, and he consistently showed greater difficulty in Turkish than in German.

Despite these limitations, our findings show that sentence comprehension in bilingual aphasia is only partially influenced by structural differences between the languages of bilingual PWA. Instead, language-selective sentence comprehension impairments seem highly sensitive to bilingualism variables such as whether bilingual individuals present language imbalance premorbidly.

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Declaration of interest

The authors report no conflicts of interest

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Appendix

List of sentences used in the experiments

Object *Which* Questions

1. Turkish test: Adam/kadın hangi adamı/kadını tokatlıyor?
　German test: Welchen Mann/Welche Frau schlägt der Mann/die Frau?
　Eng. Trans.: Which man/woman is the man/woman smacking?

2. Adam/kadın hangi adamı/kadını tekmeliyor?
　Welchen Mann/Welche Frau tritt der Mann/die Frau?
　Which man/woman is the man/woman kicking?

3. Adam/kadın hangi adamı/kadını öpüyor?
　Welchen Mann/Welche Frau küsst der Mann/die Frau?
　Which man/woman is the man/woman kissing?

4. Adam/kadın hangi adamı/kadını çekiyor?
　Welchen Mann/Welche Frau zieht der Mann/die Frau?
　Which man/woman is the man/woman pulling?

5. Adam/kadın hangi adamı/kadını itiyor?
　Welchen Mann/Welche Frau stößt der Mann/die Frau?
　Which man/woman is the man/woman pushing?

6. Adam/kadın hangi adamı/kadını kovalıyor?
　Welchen Mann/Welche Frau jagt der Mann/die Frau?
　Which man/woman is the man/woman chasing?

7. Adam/kadın hangi adamı/kadını ısırıyor?

   Welchen Mann/Welche Frau beißt der Mann/die Frau?
   Which man/woman is the man/woman biting?

8. Adam/kadın hangi adamı/kadını gıdıklıyor?

   Welchen Mann/Welche Frau kitzelt der Mann/die Frau?
   Which man/woman is the man/woman tickling?

9. Adam/kadın hangi adamı/kadını dürtüyor?

   Welchen Mann/Welche Frau piekt der Mann/die Frau?
   Which man/woman is the man/woman poking?

10. Adam/kadın hangi adamı/kadını okşuyor?

   Welchen Mann/Welche Frau streichelt der Mann/die Frau?
   Which man/woman is the man/woman stroking?

11. Adam/kadın hangi adamı/kadını boğuyor?

   Welchen Mann/Welche Frau würdt der Mann/die Frau?
   Which man/woman is the man/woman choking?

12. Adam/kadın hangi adamı/kadını çimdikliyor?

   Welchen Mann/Welche Frau kneift der Mann/die Frau?
   Which man/woman is the man/woman pinching?

Object *Who* Questions

13. *Turkish test*: Adam/kadın kimi tokatlıyor?

   German test: Wen schlägt der Mann/die Frau?
   Eng. Trans.: Who is the man/woman smacking?

14. Adam/kadın kimi tekmeliyor?

   Wen tritt der Mann/die Frau?
   Who is the man/woman kicking?

15. Adam/kadın kimi öpüyor?

   Wen küsst der Mann/die Frau?
   Who is the man/woman kissing?

16. Adam/kadın kimi çekiyor?

   Wen zieht der Mann/die Frau?
   Who is the man/woman pulling?

17. Adam/kadın kimi itiyor?

   Wen stößt der Mann/die Frau?
   Who is the man/woman pushing?

18. Adam/kadın kimi kovalıyor?

   Wen jagt der Mann/die Frau?

Who is the man/woman chasing?

19. Adam/kadın kimi ısırıyor?
    Wen beißt der Mann/die Frau?
    Who is the man/woman biting?

20. Adam/kadın kimi gıdıklıyor?
    Wen kitzelt der Mann/die Frau?
    Who is the man/woman tickling?

21. Adam/kadın kimi dürtüyor?
    Wen piekt der Mann/die Frau?
    Who is the man/woman poking?

22. Adam/kadın kimi okşuyor?
    Wen streichelt der Mann/die Frau?
    Who is the man/woman stroking?

23. Adam/kadın kimi boğuyor?
    Wen würdt der Mann/die Frau?
    Who is the man/woman choking?

24. Adam/kadın kimi çimdikliyor?
    Wen kneift der Mann/die Frau?
    Who is the man/woman pinching?

Subject *Which* Questions

25. *Turkish test*: Hangi adam/kadın adamı/kadını tokatlıyor?
    German test: Welcher Mann/Welche Frau schlägt den Mann/die Frau?
    Eng. Trans.: Which man/woman is smacking the man/woman?

26. Hangi adam/kadın adamı/kadını tekmeliyor?
    Welcher Mann/Welche Frau tritt den Mann/die Frau?
    Which man/woman is kicking the man/woman?

27. Hangi adam/kadın adamı/kadını öpüyor?
    Welcher Mann/Welche Frau küsst den Mann/die Frau?
    Which man/woman is kissing the man/woman?

28. Hangi adam/kadın adamı/kadını çekiyor?
    Welcher Mann/Welche Frau zieht den Mann/die Frau?
    Which man/woman is pulling the man/woman?

29. Hangi adam/kadın adamı/kadını itiyor?
    Welcher Mann/Welche Frau stößt den Mann/die Frau?
    Which man/woman is pushing the man/woman?

30. Hangi adam/kadın adamı/kadını kovalıyor?

Welcher Mann/Welche Frau jagt den Mann/die Frau?
Which man/woman is chasing the man/woman?

31. Hangi adam/kadın adamı/kadını ısırıyor?

    Welcher Mann/Welche Frau beißt den Mann/die Frau?
    Which man/woman is biting the man/woman?

32. Hangi adam/kadın adamı/kadını gıdıklıyor?

    Welcher Mann/Welche Frau kitzelt den Mann/die Frau?
    Which man/woman is tickling the man/woman?

33. Hangi adam/kadın adamı/kadını dürtüyor?

    Welcher Mann/Welche Frau piekt den Mann/die Frau?
    Which man/woman is poking the man/woman?

34. Hangi adam/kadın adamı/kadını okşuyor?

    Welcher Mann/Welche Frau streichelt den Mann/die Frau?
    Which man/woman is stroking the man/woman?

35. Hangi adam/kadın adamı/kadını boğuyor?

    Welcher Mann/Welche Frau würdt den Mann/die Frau?
    Which man/woman is choking the man/woman?

36. Hangi adam/kadın adamı/kadını çimdikliyor?

    Welcher Mann/Welche Frau kneift den Mann/die Frau?
    Which man/woman is pinching the man/woman?

Subject *Who* Questions

37. *Turkish test*: Kim adamı/kadını tokatlıyor?

    German test: Wer schlägt den Mann/die Frau?
    Eng. Trans.: Who is smacking the man/woman?

38. Kim adamı/kadını tekmeliyor?

    Wer tritt den Mann/die Frau?
    Who is kicking the man/woman?

39. Kim adamı/kadını öpüyor?

    Wer küsst den Mann/die Frau?
    Who is kissing the man/woman?

40. Kim adamı/kadını çekiyor?

    Wer zieht den Mann/die Frau?
    Who is pulling the man/woman?

41. Kim adamı/kadını itiyor?

    Wer stößt den Mann/die Frau?
    Who is pushing the man/woman?

42. Kim adamı/kadını kovalıyor?
  Wer jagt den Mann/die Frau?
  Who is chasing the man/woman?

43. Kim adamı/kadını ısırıyor?
  Wer beißt den Mann/die Frau?
  Who is biting the man/woman?

44. Kim adamı/kadını gıdıklıyor?
  Wer kitzelt den Mann/die Frau?
  Who is tickling the man/woman?

45. Kim adamı/kadını dürtüyor?
  Wer piekt den Mann/die Frau?
  Who is poking the man/woman?

46. Kim adamı/kadını okşuyor?
  Wer streichelt den Mann/die Frau?
  Who is stroking the man/woman?

47. Kim adamı/kadını boğuyor?
  Wer würdt den Mann/die Frau?
  Who is choking the man/woman?

48. Kim adamı/kadını çimdikliyor?
  Wer kneift den Mann/die Frau?
  Who is pinching the man/woman?