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## Subject–verb agreement dependency in Turkish Broca’s aphasia: impairments in event occurrence and consequences for discourse-linking

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### ABSTRACT

**Background:** Inflecting the verb for agreement requires an intact discourse-semantic ability in addition to that for morphosyntax, since the use of person involves a link between the participants in the speech act and the morphosyntactic expression of this feature. Unlike the first person (the Speaker), the second person (the Addressee) requires additional discourse processing, termed “discourse-linking”. Individuals with Broca’s aphasia may have impaired discourse-linking, which may affect their ability to process second person pronouns and produce verb morphology for the second person.

**Aims:** This study investigated whether the discourse-linking involved in processing second person pronouns contributes to sentence production deficits in Broca’s aphasia.

**Methods & Procedures:** The sample consisted of 16 Turkish individuals with Broca’s aphasia (mean age: 54.8 years; SD: 14.0) who were matched in age with a control group of 16 neurologically intact Turkish individuals (mean age: 54.9; SD: 13.1). Each group completed a language task with first and second person singular or plural agreement conditions. Target agreement morphology was elicited using sentence-initial first and second person singular or plural pronouns. The plural (reference to a group) has a more complex discourse-representation than the singular (reference to an individual).

**Outcomes & Results:** The group of individuals with Broca’s aphasia showed the following production hierarchy: first person singular (highest accuracy rate) > first person plural > second person singular > second person plural (lowest accuracy rate). There was no discrepancy between test conditions for the control group.

**Conclusions:** The discourse-linking involved in processing second person pronouns contributes to sentence production deficits and this deficit is exacerbated by plurality in Broca’s aphasia. We suggest that cognitive-semantic intervention which focusses on the broader underlying impairment in deciphering event occurrence features (participant-time-location) could improve the use of the second person and other discourse-linked constructions (e.g., past time reference, object pronouns) which are selectively affected in Broca’s aphasia.

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## Introduction

Broca's aphasia is primarily characterised by omissions and substitutions of grammatical morphemes in constrained tasks and in spontaneous speech (Goodglass, 1968). Some verbal affixes have been shown to be particularly prone to impairment (e.g., Burchert, Swoboda-Moll, & De Bleser, 2005; Friedmann & Grodzinsky, 1997; Varlakosta et al., 2006; Wenzlaff & Clahsen, 2005). Various proposals across several languages have been made to capture the generalization of impaired and spared verbal morphology in Broca's aphasia.

Several hypotheses share the specific assumption that agreement morphology is preserved better than tense morphology. Some researchers attribute this pattern to *pruned syntactic nodes* (i.e., the Tense node is pruned while the Agreement node remains available, due to their positions in the syntactic tree, Friedmann & Grodzinsky, 1997), whereas others attribute it to *underspecified features of the syntactic nodes* (i.e., tense is underspecified but not agreement, Wenzlaff & Clahsen, 2005; or tense and agreement are unsystematically underspecified, Burchert et al., 2005), or *system-specific differences* (i.e., tense, unlike agreement, is not a purely morphosyntactic system, and discourse-processing is required for tense but is not required for agreement, Avrutin, 2000, 2006). While there is quite some overlap between how the various hypotheses predict tense and agreement performance, only the hypothesis of Burchert et al. (2005) predicts that agreement will be impaired. Because Burchert et al. (2005) assume an unsystematic feature underspecification which is neither one-sided nor obligatory, tense, or agreement can be selectively underspecified, tense and agreement can be simultaneously underspecified, or neither will be underspecified.

Bastiaanse (2008) and Yarbay Duman and Bastiaanse (2009) also reported a deficit with tense in Broca's aphasia, but the morphological problems of individuals with Broca's aphasia were not restricted to tensed verb forms, nor were past and non-past tense equally impaired. Thus, they proposed that it is not tense that is impaired in Broca's aphasia, but time reference through verb forms in general; in particular, reference to the past is impaired. This has been explained by a difficulty understanding the *epistemic-semantic functions of verb morphology* involved in deciphering event occurrence (i.e., the degree of certainty with respect to *how* and *when* an event happened or will happen, Yarbay Duman & Bastiaanse, 2009) and *discourse-linking* the earlier event time to the speech time (i.e., past time versus non-past time-reference, Bastiaanse et al., 2011). From this perspective, the interface between morphosyntax and discourse-semantics in individuals with Broca's aphasia is an interesting area to investigate as it might permit the separation of morphosyntactic abilities and discourse-semantics abilities. The current study is the first investigation of the impact of discourse-semantics on the production of agreement morphology in Broca's aphasia.

The premise that agreement is relatively preserved in Broca's aphasia (Avrutin, 2006; Friedmann & Grodzinsky, 1997; Wenzlaff & Clahsen, 2005) conflicts with cross-linguistic data on agreement in this population, which documents individuals with Broca's aphasia making excessive agreement errors across languages (e.g., Benedet, Christiaansen, & Goodglass, 1998, for English and Spanish). However, the difficulty with a position in which agreement is occasionally impaired (Burchert et al., 2005) is that we cannot predict or account for when the impairment will be or should be observed. Overall, one limitation of previous research on agreement morphology seems to be the substantial focus on the

formal nature of agreement dependency: as such, research only considered computation within the narrow syntactic build-up of the sentence and did not consider the discourse-semantic functions of the arguments involved.

Recent theoretical analyses suggest that inflecting the verb for agreement requires an intact discourse-semantic ability in addition to that for morphosyntax, since the use of person involves a link between the participants in the speech act and the morphosyntactic expression of this feature (e.g., Bianchi, 2006; Harley & Ritter, 2002; Sigurðsson, 2004). Person expresses the status of the subject with respect to the participants in the speech act, namely who the participants are and what roles each participant plays in an event, as well as the perspective from which the event is narrated. The first person expresses identity with (or the inclusion of) the Speaker; the second person expresses identity with (or the inclusion of) the Addressee; and the third person excludes both Speaker and Addressee (Bianchi, 2006; Harley & Ritter, 2002; Sigurðsson, 2004). In contrast to the first person, which refers to or includes the Speaker, the second person necessarily requires the identification of one or more Addressee feature in the discourse, which requires additional discourse processing, termed “discourse-linking” (Harley & Ritter, 2002).

We investigated whether Turkish individuals with Broca’s aphasia demonstrated differences in producing the first and second person in constructions requiring singular or plural agreement and compared results to a group of neurologically intact Turkish individuals. The target agreement morphology was elicited using sentence-initial first and second person singular or plural subject pronouns. The plural is assumed to require a more complex discourse-participant representation than the singular, as the plural refers to a group of participants while the singular to an individual (e.g., Harley & Ritter, 2002). To our knowledge, the first and second person in singular or plural constructions have not been systematically examined within a single study of individuals with Broca’s aphasia. The advantage of a systematic investigation is that it permits us to examine the ability of individuals with Broca’s aphasia to produce specific agreement morphology pertaining to the subject pronoun they are required to process.

Turkish is a suitable language for this investigation for several reasons. The agreement morphology in Turkish is morphosyntactically and semantically transparent because Turkish uses unique agreement morphemes for the first person and second person singular or plural. Furthermore, these agreement morphemes are affixed to the lexical verb (i.e., no periphrastic forms or auxiliaries are used), all verbs are regular, and tense morphology (encoding of time-reference) does not interfere with agreement morphology (encoding of participant-reference), as tense/aspect morphemes are also unique in Turkish. Consequently, researchers can control Turkish morphosyntactic and semantic complexity and investigate the production of agreement morphology.

We hypothesised that for individuals with Broca’s aphasia, the second person pronouns would be more difficult to process and second person agreement morphology would be more difficult to produce than the first person pronouns and agreement morphology, respectively, regardless of the number (singular or plural). We also anticipated the plural to be more demanding overall than its singular counterpart because the plural requires a more complex discourse representation. This is particularly the case when a speaker-exclusive group is referred to (the second person plural pronoun) than a speaker-inclusive group (the first person plural pronoun).

## Aphasiological background

### Subject–verb agreement

Several hypotheses on tense and agreement morphology (e.g., Avrutin, 2006; Friedmann & Grodzinsky, 1997; Wenzlaff & Clahsen, 2005) predict that agreement is relatively preserved; yet cross-linguistic data indicate that impairment in tense co-occurs with impairment in agreement. First, agreement and tense were found to be equally difficult for individuals with Broca's aphasia across several languages (Burchert et al., 2005, for German; Clahsen & Ali, 2009, for English; Fyndanis et al., 2015, for Italian – with an agreement error rate of 32%, 29% and 25% and a tense error rate of 37%, 35% and 22%, in each language, respectively). Second, when tense was found to be more impaired than agreement, agreement was also reported as being severely impaired (e.g., Benedet et al., 1998, for Spanish and English, with agreement error rates of 40% and 58% for each language, respectively) or impaired at least to some degree (see for Greek: Nanousi, Masterson, Druks, & Atkinson, 2006; Varlakosta et al., 2006). Finally, agreement morphology was also impaired in narrative speech. For example, Miceli, Silveri, Romani, and Caramazza (1989) reported that Italian individuals with Broca's aphasia produced excessive agreement error rates (43% to 64%), with their sentences being subject to a mismatch between person and number agreement on the subject and the verb.

It is as yet unclear whether impairment in agreement morphology is unsystematic (Burchert et al., 2005). Although the spontaneous speech studies by Lehečková (2001) and Stavrakaki and Kouvava (2003) were not specifically on agreement, our examination of their results showed that the most common error made by Czech individuals was the use of the first person when another person form was required (corresponding to 68% of all person errors). The majority of errors were the exchange of the singular for the plural. Furthermore, in one of the two Greek individuals (SC) that Stavrakaki and Kouvava (2003) tested, all the instances of first person singular were correct whereas the second person plural was only 60% correct. Taken as a whole, these findings do not seem to support the argument that impairment in agreement morphology is unsystematic.

### Discourse-linking

Several studies have shown that linguistic processing requiring discourse-linking is difficult for individuals with Broca's aphasia: they exhibit more difficulty with discourse-linked *which*-questions, object pronouns, and past time-reference compared to *who*-questions, reflexives, and present time-reference (Avrutin, 2006, for questions and pronouns; Bastiaanse et al., 2011, for time reference; Bos, Dragoy, Avrutin, Iskra, & Bastiaanse, 2014, for questions, pronouns and time reference within a single group).

*Which*-questions, object pronouns, and past time-reference require access to additional discourse structures to link the referent outside the clause, whereas *who*-questions, reflexives (Avrutin, 2006) and present time-reference (Bastiaanse et al., 2011) do not require additional information and can be processed using narrow syntax (i.e., processed within the scope of the sentence). For example, the object pronoun *him* as in *the boy is washing him* refers to a man who is not mentioned in the sentence, whereas the reflexive *himself*, as in *the boy is washing himself* refers to the boy in the same sentence. Similarly,

the past form of the verb *write*, as in *he wrote the letter*, refers to an event time different to the speech time. The present form of this verb, *he writes a letter*, is bound to the here and now. Discourse-linking is assumed to be a central deficit which affects both language comprehension and production (Bastiaanse et al., 2011).

Avrutin (2006) suggests that compared to narrow syntax, discourse-linking requires a higher processing load because it requires simultaneous processing at two linguistic levels (discourse–syntax) and that individuals with Broca’s aphasia have limited resources to achieve this. However, there are two issues. First, Avrutin’s (2006) assumption that agreement does not require discourse-processing and would thus be easy for individuals with Broca’s aphasia to produce seems to have linguistic and computational limitations (see Introduction). Second, it is as yet unclear what resources are required for discourse-linking and why these resources are limited in individuals with Broca’s aphasia. We investigate whether the discourse-linking involved in processing of the second person subject pronouns contribute to verb agreement production deficits in Broca’s aphasia.

### Research question for the study

Do Turkish individuals with Broca’s aphasia exhibit deficits in producing agreement morphology in sentences with first (singular or plural) and second (singular or plural) person subject pronouns?

### Subject–verb agreement in Turkish grammar

Turkish is an agglutinating pro-drop language with a subject–object–verb base order.

A Turkish main clause can have the finite verb in the first person singular (1SG, see example 1, *-m*), first person plural (1PL, example 2, *-k*), second person singular (2SG, example 3, *-n*) or second person plural (2PL, example 4, *-nız*). In all four examples, the objects are in the accusative (acc) case and verbs are inflected to the past tense. The subject pronouns (*ben* “I”, *biz* “we”, *sen* “you-singular”, *siz* “you-plural”) in these examples are in parenthesis to illustrate the pro-drop nature of Turkish.

(1) 1SG

(Ben) *elma-yı soy-du-m*

(I) apple–acc peel–past–1SG

‘I peeled the apple’

(2) 1PL

(Biz) *elma-yı soy-du-k*

(We) apple–acc peel–past–1PL

‘We peeled the apple’

(3) 2SG

(Sen) *elma-yı soy-du -n*

(You) apple–acc peel–past–2SG

‘You peeled the apple’

#### (4) 2PL

(Siz) elma-yı soy-du-nuz

(You) apple-acc peel-past-2PL

'You peeled the apple'

Table 1 summarises the relevant characteristics of the verb inflections for this study. These Turkish verb inflections are part of the “*k*-paradigm”, which means that the inflection is attached to verbal stems that end with the past tense (or the conditional marker) (Göksel & Kerslake, 2005). Although the second person plural seems to consist of two separate morphemes, *-n* for second person and *-lz* for plurality, these are traditionally analysed as a single affix in Turkish. The third person is not tested in this study because the third person singular and third person plural are a zero morpheme in Turkish.

We use sentence-initial subject pronouns to elicit specific agreement morphology. Sentences with subject pronouns are more marked than sentences with null subjects in Turkish due to its pro-drop nature (Enç, 1986). When a subject pronoun is used, it indicates specific discourse functions associated with its position in the sentence: a pre-verbal pronoun indicates topic switch or contrastive focus and a post-verbal pronoun emphasizes a speaker's concern with his interlocutor (Enç, 1986). The position of the subject pronoun does not impact the form of agreement morphology.

### Study predictions

Given the characteristics of Turkish grammar and the nature of plurality in first and second person pronouns (e.g., Bianchi, 2006; Harley & Ritter, 2002) and the results from previous studies indicating that discourse-linking is impaired in Broca's aphasia (Avrutin, 2006; Bastiaanse et al., 2011), we made several predictions as to how Turkish-speaking individuals with Broca's aphasia and neurologically intact Turkish-speaking individuals would perform in a language task involving production of varied agreement morphology, pertaining to the subject pronouns they process.

### Broca group

(1) (a) Agreement morphology will be the easiest to produce in sentences with first person singular pronouns (1SG). (b) Performance will drop for sentences with second person singular or first person plural pronouns, and performance for the second person singular will be worse than the first person plural (2SG<1SG, 2SG<1PL). (c) Agreement morphology will be the most difficult to produce in sentences with second person plural pronouns (2PL).

**Table 1.** Turkish verbal agreement paradigm for the first and second persons.

	Singular	Plural
First Person	-m	-k
Second Person	-n	-nlz

(2) Error data prediction: we expected (a) more person errors in the second person than the first person; (b) more number errors in the plural than in the singular; (c) more dual errors (person and number) when there is second person and the plural number.

### **Control group**

(3) As healthy adults are expected to have intact discourse-semantic and morphosyntactic abilities, we predicted that they performed at ceiling for all test conditions.

## **Method**

### **Participants**

Two groups of individuals participated in this study: 16 Turkish individuals with Broca's aphasia (mean age: 54.8; SD: 14.0; 10 male/6 female; 6 university/10 below university level graduates) and 16 neurologically intact Turkish individuals (mean age: 54.9; SD: 13.1; 11 male/5 female; 3 university/13 below university level graduates). The two groups were matched on chronological age ( $t(30) = -.026, p = .97$ ). Participant characteristics are provided in [Appendix A](#).

Individuals with aphasia were recruited from two rehabilitation centres in Ankara, Turkey: (1) Hacettepe University Audiology and Speech Disorders Clinic and (2) Ankara Physical Medicine, Rehabilitation, Education, and Research Hospital. A speech and language therapist identified the individuals as having aphasia based on their expressive and receptive language skills. The standardised aphasia tests *The Test of Language Assessment in Aphasia* (Maviş & Toğram, 2009) or the *Gülhane Aphasia Test* (Tanrıdağ, 1993) were used to investigate language skills. The speech and language therapists confirmed that all the participants in the Broca group presented with non-fluent aphasia (i.e., speech characterised as halting and laboured). Of the 16 individuals with Broca's aphasia, 14 acquired aphasia due to left CVA and 2 due to TBI. All presented with right hemiplegia at the time of language testing, which is consistent with left-sided brain injury. All the participants were with at least three months post-onset aphasia, were right-handed and had normal or corrected to normal auditory and visual acuity. All were receiving speech therapy at the time of testing, but their intervention goals did not include areas targeted in this study.

### **Experimental design**

A sentence–picture completion task was developed with four conditions: 1SG, 1PL, 2SG and 2PL (see Turkish grammar, Examples 1–4). The vocabulary items consisted of 15 transitive verbs (e.g., “to peel”) matched with an object pair (e.g., banana–orange). There were 60 stimuli per participant (15 sentences x 4 conditions). All the verbs were inflected for unique agreement morphemes ( $-m$ : 1SG,  $-n$ : 2SG,  $-k$ : 1PL,  $-niz$ : 2PL). The target agreement morphology was elicited using a sentence-initial subject pronoun (*ben* “I”; *sen* “you”; *biz* “we”; *siz* “you (pl)”) to elicit 1SG, 2SG, 1PL and 2PL, respectively). Direct objects were in the accusative case ( $-ı$ ) and all the verbs were in the past tense ( $-DI$ ).



## Procedure

The participants were presented with two pictures of two objects on a single page. A clause was printed under each picture. The second clause was incomplete and contained a dashed line to represent a missing verb. The participants were provided with the following instructions (the text below is a translation of the Turkish instruction):

“Now I will show you pictures of two objects. Please look at them carefully. Under each picture you will see a sentence. First, I will tell you the names of the objects. Then, I will read aloud the first sentence. I will start reading the second sentence as well but I will leave it incomplete because, there (points to dash), the verb (for example, *soymak*: ‘to peel’) is missing. Please listen to me carefully and when I stop, finish the sentence with the missing verb.”

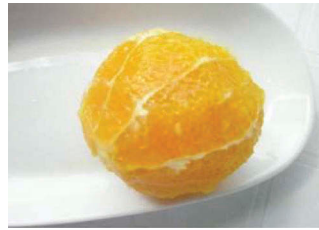
Figure 1 provides two examples of the test stimuli. For the sentence (see Figure 1(a), 1SG) “*Sen muzu soydun. Ben portakali ...*”, the target is *soydum*. For the sentence (see Figure 1(b), 2SG) “*Ben portakalı soydum. Sen muzu ...*”, the target is *soydun*. The target verb morphology was elicited using either the singular (first person singular vs. second person singular or second person singular vs. first person singular) or the plural (first person plural vs. second person plural or second person plural vs. first person plural). The order of all the pictures was pseudo-randomised in the test and the practice trials. The given and target verb agreement morphology were always different throughout the test. The participants were encouraged to read sentences with the experimenter or repeat subject pronouns in the second sentence.

Each participant completed four practice trials with each trial consisting of two items. If the participant made errors during the practice trials, the errors were corrected. For example, if the participant used 1SG morphology “*soydum*” in response to the sentence “*Biz muzu ...*” (1PL condition: the target verb “*soyduk*”), the experimenter emphasised the subject and the target verb form. The practice trials were repeated if necessary. The test commenced when the participants said they were ready.

The test was administered individually over two sessions in a quiet room. No time limit was imposed. The experimenter repeated the target sentence once on request. No feedback was provided on experimental items. The Ethics Board of the Clinical Research Centre of Ankara University, Hacettepe University Audiology and Speech Disorders Clinic, and Ankara Physical Medicine, Rehabilitation, Education, and Research Hospital approved the study design. Each participant provided written informed consent before undertaking the study.

## Scoring

A response was deemed correct when the participant produced the target verb morphology. A lexical paraphasia (e.g. saying “eat” when “peel” was required) or insertion of an additional morpheme (e.g., negation) to the verb stem was ignored if the target verb morphology was produced correctly. The total number of lexical paraphasias and morphological insertions was low and occurred only in the Broca group (3 items out of 960 test sentences, 0.3%). An error analysis was performed for each condition, focusing on the number and type of agreement errors (person, number and dual errors of “person and number”).



**Figure 1(a).** Example stimuli for the first person singular condition: “*Sen muzu soydun. Ben portakalı ... (target: soydum)*”: You peeled the banana. I peeled the orange.



**Figure 1(b).** Example stimuli for the second person singular condition: “*Ben portakalı soydum. Sen muzu ... (target: soydun)*”: I peeled the orange. You peeled the banana.

## Results

Table 2 lists the mean number (SD) and proportion of correctly produced verbs in the four conditions for the Broca’s group. Individual scores are listed in Appendix B. We carried out both quantitative and qualitative data analyses. The mean accuracy score of the control group was at ceiling for all conditions. As such, this group’s data were not considered further for statistical analysis.

### Quantitative analysis

A two-way repeated-measures ANOVA with Greenhouse–Geisser correction was performed to investigate whether there was an effect of Person (first and second person) and Number (singular and plural) on sentence production accuracy in the Broca group. The aim was to investigate whether the Broca group showed differences in producing the first person compared to the second person and producing singular agreement compared to plural agreement. Both Person and Number were treated as within-participants factors. The dependent variable was accuracy (number of correct responses).

There was a significant main effect for Person (First person:  $M = 13.12$ ;  $SE = 0.51$ ; Second Person:  $M = 8.46$ ;  $SE = 0.93$ ,  $(F(1, 15) = 34.95, p < .001, \eta^2 = .70)$ . The main effect

**Table 2.** The mean number (SD) and proportion of correctly produced verb agreement morphology for each condition. Target verb agreement morphology in each condition is *in italics*.

	First Person Singular- <i>m</i>	Second Person Singular- <i>n</i>	First Person Plural- <i>k</i>	Second Person Plural- <i>nlz</i>
Mean (SD)	14.31 (1.25)	10.87 (4.61)	11.93 (4.07)	6.06 (5.27)
Proportion	.95	.73	.80	.40

SD = Standard Deviation. Maximum score per condition is 15.

indicated differences regarding how the Broca group performed in the first and second person agreement. Pairwise comparisons indicated the mean difference (4.66) between first and second person was significant ( $p < 0.001$ , Bonferroni corrected). This means that irrespective of number agreement, sentence completion in the first person constructs was produced with greater accuracy than second person constructs. Inspection of Mean Scores indicates that the first person was easier to produce than the second person in sentences with singular agreement (1SG:  $M = 14.31$ ;  $SD = 1.25$ ; 2SG:  $M = 10.87$ ;  $SD = 4.61$ ) or plural agreement (1PL:  $M = 11.93$ ;  $SD = 4.07$ ; 2PL:  $M = 6.06$ ;  $SD = 5.27$ ).

There was also a significant main effect for Number (Singular:  $M = 12.59$ ;  $SE = 0.62$ ; Plural:  $M = 9.00$ ;  $SE = 0.95$ ,  $(F(1, 15) = 14.08, p = .002, \eta^2 = .48)$ . The main effect indicated differences regarding how the Broca group performed in the singular and plural agreement constructs. Pairwise comparisons indicated that the mean difference (3.59) between singular and plural agreement was significant ( $p = .002$ , Bonferroni corrected). That is, singular agreement was produced with greater accuracy than plural agreement, irrespective of the person agreement. Inspection of Mean Scores indicated that 1SG was easier to produce than 1PL (first singular:  $M = 14.31$ ;  $SD = 1.25$ ; first plural:  $M = 11.93$ ;  $SD = 4.07$ ) and 2SG was easier to produce than 2PL (2SG:  $M = 10.87$ ;  $SD = 4.6$ ; 2PL:  $M = 6.06$ ;  $SD = 5.27$ ). There was no significant interaction between Person and Number ( $F(1, 15) = 1.50, p = .24, \eta^2 = .09$ ). Note that the effect size for Person was larger than that for Number (see above,  $\eta^2 = .70$ ;  $\eta^2 = .48$ , respectively).

### Qualitative analysis

Table 3 presents the mean number (SD) of error types in the four conditions. There were three error types: person error (i.e., error in the use of person only – using a non-target first or second person), number error (i.e., error in the use of number only – using a non-target singular or plural number) and dual error [person and number] (i.e., simultaneous error in the use of both person and number – using a non-target first or second person and a non-target singular or plural number). A repeated measures ANOVA was completed to investigate three predictions: (a) more person errors in second person than in first person, (b) more number errors in plurals than in singulars, and (c) more dual errors [person and number] in second plurals compared to the second singulars (see Error prediction (2)). The dependent variable was the number of errors.

First, a one-way repeated measures ANOVA with a Greenhouse–Geisser correction was performed to investigate if there was an effect of Condition (within-participants factor) on the number of *person* errors. For the first person, we used total person errors in 1SG and 1PL, and for the second person, we used total person errors in 2SG and 2PL. The results

**Table 3.** The mean number (SD) of error types in verb agreement morphology production.

	Single substitution		Double substitution
	Person (first ↔ second)	Number (singular ↔ plural)	Person + Number (first ↔ second) + (singular ↔ plural)
First Person Singular	0.18 (0.54)	0.50 (1.09)	-
Second Person Singular	2.68 (4.09)	0.56 (1.36)	0.87 (2.41)
First Person Plural	0.31 (1.01)	2.43 (4.17)	0.31 (1.25)
Second Person Plural	0.68 (1.53)	3.18 (4.65)	5.06 (5.07)

SD = Standard Deviation; ↔ = substituted to or vice versa.

showed a significant main effect of Condition (first person:  $M = 0.50$ ,  $SD = 1.31$ ; second person:  $M = 3.0$ ,  $SD = 4.06$ ;  $F(1, 15) = 5.15$ ,  $p = 0.033$ ,  $\eta^2 = .27$ ). Post-hoc tests revealed that the mean difference in error rate between first person and second person ( $-2.50$ ) was significant ( $p = .033$ , Bonferroni correction applied). This means there were more person errors in second person constructs compared to first person constructs.

Second, a one-way repeated measures ANOVA with Greenhouse–Geisser correction was performed to investigate whether there was an effect of Condition (within-participants factor) on the number of *number* errors. For the singular, we used total number errors in 1SG and 2SG, and for the plural, we used total number errors in 1PL and 2PL. The results showed that there was a significant main effect of Condition (singular:  $M = 1.06$ ,  $SD = 1.76$ ; plural:  $M = 5.62$ ,  $SD = 6.22$ ;  $F(1, 15) = 7.13$ ,  $p = 0.017$ ,  $\eta^2 = .32$ ). Post-hoc tests revealed a significant mean difference between singular and plural (mean difference  $-4.56$ ,  $p = .017$ , Bonferroni correction applied). This means there were more errors for plural than for singular constructs.

Third, we looked at dual errors [person + number] in 2SG compared to 2PL. The results of a one-way repeated measures ANOVA with a Greenhouse–Geisser correction showed a significant main effect for Condition (2SG:  $M = 0.87$ ,  $SD = 2.41$ ; 2PL:  $M = 5.06$ ,  $SD = 5.07$ ;  $F(1, 15) = 6.96$ ,  $p = 0.019$ ,  $\eta^2 = .32$ ). Post-hoc tests using Bonferroni correction revealed that the mean difference between dual errors in the second person singular and the second person plural ( $-4.18$ ) was significant ( $p = .019$ ). This means that there were more dual errors in 2PL than 2SG.

## Discussion

The main research question was whether Turkish individuals with Broca's aphasia exhibit deficits in producing agreement morphology in sentences with first (singular or plural) and second (singular or plural) person subject pronouns. The results showed that agreement morphology was the easiest to produce in sentences with first person singular pronouns for the individuals with Broca's aphasia. Their performance dropped significantly for sentences with second person singular or first person plural pronouns and performance for the second person singular was worse than the first person plural. Agreement morphology was the most difficult to produce for them in sentences with second person plural pronouns. Accordingly, the following order of difficulty was observed: (least accurate) 2PL – 2SG – 1PL – 1SG (most accurate). These results were correctly anticipated in study predictions (1a-b-c) for the Broca group. The control group performed at ceiling for all test conditions, as it was foreseen in the study prediction (3).

On the basis of these results, there are three main findings for the Broca group. First, Turkish individuals with Broca's aphasia exhibit deficits in the processing of subject pronouns and the production of agreement morphology. Second, irrespective of singular or plural number, they have more difficulties processing the second person pronouns and producing agreement morphology for the second person compared with the first person. Finally, although the plural requires a more complex discourse representation compared to singulars and are overall more demanding than the singulars, the plural is more difficult to process and to produce in sentences with the second person than first person subject pronouns. There were, as correctly predicted in the study predictions (2) for the Broca group, (a) more person errors in the second person compared to the first person. There were (b)

more number errors in plurals compared to singulars and (c) dual errors [simultaneous errors to person and number] were the most frequent in second person plural constructs.

There are two implications for individuals with Broca's aphasia: (1) agreement deficiency in Broca's aphasia is not purely morphosyntactic in nature and (2) this deficiency is not limited to overall agreement features. We found that performance is more impaired in sentences with second person pronouns (speaker-external) than with first person (speaker-internal) pronouns, and the plural becomes increasingly difficult in sentences with the second person than first person plural pronouns. We conclude that the discourse-linking required in the processing of the second person (reference to one or more Addressees) makes the second person morphology more difficult to produce than the first person morphology for individuals with Broca's aphasia.

Although many of individuals with Broca's aphasia were affected in second person agreement in this study, note that not all of them present with this profile and the present study did not have a report of individual severity levels to be able to assess the source of individual variation. Individual variation may exist because sentence comprehension in individuals with Broca's aphasia can present as several distinct profiles (see, e.g., Burchert et al., 2005; Yarbay Duman, Altınok, & Maviş, 2016). Although a clear pattern emerges for the group as a whole, this overall group pattern may not be reflected in each individual. Individual variation in this study may indicate that there are individual differences in capacity for processing cognitive-semantic information: unlike the individuals without a discrepancy between comprehension of second person and first person, the individuals with a discrepancy may, for example, have a more reduced cognitive-semantic ability required for processing discourse-linking. This assumption, however, would need to be tested in a future study in which performance on comprehension of first and second person is tested alongside cognitive-semantic abilities (see, Fyndanis et al., 2018 for various cognitive factors such as working memory that may impact sentence processing and production at the group and individual level).

Our future research will investigate whether (and how) the problems that individuals with Broca's aphasia experience in processing subject pronouns, in particular the second person and the plural extend to failure in selecting target discourse-participants (e.g., second person plural: who the Addressee's are; first person plural: who the non-associates are) and how their interpretation process influences their ability for verb agreement. The next section discusses performance on agreement morphology in Broca's aphasia with regard to earlier accounts of agreement and discourse-linking in Broca's aphasia.

### ***Subject-verb agreement and discourse-linking in Broca's aphasia***

One morphosyntactic hypothesis on performance on agreement morphology is the intact Agreement node, due to its position in the syntactic tree, which would leave Agreement features unaffected (Friedmann & Grodzinsky, 1997). This explanation is not supported by the Turkish data in this study because we found that (1) agreement itself is impaired and (2), person and number features are not impaired to the same extent. We found that performance is more impaired in sentences with second person than first person plural pronouns, and the plural becomes increasingly difficult in sentences with second person plural pronouns. The increased difficulty in producing the second person and the second

person plural agreement cannot be explained by the position of the Agreement node in the syntactic tree.

Wenzlaff and Clahsen (2004) and Avrutin (2006) predicted that agreement is preserved in Broca's aphasia, assuming that agreement – as an uninterpretable feature of the Tense node – is not underspecified (Wenzlaff & Clahsen, 2004) or because computation of agreement – as a purely morphosyntactic phenomena – is unimpaired (Avrutin, 2006). Apparently, agreement is not a purely morphosyntactic phenomenon and its use is diminished in Broca's aphasia. Thus, both hypotheses need to consider the impact of discourse-semantic complexity on the production of agreement morphology in this population. Crucially, while our results on agreement morphology are not in line with the agreement component of Avrutin's (2006) hypothesis, the presence of impairments in processing discourse-linked subject pronouns is overall compatible with Avrutin (2006). The hypothesis of Burchert et al. (2005) correctly predicted that agreement is impaired in Broca's aphasia. The present results, however, also show that impairment in agreement is not due to an unsystematic underspecification of all agreement features, since we found that the second person is particularly difficult to produce.

The results are also in line with studies reporting agreement to be difficult to produce for individuals with Broca's aphasia (e.g., Nanousi et al., 2006; Varlakosta et al., 2006). The results particularly support the spontaneous speech results of Lehečková (2001) and Stavrakaki and Kouvava (2003), since our examination of their data showed that the second person and the second person plural were also more difficult to produce than the first person and the first person singular for individuals with Broca's aphasia in their studies.

In short, this study showed that grammatical morphology used for the second person is selectively affected in production in Broca's aphasia, irrespective of number, i.e., whether second person is a singular or a plural. This is because the second person is discourse-linked. These results support Bastiaanse et al. (2011) who showed that reference to the past is discourse-linked and that grammatical morphology used for the past is selectively affected. An important question which remains is what makes sentences with discourse-linking (e.g., second person: this study; past time-reference: Bastiaanse et al., 2011, object pronouns: Avrutin, 2006) particularly difficult to process or produce for individuals with Broca's aphasia.

### ***Why is discourse-linking difficult? A broader impairment in deciphering event occurrence***

As mentioned earlier (see Discourse-linking), it is yet unclear what processing resources are required for discourse-linking and why these resources are limited in individuals with Broca's aphasia. We propose that the resources required for discourse-linking are cognitive resources which permit comprehension of an event's occurrence and the use of those resources are limited in Broca's aphasia due to a deficit in the epistemic cognition capacity (i.e., the process of thinking about one's own form of knowledge and ways of knowing) to decipher event occurrence (i.e., in building up *how* and *when* an event happened or will happen or what is *possible* or *necessary* given the available evidence) in general, and event occurrence features (participant-time-location) in particular.

Grammatical constructs encode epistemic-semantic functions, in particular, the degree of certainty (certainty, probability, possibility) of event occurrence. Depending on the

information available, we use different grammatical constructs to indicate our degree of certainty of an occurrence (e.g., past tense/aspect is used to mark certainty that the event has happened; future tense/aspect is used to indicate the possibility/probability that the event is likely to happen; counterfactuals is used to mark certainty that the event did not take place; second person is used to mark certainty that the referent is an Addressee). Individuals with Broca's aphasia who have limited capacity to understand epistemic-semantic functions of grammatical constructs, in particular the degree of certainty of an occurrence are also unable to use grammatical constructs to express their degree of certainty (e.g., Yarbay Duman & Bastiaanse, 2009, for Broca's aphasia; Yarbay Duman & Topbaş, 2016, for children with specific language impairments). Accordingly, an impairment in deciphering event occurrence means that individuals with Broca's aphasia are unable to understand what the roles of participants are (this study on agreement) and what the time of the event is (see our earlier studies on tense/aspect morphology, e.g., Yarbay Duman & Bastiaanse, 2009, for Broca's aphasia; Yarbay Duman & Topbaş, 2016, for children with specific language impairments) or where an object is actually located (Yarbay Duman et al., 2016). They are then forced to search for clues (physical evidence such as seeing or hearing), for example, on the participant roles or the time of the event to be able to interpret or use relevant grammatical constructs.

We suggest that in constructs defined as "non-discourse-linked" in studies on discourse-linking, event occurrence features are evident by non-epistemic inference (i.e., lack of the requirement for processing/attributing the degree of certainty), derived from physical seeing or hearing cues. In contrast, in discourse-linked constructs, event occurrence features need to be deciphered by *epistemic inference* (i.e., the requirement for processing/attributing the degree of certainty), since physical evidence does not assist in deciphering the event features. The following consequences are observed.

The first person and present time reference is the easiest for individuals with Broca's aphasia to produce because they, as with all speakers or listeners, are often *witnesses* to an event. In other words, they know the participant role (the Speaker: the one who speaks) and the time of the event (Present: here and now: e.g., a man's drinking of milk). Knowing event occurrence features: the Speaker or the event time, allows them a better chance at processing and producing the first person and present time reference, respectively.

The second person and past time reference is hard for individuals with Broca's aphasia to produce because finding physical evidence for an Addressee role in discourse (second person) or an event which occurred in the past (past time reference) is more difficult, particularly in everyday conversations when more than two people are involved in the speech event and the speaker/listener has memory limitations. When individuals with Broca's aphasia are required to *epistemically infer* (rather than "know", by non-epistemic inference) the participant role or event time to decipher event occurrence, they often fail, since it is not possible to link an unknown addressee role or unknown event time with agreement morphology or the speech time, respectively. Similar outcomes can be expected for discourse-linked object pronouns compared to reflexives, since only the participant role expressed by object pronouns needs to be inferred from among a set of potential discourse participants.

Crucially, discourse-linking is not the only condition that requires individuals with Broca's aphasia to epistemically infer. In Turkish, factual and counterfactual conditionals are formed by past tense and conditional morphemes (-DI and -SE, respectively). When

the past tense morpheme precedes the conditional, the sentence is a factual (e.g., *gömlëğ-i ütüle-diy-se dolab-a as-ar*; the shirt-acc iron-past-conditional/3sg the closet-dat hang-aorist/3sg; "If he has ironed the shirt, he will hang it in the closet") and when the past tense morpheme follows the conditional, the sentence is a counterfactual (e.g., *gömlëğ-i ütüle-sey-di dolab-a as-ar-di*; the shirt-acc iron-conditional-past/3sg the closet-dat hang-aorist-past/3sg; "if he had ironed the shirt, he would have hung it in the closet") (see, Yarbay Duman et al., 2016).

Accordingly, Turkish factual and counterfactual conditionals are morphosyntactically equivalent *if*-clauses, but the latter is epistemically and cognitively more complex (i.e., processing counterfactuals requires keeping *multiple epistemic possibilities* in mind to generate an alternative event and outcome, e.g., for the counterfactual sentence above: the shirt was not ironed and therefore, it was certainly not hung in the closet). Unlike their neurologically intact peers, Turkish individuals with Broca's aphasia had more difficulty processing counterfactuals than factuals (i.e., selection of a distracter picture with an ironed shirt, hung in the closet was the most common error type) (Yarbay Duman et al., 2016). This suggests that epistemic and cognitive complexity adds to sentence comprehension deficits in Turkish individuals with Broca's aphasia.

We have three main recommendations for future research. First, discourse-linking should not be treated as an all-or-nothing phenomenon since the requirement for discourse-linking may vary depending on the linguistic context. For example, the first person subject pronoun *I* can be discourse-linked in a direct report construction with a perspective shift: in *John said "I cook today"*, *I* refers to *John* and not the speaker of this utterance. More processing difficulties will thus be observed with the subject pronoun *I* when it does not refer to the speaker than when it does. Accordingly, when an individual with Broca's aphasia uses correct verb agreement (first singular) pertaining to the subject pronoun *I* in the above sentence, it does not necessarily mean that he/she is able to epistemically infer or discourse-link the argument. Köder, Maier, and Hendriks (2015) have shown in healthy speakers that perspective shift in a direct report increased the processing effort of subject pronouns compared to indirect report (*John said that he cooks today*). The authors suggested that direct report was morphosyntactically easier but cognitively more demanding than indirect report, since the listener had to inhibit his representation of the actual reporting speaker's perspective.

Second, we recommend that the saliency of the cues around individuals with Broca's aphasia should be taken into account, since the degree of saliency of the cues around them may affect their performance on discourse-linked grammatical elements. For example, the discourse-linked second person singular would be relatively easier to interpret or produce for them when there is only one person other than the self in the speech act (i.e., there is only one possible referent for an Addressee role) than when more than two people are speaking (i.e., there is more than one potential referent for an Addressee role). Although the former discourse context reveals who the Addressee is, the latter forces the listener to process and infer who the Addressee might be.

Finally, new study methods could add to our understanding of the nature of linguistic and cognitive impairments in terms of discourse-linking and epistemic inference in Broca's aphasia. Earlier studies of discourse-linking, including for Turkish, share that they uniformly contrasted the ability to produce or comprehend two sentences, each with a different type of grammatical construct (e.g., the past tense/aspect vs. present tense/aspect; object pronouns vs. reflexives) and epistemic information about the event-time (past vs. non-



past) or participant information (sentence external vs. internal referent) changed as a function of which of the two grammatical construct was addressed to the participant.

On the basis of the Turkish data and the assumptions about epistemic inference, the question which now arises is whether the influence of epistemic inference can also be attested for a single grammatical construct when the grammatical construct is kept constant across test conditions, and the information type (non-epistemic inference vs. epistemic inference) is varied. We are currently conducting such a study on Broca's aphasia involving Turkish speakers. Our preliminary results show that the processing the grammatical construct (*must*) is impaired when epistemic inference (i.e., the degree of certainty) is required and preserved when it is not required (i.e., non-epistemic inference: the required degree of certainty is made available by means of physical cues in the test condition).

We conclude that individuals with Broca's aphasia are deficient in discourse-linking (Avrutin, 2006; Bastiaanse et al., 2011), as a consequence of a broader impairment in deciphering event occurrence features, particularly when epistemic inference is required. We, therefore, propose that future clinical intervention in Broca's aphasia should target improving understanding of event occurrence: that is, *how* and *when* the event happened or will happen, to improve the individual's ability to decipher participant roles and the event time simultaneously. Such a cognitive-semantic intervention would improve the use of discourse-linked grammatical constructs in Broca's aphasia.

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## Appendix A. Broca's aphasia participant characteristics

	Age	Sex	Education	Handedness	MPO	Cause	Hemiplegia
B1	65	M	Primary	Right	11	L- CVA	Right
B2	75	M	University	Right	48	L- CVA	Right
B3	54	M	High School	Right	24	L-CVA	Right
B4	65	M	Primary	Right	24	L-CVA	Right
B5	65	M	University	Right	36	L-CVA	Right
B6	59	M	Primary	Right	14	L-CVA	Right
B7	70	F	Primary	Right	5	L-CVA	Right
B8	40	M	University	Right	4	L-CVA	Right
B9	27	F	High School	Right	12	L-CVA	Right
B10	35	F	University	Right	30	L-CVA	Right
B11	60	M	Primary	Right	3.5	L-CVA	Right
B12	33	M	High School	Right	12	L-CVA	Right
B13	50	M	High School	Right	4	TBI	Right
B14	59	F	University	Right	18	TBI	Right
B15	57	M	Primary	Right	7	L-CVA	Right
B16	62	F	Primary	Right	24	L-CVA	Right
Mean (SD)	54.08 (14.0)						

B = Broca; SD = Standard Deviation; M = male; F = female; MPO = months post onset; L-CVA = left cerebrovascular accident; TBI = traumatic brain injury

**Appendix B. Participant performance (maximum score: 15) per condition and error type**

	First Person Singular					Second Person Singular					First Person Plural					Second Person Plural				
	Correct		Errors			Correct		Errors			Correct		Errors			Correct		Errors		
	P	N	PN	P	N	PN	P	N	PN	P	N	PN	P	N	PN	P	N	PN		
B1	15	0	0	0	0	0	15	0	0	0	15	0	0	0	0	8	0	0	7	
B2	14	0	0	0	0	10	0	0	5	15	0	0	0	0	15	0	0	0	0	
B3	15	0	0	0	0	0	0	15	0	0	0	0	15	0	0	0	0	0	15	
B4	15	0	0	0	0	12	1	0	2	15	0	0	0	0	15	0	0	0	0	
B5	15	0	0	0	0	14	1	0	0	10	5	0	0	0	2	0	0	6	7	
B6	12	2	1	13	0	15	0	8	0	6	13	0	2	0	2	1	10	2	2	
B7	15	0	0	0	0	8	7	0	0	6	15	0	9	0	9	0	1	5	8	
B8	15	0	0	0	0	11	4	0	0	15	0	0	0	0	7	0	0	0	8	
B9	15	0	0	0	0	15	0	0	0	12	0	0	3	0	6	0	0	0	9	
B10	15	0	0	0	0	8	7	0	0	13	0	2	0	0	0	4	6	0	5	
B11	14	1	0	0	0	15	0	0	0	11	0	0	0	4	14	1	0	0	0	
B12	11	0	4	0	4	3	4	6	2	14	0	0	0	1	7	5	2	1	1	
B13	15	0	0	0	0	14	1	0	0	15	0	0	0	0	0	0	0	0	15	
B14	13	0	2	0	0	12	3	0	0	10	0	5	0	0	0	0	15	0	0	
B15	15	0	0	0	0	15	0	0	0	12	0	3	0	0	6	0	2	7	0	
B16	15	0	0	0	0	7	0	8	0	15	0	0	0	0	6	0	9	0	0	
Mean	14.31	0.18	0.50	0	10.87	2.68	0.56	0.87	0.31	11.93	0.31	2.43	0.31	0.68	6.06	3.18	5.06	5.06	5.06	
(SD)	(1.25)	(0.54)	(1.09)	(0)	(4.61)	(4.09)	(1.36)	(2.41)	(1.01)	(4.07)	(1.01)	(4.17)	(1.25)	(1.53)	(5.27)	(4.65)	(5.07)	(5.07)	(5.07)	

B = Broca; SD = standard deviation. P = Person; N = Number; PN = combination of Person and Number errors.