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ABSTRACT

Background: The distribution of pronouns varies cross-linguistically. This distribution has led to conflicting results in studies that investigated pronoun resolution in agrammatic individuals. In the investigation of pronominal resolution, the linguistic phenomenon of "resumption" is understudied in agrammatism. The construction of pronominal resolution in Akan presents the opportunity to thoroughly examine resumption.

Aims: To start, the present study examines the production of (pronominal) resumption in Akan focus constructions (*who*-questions and focused declaratives). Second, we explore the effect of grammatical tone on the processing of pronominal (resumption) since Akan is a tonal language.

Methods & Procedures: First, we tested the ability to distinguish linguistic and non-linguistic tone in Akan agrammatic speakers. Then, we administered an elicitation task to five Akan agrammatic individuals, controlling for the structural variations in the realization of resumption: focused *who*-questions and declaratives with (i) only a resumptive pronoun, (ii) only a clause determiner, (iii) a resumptive pronoun and a clause determiner co-occurring, and (iv) neither a resumptive pronoun nor a clause determiner.

Outcomes & Results: Tone discrimination .both for pitch and for lexical tone was unimpaired. The production task demonstrated that the production of resumptive pronouns and clause determiners was intact. However, the production of declarative sentences in derived word order was impaired; *wh*-object questions were relatively well-preserved.

Conclusions: We argue that the problems with sentence production are highly selective: linguistic tones and resumption are intact but word order is impaired in non-canonical declarative sentences.

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Introduction

Morphosyntactic deficits generally characterize the impoverished language of individuals with agrammatism (Caramazza & Berndt, 1985; Goodglass, 1968; Menn & Obler, 1990). Agrammatic speakers have problems producing free and bound morphemes (e.g., verb inflection: Bastiaanse, 2008; Bastiaanse & Jonkers, 1998; Friedmann, 2000; Friedmann & Grodzinsky, 1997), but this is not the only difficulty observed. Verbs with complex argument structure have been found to be difficult to produce both in spontaneous speech (Bastiaanse, Hugen, Kos, & van Zonneveld, 2002; Thompson, Shapiro, Li, & Schendel, 1995) and in controlled production experiments (Bastiaanse and Van Zonneveld., 2005; Burchert, Meiner, & De Bleser, 2008; Thompson, 2003). Studies in agrammatism have also identified deficiencies mainly related to structures with non-canonical word order (Abuom & Bastiaanse, 2013; Bastiaanse & Van Zonneveld, 2006; Martinez-Ferreiro et al., 2014; Neuhaus & Penke, 2008; Thompson, Shapiro, & Roberts, 1993; Van der Meulen, Bastiaanse, & Rooryck, 2005) and embedding (Bates, Friederici, Wulfeck, & Juarez, 1988; Nespoulous, Dordain, Perron, Jarema, & Chazal, 1990; Thompson, Lange, Schneider, & Shapiro, 2007; Thompson, Shapiro, Tait, Jacobs, & Schneider, 1996). There have been inconsistent results across languages and different language modalities (Cho Reyes and Thompson, 2012; Friedmann, 2002; Hanne, Sekerina, Vasishth, Burchert, & De Blesser, 2015; Hickok & Avrutin, 1996; Neuhaus & Penke, 2008; Thompson, Tait, Ballard, & Fix, 1999). For instance, Neuhaus and Penke (2008) found that the production of object *wh*-questions in nine German agrammatic individuals is relatively spared. However, Friedmann (2002) tested 13 Hebrew and two Palestinian Arabic agrammatic speakers and found the production of these questions to be impaired.

Processing of pronouns is also problematic for agrammatic speakers. Cross-linguistic studies have shown that agrammatic speakers produce fewer pronouns in comparison to non-brain-damaged speakers (Greek: Stavrakaki & Kouvava, 2003; French: Nespoulous et al., 1990; Italian: Miceli & Mazzucchi, 1990). Other studies demonstrated that different types of pronouns are unequally affected in agrammatism. For instance, object clitics have been found to be more prone to omission than subject clitics or reflexives (Martinez-Ferreiro, 2010; Nerantzini, Papadopoulou, & Varlokosta, 2010; Sánchez-Alonso, Martínez-Ferreiro, & Bastiaanse, 2011).

However, not all pronoun types have been equally investigated. Resumptive pronouns are understudied in agrammatic speech. Friedman et al., (2008) assessed Hebrew-speaking children with hearing impairment and found that the presence of resumptive pronouns served as a compensatory strategy in the production of object relative clauses. Friedmann (2008) further investigated the effect of the resumptive pronouns in the comprehension of object relative clauses in Hebrew speakers with agrammatism but noticed that the presence of the resumptive pronoun did not enhance performance in comprehension in this population. The same was found for Akan (Lartey et al., submitted).

Linguistic tone production is a linguistic aspect that has scarcely been investigated. Brain damage in the left hemisphere has been found to cause tone production problems (Naesar & Chan, 1980; Packard, 1986; Ryalls & Reinvang, 1986; Gandour, Holasuit-Petty, & Dardarananda, 1988; Gandour et al., 1992a; Yiu and Fok, 1995; Liang & Heuven, 2004; Kadyamusuma, De Blesser, & Mayer, 2011). It is worth noting that results on tone production across individuals with aphasia are inconsistent. Gandour et al. (1992a),

examined stroke victims in the acute stage and observed tone production deficits. Prior to this, Gandour et al. (1988) reported tone production deficiencies in six Thai speakers with aphasia tested after the acute stage. In tone production studies, the focus point has been whether certain tones are more difficult to produce than others. Gandour et al. (1992b) reported that dynamic tones (e.g., rising and falling tones) were more easily impaired than static tones (e.g., high, mid, and low tones). However, this finding is yet to be replicated. All these studies are on lexical tones, but the production of grammatical tones has not been explored in brain-damaged individuals. This is partly because most of the tone languages like Chinese and Thai studied do not have the grammatical tone feature. In the Akan context, Tsiwah, Lartey, Amponsah, Martínez-Ferreiro, and Bastiaanse (under review) did not find the production of Akan grammatical tones problematic for individuals with agrammatism, when processing different time references.

In the present study, we investigate the production of resumptive pronouns and the phenomenon of resumption in Akan speakers with agrammatism, assessing Akan *who*-questions and focused declaratives. Akan is a tone language and tone plays a crucial role in the execution of resumption. The addition introduces a new variable (tone) to the ongoing discussion on pronominal resolution and resumption. We will first shortly address the neurolinguistic theories related to our study and introduce the relevant characteristics of Akan.

Neurolinguistic accounts of sentence production

The use of grammatical tools for the description of agrammatism is important (Grodzinsky, 1990). Syntactic theories within the generative grammar tradition (Chomsky, 1986, 1995; Pollock, 1989) stipulate that sentences be represented as phrasal structures called *syntactic trees*. The complementizer phrase is the highest phrasal node on the tree and host complementizers like "that", and *wh*-morphemes (who, what). The accessibility on the CP node is critical in the construction of embedded sentences and *wh*-questions. Hagiwara (1995) was one of the first to argue that agrammatic speakers had problems accessing the top of the syntactic tree. Friedmann and Grodzinsky (1997) reported that a Hebrew native speaker with agrammatism showed a dissociation between tense, agreement morphology, that is, agreement inflection was intact, and tense inflection was impaired. Following Pollock's (1989) Split Inflection Hypothesis, Friedmann and Grodzinsky (1997) assumed the two nodes, tense and agreement to be separately represented in the syntactic tree and the agreement node to be located below the tense node. The Tree Pruning Hypothesis (Friedmann & Grodzinsky, 1997) was then to account for the dissociation observed. The hypothesis stated that agrammatic speakers are unable to access functional projections in the syntactic tree from the tense node upwards, including the CP-node, because the tree was pruned due to brain damage. In effect, agrammatic speakers failed to formulate structures that require higher nodes like *wh*-questions and embedded sentences. However, studies in other languages have challenged the claims of the TPH based on verb inflection (e.g., Wenzlaff & Clahsen, 2004, 2005; Burchert, Swoboda-Moll, & De Bleser, 2005 for German; Stavrakaki & Kouvava, 2003; Nanousi, Masterson, Druks, & Atkinson, 2006 for Greek). Syntactic transformations low in the tree have also been found to be impaired (Bastiaanse et al., 2003; Burchert, De Bleser, & Sonntag, 2003)

Bastiaanse and colleagues showed in a number of studies (Bastiaanse & van Zonneveld, 1998; 2005, 2006; Bastiaanse et al., 2002, 2003) that sentences in which elements were not in a canonical order were difficult to comprehend and to produce for agrammatic individuals. Bastiaanse and Van Zonneveld (2005) proposed the Derived Order Problem Hypothesis, which posits that;

(a) Every language has a base word order (e.g., Subject-Verb-Object for English; Subject-Object-Verb for Dutch and German) and that all other word orders are derived.

(b) For agrammatic individuals, sentences in the base word order are easier to produce and comprehend than those in the derived word order (e.g., *who*-object questions, as in 1b)

(1) a. Who t$_{who}$ pushed the man?   Basic word order
    b. Who did the man push t$_{who}$?   Derived word order

The DOP-H, meant to describe word-order problems in agrammatic individuals, has been tested cross-linguistically (Dutch, Italian, Turkish, English, see, for example, Bastiaanse et al., 2003; Bastiaanse & Thompson, 2003; Bastiaanse & Van Zonneveld, 2005, 2006, 2011; Yarbay Duman, Aygen, ¨Ozgirgin, & Bastiaanse, 2007, 2008). The DOP-H is relatively theory-neutral in the sense that its definition of derivation is extensive and not strictly dependent on theories related to movement, binding, co-referencing or any syntactic transformation mechanism. In addition, it is an overarching theory; thus, it covers both production and comprehension.

The akan language and relevant features for the current study

Akan is a language spoken in Ghana and parts of Cote d'Ivoire. Akan is classified as Kwa language of the Niger–Congo phylum. According to the Ghanaian education policy, a native language can be used as a medium of instruction until the 3rd Grade (Mfum-Mensah, 2005). In the south of Ghana, where Akan is predominantly spoken, most children are expected to read and write Akan before 4th Grade. English then becomes the language of instruction in schools but Akan remains predominantly used in all spheres of life.

Word order and tone in Akan

The base word order in Akan is Subject-Verb-Object (SVO; Saah, 1994). Akan is a tonal language with two main tones, high and low, usually transcribed as [´] and [`], respectively (Dolphyne, 1988). These tones are used to make both grammatical and lexical distinctions. In the next section, formation of focus constructions and the use of grammatical tones in pronominal resolution and resumption in Akan are described.

Focused construction formation in Akan

Any lexical element in a sentence structure can be focused. There are two focus markers in Akan, "*na*" and "*dεε*". Every focused constituent must be realized before a focus particle;

otherwise, the structure is ungrammatical (2). This is required in the formation of both questions[1] and declaratives.

(2) a. Declarative base order

     Me   *wosoo*   **akonwa no**

     I   shake.PST   chair the   Grammatical

     'I shook the chair'

  b. Focused declarative

    akonwa no na   *me*   *woso-e*

    Chair the FOC I   shake.PST   Grammatical

    'It is the chair that I shook'

  c. **na*   *akonwa* *no*   *me*   *woso-e*

    FOC   chair   the   I   shake.PST   Ungrammatical

    'It is the chair that I shook'

The two structures (2a and 2b) essentially convey the same message, that is, the speaker shook a chair. However, in (2b), the speaker asserts that "*the chair and only the chair was what I shook*". The whole sentence can be paraphrased as an object cleft in English and is similar in contrastive nature. Henceforth, structures like 2b will be named in the current study as "focused declaratives".

Resumptive pronouns and clause determiners in Akan

In the formation of Akan focus structures, a resumptive pronoun may be used at the clause final position. Syntactically, pronominal resumption shows the syntactic transformation of a derived nominal constituent to construct focus, topic, relative, and question structures. Resumptive pronouns are not used in English (3a-c).

(3)   a. [Who$_1$ did [the woman hug t_1]]?

    b. [Who$_1$ [t$_1$ hugged the woman]]?

    c.* [Who$_1$ did [the woman hug t_1**him/her**]]?

In example (3) the original position of the *wh*-word is marked *t*. A phonetically null element indicates the base-generation position of a displaced element. In English, the derived element cannot be replaced with a pronominal form (3c). However, in Akan, Hausa and Hebrew resumptive pronouns can fill in the original position of the derived element with a resumptive pronoun (RP), which matches the morpho-syntactic features of the moved constituent (Saah, 1994; McCracken, 2013: see, p. 4).

(4)   a. *Hena*   *na*   *maame*   *no*   *twe-e*   ***no***?

       Who   FOC   woman   the   pull.PST   him/her (RP)

       'Who did the woman pull?'

In example (4), the resumptive pronoun is represented as "*no*" but the morpheme "*no*" in Akan can have three different functions in a sentence. It can be a definite article (the), a clause determiner[2] (CD) and a resumptive pronoun (RP). The distinction between the three can only be made based on the context and the tone they carry. When used as a resumptive pronoun, the tone on the vowel is low, but when used as a definite article or clause determiner, the tone on the vowel is high (5). The resumptive pronoun *nò* can be replaced by a clause determiner *nó*; combination of both is also possible. Notice that neither the resumptive pronoun nor the clause determiner is obligatory. The meaning of the sentence is left intact with these structural variations.

(5) *Hena*   *na*   *maame*   ***nó***   *etwe*   ***(nò)***   ***(nó)?***

    Who   FOC   woman   the   PROG.pull   RP   CD

    'Who is the woman pulling?'

From the earlierexamples, it is clear that resumptive pronouns in Akan (but not clause determiners) are bound within the sentence. The production of intrasentential binding in agrammatic production has been understudied. There are some studies on comprehension of reflexives versus pronouns that show the comprehension of sentence-bound refelexives is relatively spared (Avrutin, 2006; Grodzinsky, Wexler, Chien, Marakovitz, & Solomon, 1993). According to Avrutin (2006) this is because reflexives can be processed within the sentence, as opposed to pronouns that have to be linked to the extra-sentential discourse. Resumptive pronouns and clause determiners can also be processed by clausal syntax and should, thus, be relatively spared.

The current study

Given that this study focuses on virtually unexplored constructions in an underrepresented language, a series of questions need to be addressed. In what follows, we present the questions of interest in the present work.

Grammatical tone and resumption in Akan who-questions and declaratives

Few studies have investigated the processing of resumptive pronouns and the concept of resumption in agrammatism. Friedmann (2008) tested Hebrew speakers with agrammatic aphasia and found that comprehension of object relative clauses was impaired regardless of the presence or absence of a resumptive pronoun. The main question of the current study is how agrammatic individuals will perform in a production experiment investigating pronominal resumption and the concept of resumption in general. In addition, we assessed how Akan agrammatic speakers produce the structural variations in the realization of resumption in Akan *who*-questions and focused declaratives.

In the previous sections, the role of grammatical tones in relation to resumption in Akan focus constructions was introduced, where the tone is used to make a distinction between a resumptive pronoun and a clause determiner. So far, it is unknown whether the grammatical tone is affected in individuals with agrammatism. Since the only difference between Akan resumptive pronoun and clause determiner is grammatical tone,

varying conditions with and without the tone elements is an excellent way to test the production of grammatical tone.

Focus marking in Akan

In Akan, focus marking is essential in the construction of questions and declaratives. For content questions like *who*-questions, we have seen that focusing is not always required because the question word can be realized in situ. The current work explores the effect of focused elements on production in Akan *who*-questions and focused declaratives. The assessment of *who*-question formation in Akan agrammatic speakers is interesting because object *who*-questions are constructed by either focusing the *wh*-word or with the *wh*-word *in situ*. The question then is, are agrammatic individuals able to produce both structures?

Neurolinguistic approaches to the effect of word order

In the present study, sentence structure is key to our investigations and analysis. Akan *who*-questions and declaratives are assessed in base and derived order. Two neurolinguistic theories, the Derived Order Problem Hypothesis (DOP-H: Bastiaanse & Van Zonneveld, 2005) and the Tree Pruning Hypothesis (TPH: Friedmann & Grodzinsky, 1997) have been highlighted to help us understand our observations. Bastiaanse and Van Zonneveld's DOP-H (2005) predicts sentences in the base word order to be easier to produce than those in the derived order. Following the DOP-H's assertions, we hypothesize Akan *who*-questions and declaratives in the derived word order to be relatively difficult to produce compared to the *who*-questions and declaratives in base word order. Friedmann and Grodzinsky's TPH (1997) predicts that the CP-node of sentences in a syntactic tree is inaccessible, so all focus constructions should be impaired.

Currently, there are no neurolinguistic theories on the production of resumptive pronouns and clause determiners in agrammatic speech. In addition, the effect of agrammatism on grammatical tone-production is unknown. Based on syntactic theories, it is predicted that the production of Akan resumptive pronouns and clause determiners is left relatively intact since they are bound within the sentence and other bound elements, such as reflexives, have been found to be left relatively intact in aphasic speakers (Avrutin, 2006).

Methods

Participants

The present study included two groups of participants, five with left hemisphere brain-damaged and 10 non-brain-damaged (NBD) speakers. The individuals in the brain-damaged group all suffered from agrammatic aphasia (four males; mean age of 52.8, range: 37–69). The NBD group consisted of five females and five males with a mean age of 51.7 (range: 20–73). Recruitment of the agrammatic group was done in the Korle Bu Teaching Hospital (KBTH, Accra/Ghana). All participants were right-handed and had no problems with vision, hearing or any psychological defects. Paralysis on the right side was manifest in all agrammatic speakers that were reported to have suffered a single stroke. The time post-onset ranged from 7 to 25 months. All participants in the NBD and

agrammatic group were Akan native speakers and confirmed Akan to be their principal language of communication since birth. All participants signed an informed consent form before testing commenced.

In Ghana, there are no standardized test materials to diagnose aphasia. Nonetheless, all recruited individuals with aphasia had been diagnosed by a speech and language therapist as being aphasic. This classification was not suitable for the present study, so we judged the presence of agrammatism based on spontaneous speech analysis[3]. We found that agrammatic speakers in the current study showed reduced speech-rate, reduced mean-length of utterances, fewer correct sentences, and fewer embedded clauses (see Table 1). This finding is in line with the observations of Bastiaanse and Jonkers (1998) in their group of Dutch agrammatic speakers.

Additionally, we adapted the subtest on auditory word comprehension of the Boston Diagnostic Aphasia Examination (BDAE: Goodglass & Kaplan, 1972) to Akan to assess agrammatic speakers' word comprehension. In the adapted BDAE, we concentrated on the verb, object and number subsets. See the scores on the BDAE in Table 2. The agrammatic speakers were clearly not deficient in single-word comprehension. The severity of the aphasia suffered by the brain-damaged participants was checked by administering the

Table 1. Spontaneous speech analysis of IWAs and NBDs.

Participants	Speech rate (wpm)	MLU	Embedding (%)	Grammatical errors (%)
IWAs				
P1	95	2.5	0	23.5
P2	34	4.5	24.3	19.5
P3	86	3.8	18.9	38.4
P4	98	4.8	13.6	22.7
P5	66	3.55	14	18.6
Mean	75.8	3.83	14.16	24.54
NBDs (n = 10)				
Scores (range)	120 – 153	6.7–7.7	34 – 38.4	0 – 9.4
Mean	134.2	6.9	38.82	3.9

Table 2. Demographic data of all participants and scores of the agrammatic speakers on BDAE and token test.

Participants	Gender	Age	Handedness	Education (Years)	Time post onset (months)	Native language	BDAE (_/46)	Token test score (_/36)
Patients								
P1	M	37	R	16	7	Akan	44	23.5
P2	F	49	R	12	7	Akan	42	7
P3	M	69	R	13	24	Akan	42	10
P4	M	60	R	10	18	Akan	46	15
P5	M	49	R	10	25	Akan	46	22.5
Non-brain damaged								
NBD1	M	39	R	10	-	Akan	46	-
NBD2	M	46	R	10	-	Akan	46	-
NBD3	M	57	R	12	-	Akan	46	-
NBD4	M	64	R	10	-	Akan	46	-
NBD5	M	67	R	12	-	Akan	46	-
NBD6	F	20	R	6	-	Akan	46	-
NBD7	F	49	R	14	-	Akan	46	-
NBD8	F	73	R	10	-	Akan	46	-
NBD9	F	50	R	10	-	Akan	46	-
NBD10	F	52	R	12	-	Akan	46	-

Token Test (De Renzi & Faglioni, 1978). Specifically, we administered the Token Test Perspex, the analogous version of the Multilingual Token Test (Bastiaanse, Raaijmakers, Satoer, & Visch-Brink, 2016). The scores on the Token Test showed different levels of severity amongst the brain-damaged group. Table 2 shows the demographic data of all participants and the performance of agrammatic individuals on the BDAE and the Token Test.

Since one of the variables we examined in the sentence production test is grammatical tone, two tone-discrimination tests were administered. First, in the online Tone Screening Test (Kayser, 2011; Wexler, Stevens, Bowers, Sernyak, & Goldman-Rakic, 1998), we played two non-linguistic tones for the participant who had to indicate whether the tones s/he heard were the "same" or "different". Second, we tested lexical tone discrimination using Akan words, for which the agrammatic speakers heard two words that were identical or only differed in tone: they had to indicate whether the words they heard were the "same" or "different". The agrammatic participants had problems neither with non-linguistic nor with linguistic tone perception. See Appendix 1 for the scores on the tone discrimination tests.

Materials and design

We conducted two elicitation tasks, one with *who*-questions and the second one with declaratives. A total of 20 pictures (presented on a white background) were taken with a digital camera (IXUS 275 HS, Canon). Two native Akan speakers, who did not take part in the main experiment, crosschecked the pictures. A name agreement test was conducted, where the informants were asked to produce the first verb that came to mind in Akan when the pictures were shown to them. There was 100% accuracy for all pictures except one picture they both named as "to hit" but was used in the study as "to hurt". Nonetheless, the informants admitted it also demonstrates the verb "to hurt" and so this picture was maintained.

We created two separate tasks for the focused declaratives and the object questions. Each task had five conditions of 10 items, adding up to 50 items per task. These items were preceded by three examples. In each task, the order of the items was pseudo-randomized to make sure that items from one condition did not occur sequentially. The same verbs were used for all the five conditions. See Tables 3 and 4 for particulars about experimental conditions with examples.

Table 3. Experimental conditions for the *who*-questions with examples.

| Word order	Conditions	Sentences
Base	Object *who*-question (*in situ*) Baseline	*Papa no e- pia hena?* man DET PROG-push who? "Who is the man pushing?"
Derived	Object-focused *who*-question (with resumptive pronoun)	*Hena na papa no e-pia **nò** ?* Who FOC man DET PROG-push **him/her** "Who is the man pushing?"
Derived	Object-focused *who*-question (with Clause determiner)	*Hena na papa no e-pia **nó** ?* Who FOC man DET PROG-push **CD** "Who is the man pushing?"
Derived	Object-focused *who*-question (with both RP & CD)	*Hena na papa no e-pia **nò nó** ?* Who FOC man DET PROG-push **RP CD** "Who is the man pushing?"
Derived	Object-focused *who*-question (Empty Gap)	*Hena na papa no e-pia _ ?* Who FOC man DET PROG-push "Who is the man pushing?"

Table 4. Experimental conditions for declaratives with examples.

Word order	Conditions	Sentences
Base	Subject-focused declarative (baseline)	*Papa no na o-pia maame no* Man DET FOC he/she-PROG-push woman DET "The man is the one pushing the woman"
Derived	Object-focused declarative (with resumptive pronoun)	*Papa no na maame no e-pia nò* Man DET FOC woman DET PROG-push **him/her** "The man is the one the woman is pushing"
Derived	Object-focused declarative (with Clause determiner)	*Papa no na maame no e-pia nó* Man DET FOC woman DET PROG-push **CD** "The man is the one the woman is pushing"
Derived	Object-focused declarative (with both RP & CD)	*Papa no na maame no e-pia nò nó* Man DET FOC woman DET PROG-push **RP CD** "The man is the one the woman is pushing"
Derived	Object-focused declarative (Empty Gap)	*Papa no na maame no e-pia _* Man DET FOC woman DET PROG-push "The man is the one the woman is pushing"

Procedure

Elicitation tasks were conducted for both *who*-questions and focused declaratives. In both cases, the instructions of the test were read aloud to the participant and the practice materials were administered to make sure the participant understood what was required for the test. The participants were corrected and given feedback during the practice items. No further feedback was given during the test. The experimenter showed two pictures (Figure 1) to the participant and produced the prime sentence corresponding to the

Pia (**push**)
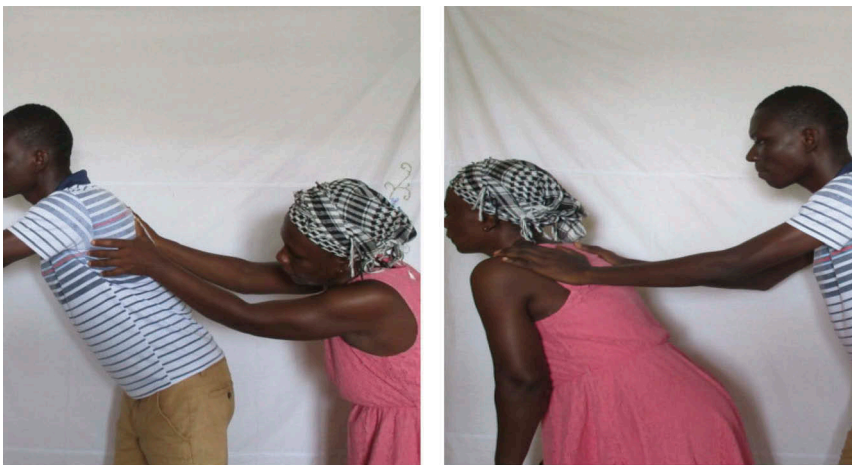
a   b

Figure 1. An example of items used for the experiment. [To view this figure in color, please see the online version of this journal.]

picture displayed at the left-hand side. The structure produced by the experimenter was supposed to prime participants to produce a similar structure for the picture on the right. The only difference in the target response was the change of thematic roles in comparison to the one the experimenter produced. This procedure has been successfully administered in other studies (Burchert et al., 2008; Yarbay Duman et al., 2008).The same procedure was used to elicit both the *who*-questions and declaratives. Each test session lasted between 30- and 50- min including breaks.

Experimenter: *wohwɛ nfoni mienu wei mu a, nea ɛkɔ so yɛ 'pia'. Obi pia obi, nti sɛ mehwɛ nfoni wei mu a metumi ebisa sɛ,' Hena na maame no epia* **nò**?'. *Wonso wohwɛ nfoni wei mu a wobebisa sɛ* …

"When you look at these pictures, the ongoing action is 'to push'. Looking at this picture (Experimenter points to picture A), I can ask the question, 'Who is pushing the man?' If you (the participant) look at this picture (picture B) you can ask the question … "
Participant: *Hena na papa no epia* **nò**?
"Who is the man pushing?" (Target response)

Scoring and statistical analysis

The sessions were audio-recorded and the sentences produced by the participants were transcribed orthographically. The tone of the resumptive pronoun/clause determiner was clearly indicated. Responses were scored as correct when the participant produced the required target sentence. Two types of analyses were performed, qualitative (correct-incorrect) and quantitative.

For the qualitative analysis, there were three main error types determined post hoc, based on the errors made during testing. These error types directly addressed the research questions of the current study. They were; word-order-related errors, resumption errors and focus marking errors. The three main error types were sub-classified into six different error types for a detailed assessment. The following errors were distinguished:

A: thematic roles, agent and theme were reversed but word-order structure was left intact
B: incorrect word order (the use of SVO instead of OSV without thematic role reversal)
C: omission of the clause determiner when it occurs with the RP
D: inserting the wrong "*no*" morpheme clause finally (substituting RP for CD and vice versa)
E: inserting a morpheme when not primed to do so
F: focus marker "*na*" is omitted.

A and B are word-order-related errors; C, D, and E represent resumption errors; F is for focus marking errors.

For the quantitative analysis, statistical mechanisms were applied on both correct and incorrect responses. A generalized linear mixed-effects modeling (GLMM) was performed, using the *glmer* function of the *lme4* package (Bates, et al., 2015) and the *glht* function of the multcomp package (Hothorn, Bretz, Westfall, Heiberger & Schuetzenmeister, 2013) in R (R Core Team, 2013). The GLMM was adopted because it robustly processes random effects. The GLMM also helped us account for variations across participants and items because of the relatively small sample size recorded. The dependent variable (score) was

log-linked accuracy (1 = correct, 0 = incorrect) with fixed effect factor "Condition" (RP, CD, RP&CD, Empty Gap) and random-effect factors for "Participants" and "Item". A model was developed to investigate the differences between conditions for the agrammatic speakers. We developed **a** model by excluding insignificant parameters from a full model (with interactions) based on the Awake Information Criterion (AIC) and log likelihood-ratio tests (significance defined as $p < 0.05$). This exclusion was also to achieve model convergence. To better understand the effect of word order, we substituted the fixed factor (conditions) in the previous model with word order (base vs derived).

Results

Quantitative analysis

The non-brain-damaged participants performed at ceiling on both *who*-questions and declaratives. This result shows that the test is appropriate and that errors made by the agrammatic group most likely due to their aphasia rather than weaknesses in the test design. The accuracy scores of the participants with agrammatic aphasia are shown in Table 5.

A multiple comparison test was conducted to highlight differences between conditions for both *who*-questions and declaratives. Performance on the subject-focused declarative condition (baseline) was significantly higher than on the object-focused declarative conditions (with Resumptive Pronoun: $Z = 3.35$, SE = 1.13, $p = 0.02$; with Clause Determiner: $Z = 3.95$, SE = 0.46, $p < 0.01$; with both ResPro and ClauseDet: $Z = 4.11$, SE = 0.46, $p < 0.01$; with Empty Gap: $Z = 4.7$, SE = 0.42, $p < 0.01$). There was no significant difference between the *who*-question *in situ* condition (baseline) and the object-focused *who*-questions (with Resumptive Pronoun: $Z = -1.18$, SE = 0.48, $p = 0.98$; with Clause Determiner: $Z = 1.39$, SE = 0.48, $p = 0.94$; with both ResPro and ClauseDet: $Z = -1.39$, SE = 0.48, $p = 0.94$; with Empty Gap: $Z = 0.25$, SE = 0.51, $p = 1$). There was a significant difference between the production of base order structures and derived

Table 5. Mean accuracy score of speakers with agrammatism and NBDs on *who*-questions and declaratives.

	Base word order		Derived word order							
	Wh- In situ	Subj. Focus Decl.	Resumptive pronoun (RP)		Clause determiner (CD)		RP & CD		Gap	
			wh-Q (%)	Decl. (%)	*wh*-Q (%)	Decl. (%)	*wh*-Q (%)	Decl. (%)	*wh*-Q (%)	Decl. (%)
	Baseline Conditions									
IWAs										
P1	80	100	100	10	100	20	100	30	100	10
P2	90	100	50	40	40	30	60	40	70	40
P3	80	80	100	40	100	20	90	10	100	10
P4	90	60	50	70	60	80	60	70	70	70
P5	70	70	60	60	50	60	40	50	60	60
Mean	82	82	72	44	70	42	70	40	80	38
SD	8.37	17.89	25.88	23.02	28.28	26.83	24.49	22.36	18.71	27.75
NBDs (group)										
Mean	99	99	100	99	99	98	99	99	100	98
SD	3.16	3.16	-	3.16	3.16	4.22	3.16	3.16	-	4.22

wh-Q = *who*-question; Subj. FOC Decl. = subject-focused declarative; Decl. = declarative

order structures (Z = 3.24, SE = 0.39, p < 0.01). Statistically, performance did not differ between the resumption variations for both object-focused *who*-questions and object-focused declaratives. See the results of the comparisons between the different resumption types in Table 6.

Qualitative analysis

We determined likely errors that could be made post hoc and categorized them into six groups after our observations of the agrammatic individuals during testing. See categorizations later. Figure 2 shows the distribution of the different error types on the object-focused *who*-questions and declaratives.

The most frequent error type in object-focused *who*-questions and object-focused declaratives was word order related. Word-order errors were classified into two groups, A and B. In A, the agrammatic speakers interchanged the thematic roles (agent and theme) in the sentence without changing the word order. For instance, an agrammatic speaker produced *"papa nó na maame nó epia nò"* "The man is the one the woman is pushing" when the target sentence is *"maame nó na papa nó epia nò"* The woman is the one the man is pushing'. For B, the agrammatic individual did not interchange the thematic role but rather reverted to the baseline word-order structure. For example, the experimenter primes the agrammatic speaker with *"papa nó na maame nó epia"* "The man is the one the woman is pushing" (object-verb-subject) but the individual with agrammatism produces *"maame no epia papa nò"* "The woman is pushing the man" (subject-verb-object). This error type accounted for almost 50% of the errors in both object-focused *who*-questions and

Table 6. Output of comparison between the different resumption types.

Main effects	Statistical values		
GLMER ouput	SE	Z score	P-value
Intercept (Condition = CDquestion)	0.31	2.696	0.07
Condition = CDdeclarative	0.42	−2.784	0.0053**
Condition = EmptyGapquestion	0.47	1.151	0.2498
Condition = EmptyGapdeclarative	0.42	−3.156	0.0016**
Condition = Insituquestion (baseline)	0.48	1.395	0.1628
Condition = RPandCDquestion	0.43	0	1
Condition = RPandCDdeclarative	0.42	−2.971	0.0029**
Condition = RPquestion	0.44	0.221	0.8252
Condition = RPdeclarative	1.11	−2.814	0.0049**
Condition = Subjectdeclarative (baseline)	0.48	1.395	0.1628
Post hoc analysis: Multiple comparisons of Means (Turkey contrasts)			
Between object who-questions			
RP – CD	0.44	0.221	1
RP – RP&CD	0.44	0.221	1
RP – Empty Gap	0.47	−0.935	0.9973
CD – RP&CD	0.43	0	1
Empty Gap – CD	0.47	1.151	0.9859
Empty Gap – RP&CD	0.47	−1.151	0.9859
Between object-focused declaratives			
RP – CD	0.43	1.04	0.9936
RP – RP&CD	0.43	1.228	0.9771
RP – Empty Gap	0.43	1.417	0.9392
CD – RP&CD	0.4	−0.204	1
Empty Gap – CD	0.41	−0.409	1
Empty Gap – RP&CD	0.41	0.205	1

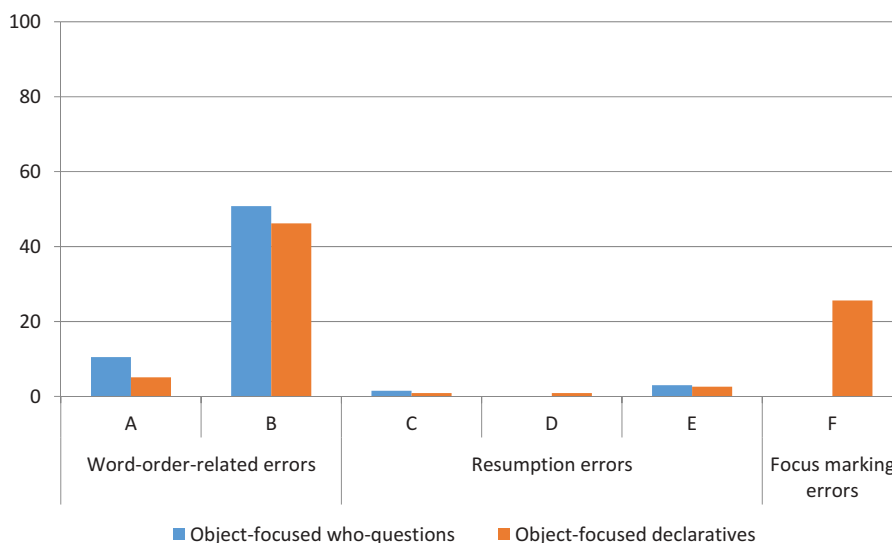Note: RP = resumptive pronoun; CD = clause determiner.

Figure 2. shows the three main error classifications sub-categorized into six different error types; A: thematic roles of agent and theme were reversed but word order structure is left intact; B: incorrect word order (use SVO instead of OSV without thematic role reversal); C: omission of the clause determiner when it occurs with the RP; D: inserting the wrong "*no*" morpheme clause finally (substituting RP for CD and vice versa); E: inserting a morpheme when not primed to do so; F: focus marker "*na*" is omitted. [To view this figure in color, please see the online version of this journal.]

declaratives. We also see that the agrammatic speakers produced an insignificant amount of errors in relation to resumption (see C, D, and E in Figure 2).

Figure 2 shows that some agrammatic speakers produced structures without the focus marker "*na*"(n = 25.6%). This makes such sentences ungrammatical. It is worth noting that when the agrammatic speakers used the focus marker, it always was in the correct position.

Discussion

In the present study, we explored three main issues. First, we investigated the production of resumption (pronoun/clause determiner) in Akan *who*-questions and declaratives, testing Akan speakers with agrammatism. The different grammatical configurations of pronominal resolution and resumption in Akan were analyzed. These structural differences were to help us understand the effect of the presence and absence of resumptive pronouns and clause determiners in the production of questions and declaratives in Akan agrammatic speakers. According to Avrutin (2006) the production of the resumptive pronoun and the clause determiner is expected to be relatively spared since they are bound within a sentence.- Second, we explored how Akan agrammatic individuals produce focused constructions in Akan *who*-questions and declaratives. According to the DOP-H, the production of these focused constructions is impaired. Finally, neurolinguistics theories were assessed to help us understand the deficits observed in the current study.

Production of resumption in akan who-questions and declaratives

Quantitatively, the data show that the production of object-focused *who*-questions in the speakers with agrammatism was relatively spared. The resumptive pronoun and/or clause determiner neither enhanced nor worsened performance. This finding is in line with a comprehension study by Friedmann (2008) where the presence or absence of a resumptive pronoun did not affect performance in Hebrew agrammatic speakers. For the declaratives, there were significant differences in performance between the subject-focused declaratives (baseline) and object-focused declaratives. However, within the object-focused constructions, we did not find an effect for the resumptive pronoun and clause determiner. Our quantitative analysis showed that focused object *who*-questions were better produced than object-focused declarative constructions.

In the error analysis, two main observations were made. First, most of the errors recorded for both *who*-questions and declaratives were linked to agrammatic speakers' inability to use the correct word order when the agrammatic speaker was primed to produce a structure with a derived word order. Difficulties in the production of structures with derived word order explain our second observation. We found that the substitutions were mainly a *wh*-in situ question for the *who*-questions and a subject-focused declarative for the focused declaratives. Notice that both structures are grammatically correct but are not the target structure.

The production of the distinct tones on the resumptive pronoun and the clause determiner was observed to be spared. This result adds a new dimension to the ongoing discussion in the literature on tone production difficulties in left hemisphere brain-damaged individuals (Naesar and Chan 1980; Packard, 1986; Ryalls & Reinvang, 1986; Gandour et al., 1988; Gandour et al., 1992a; Yiu and Fok, 1995; Liang & Heuven, 2004; Kadyamusuma, 2011). All the tone production studies in agrammatism investigated lexical tones and showed that individuals with left hemisphere brain-damage were deficient in lexical tone production. The current study, however, assessed grammatical tones and the data show that Akan left hemisphere brain-damaged agrammatic speakers do not have problems producing the correct grammatical tones on resumptive pronouns and clause determiners.

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Interestingly, another production study on Akan grammatical tones showed similar results (Tsiwah et al., under review). However, when comprehension of similar RP and CP structures is tested, Akan agrammatic speakers do show a deficit (Lartey, Tsiwah, Amponsah, Martínez-Ferreiro, & Bastiaanse, under review), showing that grammatical

tone is vulnerable. An explanation for the finding that the production of grammatical tone is not impaired in the current study may be that errors with grammatical tone would result in ungrammatical structures. It has been argued that such structures are not produced by agrammatic speakers (Bastiaanse & Thompson, 2003; Grodzinsky, 1990). Instead of producing these ungrammatical structures, the Akan agrammatic speakers seem to resort to base order sentences when too much grammatical complexity is required.

Focus marking

In languages like English, focused elements in sentences are not morphologically marked. Akan marks its focused constituents with the free morpheme "*na*". The present study sought to find out if Akan agrammatic individuals could produce focused structures. We indicated that the *who*-question conditions presented the opportunity for such analysis because in that structure, a question can be formed with a focused question word or with the question-word in situ; the meaning of both sentences is similar. Our data showed that the agrammatic speakers hardly ever omitted the focus marker in *who*-questions. Focus-marker omissions were observed primarily on the object-focused declaratives. We argue that focus marking is largely spared in *who*-question production because linguistically, object questions are inherently considered focused. This makes the phenomenon of focusing relatively easy to produce. Thus, even though the use of focus marking in Akan *who*-questions is optional, the inherently focused nature of *wh*-questions makes it less problematic to produce. In addition, errors on focus formation were not observed in isolation but also combined with thematic role reversals.

The results interpreted in a neurolinguistics framework

Although an effect of word order was found, the focused *wh*-object questions were not more difficult than the *wh*-object questions *in situ*. This is due to the fact that two agrammatic speakers (P1 and P3) perform at ceiling in both conditions, whereas the other three participants were impaired. The good performance of P1 and P3 cannot be attributed to severity: they were the most impaired participants on declarative sentences in derived order. According to the TPH (Friedmann & Grodzinsky, 1997), the focused *wh*-object questions should be problematic to produce, because individuals with agrammatism cannot project to the CP node in the syntactic tree. The current results are not in line with this hypothesis: two agrammatic speakers are able to produce the focused object *wh*-questions correctly, and the other agrammatic speakers make word-order errors, but they do produce the *wh*-word in sentence initial position. Neuhaus and Penke (2008) also found that object *wh*-question production in their German agrammatic speakers was spared, with the *wh*-word in topicalized position. Our results are in the middle: some agrammatic speakers can produce this question type perfectly, others cannot. This pattern is in line with comprehension data of *wh*-object questions reported by Thompson et al. (1999).

The data showed that subject-focused declaratives were less problematic than object-focused declaratives. This is predicted by the DOP-H. Bastiaanse and Van Zonneveld

(2005) assume that all languages have a base word order and all other word orders are derived. The latter is expected to be difficult for speakers with agrammatism. The DOP-H explains our findings on the focused declaratives correctly, because they were significantly more impaired than the subject-focused constructions and there was no difference between the object-focused declaratives with all the structural variations (resumptive pronoun and/or clause determiner). This is in line with the findings of Abuom and Bastiaanse (2013) for Swahili and English agrammatic bilinguals. The DOP-H also predicts that focused *wh*-questions will be problematic because constituents appear in derived order. This deficit was earlier reported for French (Van der Meulen et al., 2005). However, accuracy on base order structures was not different from those in derived order. Neuhaus and Penke (2008) made similar observations in nine German agrammatic speakers. Hickok and Avrutin's (1996) discourse-linking hypothesis, if extended to production, explains our observation on the *who*-questions. Hickok and Avrutin (1996) argue that *who*-questions are non-discourse linked; hence, they are relatively easy to comprehend. Our results show that object *who*-question production is indeed relatively spared. Even though the discourse-linking hypothesis is originally proposed to explain comprehension deficits, it is in line with our production data on the *who*-questions.

The outcome of the error analysis supports the DOP-H. The data indicate that the most frequent error type is associated with word order. Agrammatic speakers usually opted for base word-order structures even when primed with derived order structures. In addition, most of the substitution errors were base word order instead of derived word-order structures. The DOP-H explains why such errors were made. Structures in the base word order are less difficult to produce.

Conclusion

Our data and analysis (quantitative and qualitative) show an extensive word-order deficiency in the Akan speaking agrammatic individuals. A neurolinguistic approach to the effect of word order on performance suggests that the data of the current study can best be explained by the DOP-H. However, the DOP-H does not predict the high accuracy scores on *who*-questions. Word-order deficiencies reflected in the omission of focus markers mainly occur in declaratives even though focus marking was largely preserved. The current study has shown that the production of resumptive pronouns is relatively spared in agrammatic aphasia parallel to what Friedmann (2008) found for comprehension. In clinical terms, the current work provides evidence to Akan speech therapists to develop and include diagnostic tests on word order and resumption processing in Akan agrammatic speakers. The novel finding of this study is that Akan agrammatic speakers, who have problems with the production of sentences in derived word order, made no errors with grammatical tone. The reason for this may be that errors with grammatical tone would have resulted in ungrammatical structures since tone is crucial in the formation of Akan pronominal resumption.

Notes

1. In the formation of wh-questions in Akan, the question word can also be found *in situ* (Saah, 1994). The *wh*-word in object questions is in the base position. See example later:

2. In Akan, a clause determiner is a morpheme used to mark the end of a clause. Semantically, it does not add any extra information to the sentence. It acts as a clause boundary.
3. We employed Menn and Obler (1990) as a guide in the process. Factors such as grammaticality of utterances produced, speech rate, diversity in the use of lexical verbs and nouns.

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Appendix 1. Scores on tone discrimination tests

	Individuals with agrammatism	
	Tone screening test score (_/60)	Lexical tone discrimination test score (_/30)
P1	54	29
P2	55	26
P3	59	28
P4	58	28
P5	43	26
Mean	53.8	27.4
SD	6.38	1.34
Non-brain-damaged participants		
NBD1	56	30
NBD2	58	30
NBD3	59	30
NBD4	57	30
NBD5	60	30
NBD6	60	29
NBD7	58	30
NBD8	57	30
NBD9	56	29
NBD10	59	30
Mean	58	29.8
SD	1.49	0.42

The TST had three blocks. P3 had the lowest score on the TST due to technical difficulties encountered in the first block of testing and not because of a limited capacity to perform due to brain damage. Scores of P3 on the other two blocks are comparable to the NBDs.