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Syntactic complexity in the presence of an intervener: the case of an Italian speaker with anomia

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ABSTRACT

Background: A robust finding from language acquisition, adult processing, and individuals with language impairment is that certain types of Object Relatives (ORs) and Object Questions (OQs) are more challenging in both production and comprehension compared to their Subject counterparts. Approaches informed by linguistic theory have been proposed to clarify the source of the difficulties with these sentences in people with aphasia, with recent models supporting the idea of a grammatically based resource reduction selectively affecting sentences that require the processing of an element acting as an intervener.

Aims: This work presents new evidence to the study of syntactic competence in people with acquired language disorders, from a pilot study exploring in detail the morphosyntactic competence of an Italian speaker with anomia.

Methods & Procedures: The clinical diagnosis of anomia in the participant revealed a deficit in lexical retrieval with no deficit at grammatical level. Morphosyntactic competence was investigated through a series of off-line tasks on both comprehension and production.

Outcomes & Results: The morphosyntactic abilities of the participant turned out to be for the most part intact with no difficulties such as agrammatism. However, a selective deficit in the computation of certain ORs and OQs emerged. The deficit was selective for structures with an intervener and more specifically for structures in which the featural specification of the intervening subject is included in the specification of the displaced object.

Conclusions: Syntactic asymmetries emerged in the performance of an individual with anomia, with no apparent morphosyntactic impairment or sign of agrammatism. The deficit of the syntactic computation was selective and compatible with the grammatical Featural Relativized Minimality approach to the difficulties in the computation of sentences with an intervener. The preliminary results presented in this work suggest that the analysis of sentences with an intervener may be a sensitive test for the diagnosis of a syntactic based impairment and that formal linguistic models may offer promising tools for exploring linguistic deficits. Further investigation is necessary to strengthen these findings.

KEYWORDS: Anomia; Object Relatives; Object Questions; Syntax; Featural Relativized Minimality; Agrammatism.

1. Introduction

For many years, the language deficit of individuals with Broca's aphasia has been described as a syntactic deficit selectively affecting production (Goodglass & Berko, 1960; Schwarz, Saffran & Marin, 1980). Data from people with aphasia showed that this hypothesis needed to be refined. Not every syntactic operation was impaired (see for example De Blaser & Bayer, 1985 on nominal and adjectival agreement; Hagiwara, 1995 on negation; Ruigendijk & Bastiaanse, 1999, Ruigendijk, 2002 on case; Avrutin, 1999, Bastiaanse & Van Zonneveld, 1998 on finite verbs) and not only production was affected (see Caramazza & Zurif, 1976 seminal work and references included in Druks, 2016 on the theories proposed on agrammatism). These individuals seemed to have great difficulty with semantically reversible sentences with so-called non-canonical order of arguments, like Passives (1), Object Relatives (ORs, (2)), Object Clefts (3), and Object Questions (OQs, (4)), in both comprehension and production (Caramazza & Zurif, 1976; Berndt & Caramazza, 1980; Schwartz, Saffran & Marin, 1980).

(1)	The child was dried by the woman	chance level
(2)	The child who the woman dried…	chance level
(3)	This is the child who the woman dried	chance level
(4)	Which child did the woman dry?	chance level

New models inspired by linguistic theory were thus developed to account for the failure with complex syntactic structures and for the selective impairment in sentences with non-canonical order of arguments, involving an object dependency.

The *Tree-Pruning Hypothesis, or TPH* (Friedmann, 2001, 2002) captured the difficulties observed in the production of verbal inflection, embedded sentences, relative clauses and wh-questions, by proposing that people with agrammatism could not fully access

the syntactic structure necessary for the construction of sentences with a movement affecting the higher part of the syntactic tree. This model had the benefit of making clear predictions for language rehabilitation techniques, with training of more complex sentences, such as wh-questions, proving more effective than training of simpler items (Friedmann, Olenik & Gil, 2000; Friedmann, 2005).

A second theoretical model, The *Trace Deletion Hypothesis, TDH* (Grodzinsky, 1990) was proposed with the aim of accounting for the inability of individuals with agrammatism to comprehend non-canonical sentences involving an object dependency, suggesting that these individuals are not able to keep track of the displaced argument and apply a default strategy (NP1=Agent). This proposal was very influential in the debate on the linguistic dimension of the agrammatic deficit (see Druks, 2016 for a full review) but was falsified by experimental evidence on impaired structures with no traces (see Friedmann, 2006; Hickok, Zurif & Canseco-Gonzalez, 1993). While the approach proposed by Grodzinsky to language impairment is essential for focusing on specific linguistic abilities, it does not make it clear how linguistic information is integrated into the structure, and consequently why traces should be subject to this special deletion.

More recently, *Generalized Minimality* (Grillo, 2005, 2008) proposed that the linguistic competence of people with Broca's aphasia is not impaired and that their difficulties stem from reduced computational resources (see also Garraffa & Grillo, 2008; Garraffa & Learmonth, 2013). These individuals have problems in the comprehension and production of ORs and OQs, as these structures involve the construction of a dependency across an intervening element. This specific configuration is computationally costly and individuals with Broca's aphasia access a reduced representation that is not specified enough to distinguish between the arguments in the structure. The loss of (syntactic) processing abilities compromises the representation of the full array of morphosyntactic features normally associated with syntactic elements, thus giving rise

to a more general occurrence of Relativized Minimality type effects (Rizzi, 1990) in the relevant syntactic configurations (see Garraffa & Grillo, 2008 for a single case agrammatic speaker). A schema of the abstract configuration of a dependency across an intervener in both healthy adult speakers and speakers with asyntactic comprehension is presented in (5) and (6) (in these examples the subject *the woman* intervenes in the dependency between the target and the original positions of the object *the boy*). In the examples, OP stands for a feature belonging to the Operator class, while A stands for a feature belonging to the Argumental Class; under GM, the retrieval of Operator features is likely to be compromised in cases of reduced processing abilities. Crucially for the hypothesis, the retrieval of grammatical features in (6) is not rich enough to distinguish the two arguments of the sentence, in contrast with (5).

(5) OBJECT RELATIVE HEALTHY ADULT SPEAKER REPRESENTATION

This is the boy [who [the woman][< … > dried < the boy >]]

[D,N,Θ_2,$\varphi_{s,acc}$,op]OP [D,N,Θ_1,$\varphi_{s,nom}$]A [D,N,Θ_2,$\varphi_{s,acc}$,op]OP

(6) OBJECT RELATIVE ASYNTACTIC REPRESENTATION

This is the boy [who [the woman][< … > dried < the boy >]]

[D,N,$\Theta_?$,$\varphi_{s,}$…]A [D,N,$\Theta_?$,φ_s,…]A [D,N, Θ_2, $\varphi_{s,...}$]A

Generalized Minimality is based on a general principle of locality extensively studied in natural languages. This locality principle, Relativized Minimality formulated in featural terms (Rizzi, 1990, 2004; Starke, 2001; Friedmann et al., 2009; see below) expresses the fact that syntactic movement of an argument fails in the presence of a structurally intervening element in the syntactic hierarchy when that element shares grammatical features with the moved element, as indicated in (7).

(7) Given three elements X…Z…Y,

Y is in a local relation with X if there is no Z such that

- Z intervenes between X and Y;
- Z matches X in relevant features.

Looking at the local relation of movement, in (7) X is the target of movement, Z is the intervening element and Y the origin of movement. (8) and (9) rephrase (5) and (6) based on (7) (on healthy adult speakers see Belletti et al., 2012 and references therein for results from offline comprehension, Belletti & Rizzi, 2013 for overview and references on results from online reading and online comprehension).

(8) … X … Z … Y

$[\ldots]_{OP} \ldots[\ldots]_{A} \ldots[\ldots]_{OP}$ ✓ Adult speaker representation Above chance performance

(9) …X … Z … Y

$[\ldots]_{A} \ldots[\ldots]_{A} \ldots[\ldots]_{A}$ ✗ Asyntactic representation Chance level performance

Based on results from acquisition, an approach directly grounded in the grammatical principle of featural Relativized Minimality (fRM) and close in spirit to Generalized Minimality, was developed and expanded systematizing the featural specifications holding in non-local object dependencies (Friedmann et al., 2009). Table 1, based on Friedmann et al. (2009) and Belletti et al. (2012), is adapted to the specific comparison between (healthy) adult speakers versus developing and impaired speakers. It summarizes the possible relations holding between the featural specification of a target element X and the intervener Z; the relations are expressed in set theoretic terms where A, B, and C are features relevant for the locality principle

(i.e. features to which fRM is sensitive, such as number in many languages, Adani et al., 2010, or gender in languages such as Hebrew, Belletti et al., 2012).

[Table 1 here]

When the grammatical specification of the intervening element Z is identical to the specification of the target element X, a local relation between X and Y cannot be established and the structure is ruled out by the grammar. This is expressed as an identity relation between the two elements (A). When their featural specifications are disjointed, the locality principle is satisfied and the structure is well-formed (D). The structure also works when X is more richly specified than Z and it includes the featural specification of Z (see inclusion in B) or when the featural specifications of A and Z are in the intersection relation (illustrated in C). The system applies to structures with non-local dependencies, such as the case of ORs and OQs, where there is an element acting as an intervener, namely the preverbal lexical subject.

According to this approach, inclusion is the hardest relation among the possible featural relations in the intervention configuration. The system of a (healthy) adult speaker can compute inclusion (although with more difficulties than disjunction, as indicated by results from psycholinguistic online techniques; see Belletti & Rizzi, 2013 for overview and references), but it fails with identity. In contrast, the system of a developing or impaired speaker does not tolerate inclusion.

This approach can explain the selective difficulties with certain types of ORs and OQs and more generally long-distance dependencies in individuals suffering from language related pathologies (Hickok & Avrutin, 1996, Garraffa, 2007, Grillo, 2008, Garraffa & Grillo, 2008, Sheppard et al., 2015, Friedmann et al., 2017, Terzi & Nanousi, 2018 on aphasia; Novogrodsky & Friedmann, 2006, Friedmann & Novogrodsky, 2008, Contemori & Garraffa, 2010, Friedmann et al., 2015 on specific language impairment; Volpato & Vernice, 2014 on hearing

impairment; Durrleman et al., 2016 on autism; Caloi, 2013 on Alzheimer). ORs like (10a-b) are quite easy to compute for individuals with language impairment, while ORs of the type in (10c) appear to be hard. Similarly, no problems arise in the computation of *Who* OQs like (11b), whereas the computation of *Which* OQs as in (11c) appears to be difficult. The NP feature associated with lexically restricted nominal elements (i.e. lexical noun phrases) in Friedmann et al. (2009), as well as the features R and Q, are adopted in the representations in (10) and (11) and throughout (the position of origin of the moved element inside the clause, i.e. Y of (7)-(9) and Table 1, is indicated in < > brackets here and throughout). In (10) and (11) the intervener is in bold for clarity.

(10) a. (Show me) who **the mom** hugs <who> — Disjunction
R NP R

b. (Show me) the girls that **the mom** hugs <the girls> — Intersection
R NP plur NP sing R NP plur

c. (Show me) the girl that **the mom** hugs <the girl> — Inclusion
R NP NP R NP

(11) a. Which girl hugs <which girl> the woman? — No intervention
Q NP Q NP

b. Who does **the girl** hug <who >? — Disjunction
Q NP Q

c. Which woman does **the girl** hug <which woman> — Inclusion
Q NP NP Q NP

A system with weaker computational capacities could be able to compute intervention but not the hardest configuration of inclusion.

Individuals affected by language related pathologies have also shown difficulties with

ORs with a post-verbal subject such as (12) (Volpato & Adani, 2009, Friedmann et al., 2010 on hearing-impaired children; Garraffa, 2008 on aphasia).

(12) L'elefante che bagnano i leoni
The elephant that wet the lions
'The elephant that the lions wet'

The complexity of ORs with a post-verbal subject can be traced back to the intervention configuration present in the subject-verb agreement process in the derivation of these structures. Assuming an intermediate step in the movement of the object toward the relative head position, the inflectional head of the verb in the high part of the clause structure can erroneously agree with the intervening object copy, rather than with the lower post-verbal subject, inducing agreement errors (see Guasti et al., 2012 on Italian OQs, building on Guasti & Rizzi, 2002, Franck et al., 2002, 2006). ORs with a post-verbal subject would thus be difficult because of the intervention configuration present in the post-verbal subject–verb agreement process. This would justify why individuals with language impairment make agreement errors significantly more often than healthy adults in structures like (12) and tend to interpret the relative clause as a subject relative (as in: *L'elefante che bagna i leoni, 'The elephant that wets the lions'*) (Volpato & Adani, 2009, Friedmann et al. 2010, Garraffa, 2008).

The same hypothesis explains the difficulties observed with Italian Wh-Object Questions (Guasti et al., 2009, Guasti et al. 2012 on children and adults, Belletti & Guasti, 2015 for overview; Grillo, 2008 on aphasia). Given the post-verbal position of the subject in Italian Wh-OQs, an intervention configuration inducing agreement errors is present in the subject-verb agreement process in these structures.

Finally, healthy adults and older children master passive sentences like (13b) and (14b)

as a substitution for the production of ORs and OQs (Belletti & Contemori, 2010, Contemori & Belletti, 2014, Guasti & Cardinaletti, 2003, Guasti et al., 2012, Belletti & Guasti, 2015 for overview).

(13) a. Elicited OR: Il leone che l'elefante bagna

'The lion that the elephant is wetting'

b. Structure produced: Il leone che è bagnato dall'elefante

'The lion that is wet by the elephant'

(14) a. Elicited OQ: Quale leone bagnano gli elefanti?

Which lion wet the elephants

'Which lion are the elephants wetting?'

b. Structure produced: Quale leone è bagnato dagli elefanti?

'Which lion is wet by the elephants?'

Sentences like (13b) are usually called Passive ORs (PORs) and sentences like (14b) are usually called Passive OQs (POQs) indicating that a sentence in the passive voice is produced in place of the elicited active OR and active OQ, respectively. Notice that these sentences are subject relatives (SRs) and subject questions (SQs), not inducing intervention effects. These structures have been hypothesized to take priority over ORs and OQs in elicited production experiments, because they are felicitous answers for the elicitation context and do not involve intervention (see Belletti, 2014 assuming the derivation of passive in Collins, 2005 for details). As a matter of fact, both children and adults perform better in the comprehension of PORs compared to ORs (Contemori & Belletti, 2014, Lin & Bever, 2006). The same analysis can be extended to account for the use of POQs in elicited production studies (Guasti et al., 2012; Riches &

Garraffa, 2017).

2. Current study

The present study is an in-depth investigation of the morphosyntactic abilities of an Italian speaker with anomia. We analyzed a number of morphosyntactic domains in order to verify whether the morphosyntactic abilities of this speaker were unimpaired, as attested by the clinical diagnosis of anomia. Then, we explored comprehension and production of Active and Passive sentences, Relative Clauses and Wh-questions. Relative clauses with number mismatch between subject and object were included in the study, as well as Passive Object Relatives (POR) and Passive Object Questions (POQ). The approach based on featural Relativized Minimality makes some clear predictions: we expect ORs with number match (intervention configuration of inclusion) to be harder than ORs with number mismatch (intervention configuration of intersection) and overall harder than SRs, PORs Wh-SQs, and POQs (no intervention); we also expect Italian Wh-OQs and ORs with a post-verbal subject to be hard to compute, because of the described intervention configuration present in the agreement process of object dependencies in which the subject is located post-verbally; furthermore, we expect difficulties with structures involving intervention to show up in both comprehension and production, as grammar is part of both comprehension and production systems.

We note that previous grammatically based accounts such as TPH and TDH would not make any fine-grained distinction like the ones just described: in the former account any kind of dependency involving the highest part of the clause (A'-dependency) is just not computable, while in the latter, no difference between the featural mis/match conditions and types of intervention is expected to emerge. In contrast, the grammatical GM and fRM approaches reviewed above, based on a refined specification of the concept of intervention expressed in featural terms, capture the aforementioned subtle distinctions. Such distinctions, it turns out,

play a role in aphasia much as they do in acquisition and in the different forms of language impairments mentioned in section 1.

The next sections will present this single-case study of a speaker with anomia. First, we will briefly illustrate the various morphosyntactic domains investigated in this speaker. We will then focus on the performance with Relative Clauses and Wh-questions, testing the following configurations in terms of the featural relations of the fRM approach as schematized in Table 1: SR and OR in number match and number mismatch conditions, POR, OR with a post-verbal subject, Who and Which SQ and OQ, and POQ. The study is a pilot study having various methodological limitations (a small control group size, a low number of items in some experimental conditions, and a number of items unbalanced across tasks and conditions; see section 2.1 below). Further data would therefore be necessary to corroborate the results, which nonetheless appear to be very clear and interesting, and point towards a new and promising direction of research.

2.1 Methods

Participants

F.G. is a 66-year-old right-handed Italian man with eight years of education. He worked all his life in the family business as a shop seller. At the age of 64, a first-time haemorrhagic stroke in the left temporal-parietal area caused an anomic aphasia of mild severity. At the age of 65, a second haemorrhagic stroke in the left temporal-parietal-occipital area worsened his anomia. Table 2 presents the PWA's demographic and medical details with an overview of diagnostic aphasia language assessment scores.

[Table 2 here]

The BADA (Batteria per l'Analisi dei Deficit Afasici, Miceli et al., 1994) reveals selective difficulties in naming. Interestingly, the lexical retrieval deficit appears to be comparable on both objects and actions (see Zingeser & Brendt, 1990 for a similar result in anomia compared to agrammatism). The AAT (Aachener Aphasie Test, Luzzatti et al., 1996) reveals some more detailed aspects of F.G.'s language impairment. The AAT scores show a moderate deficit in naming, in line with the results from BADA, and a mild deficit in token test, repetition, and sentence comprehension. No deficit is reported for word comprehension and writing.

F.G.'s scores in naming tasks mirror his spontaneous production, with occurrences of verbal paraphasia (mainly superordinate semantic paraphasias) and many semantic circumlocutions, but not phonological errors. A corpus of spontaneous production was collected during the sessions with F.G.. As can be seen from the transcription in (15), his speech is fragmented with a clear word finding impairment, but no omissions or substitution of functional words.

(15) F.G.is describing a picture of a farm with different animals and actions:

''Questi animali, questi sono animali, dentro… questo è un…una…come si dice? un…questo è un…non mi viene, non me la ricordo… eh, si chiama? questo è un…un pos… Le parole…ero partito bene. Uomo. Una macchina, macchina. Questo è un pur.. pur… pos… can… cam… camioncino. Questa è una macchina, questo è un furgone.

Questo è uno ini…in…in macchina, la macchina. Questo è un uomo, un…un uomo che c'ha un canino. Questi due…casa…casa. Questo è un…dove si veste la…dove si butta la roba, dove si mette la roba, è un…non mi viene.

Qua, questo è un…animale, un animaletto. Che c'è di nuovo poi da sapere? Anche questo qui? Sono ragazzi che davanti c'hanno questi animal…questi…ani…ani…che

corrono…i.cavalli, sono dei cavalli davanti a questi ragazzi, che qui escono da…prima stavano qui, dentro a… non mi viene. Loro invece vivono qui in casa, dentro la casa.''

"These are animals, these are animals in a … this is a… can't find the word! A.. this is a… I can't remember…it is called… a….a… I had a good start, but the words! Man. A car, car. This is a…[fragments of the word pur, pur, pos, can, cam] a van. This is a car and this is a van.

This is [some]one in …in.. a car, a car. This is a man, a…a… man who has a doggy. These two…house…house. This is a... where you change yourself…where you throw stuff out, where you put stuff, this is a… I can't find the word.

Here, this is an… animal , a small animal. What else should I know? Also this one? These are some guys who have some animals in front of them… these animals… these.. ani… ani… who ride… the horses, these are horses in front of these guys who are getting out from… first they were here, in the…. can't find the word! The other ones, they live in the house, inside the house.''

This study was conducted four months after the second neurological event. The morphosyntactic assessment took place in the hospital where F.G. was in therapy. F.G.'s speech therapy was targeting the recovery of lexical retrieval, and thus did not concern the areas investigated in this study.

F.G.'s performances in all experimental tasks were compared with those of a control group of six healthy Italian men paired with F.G. in age (Mean Chronological Age: 68; SD: 1.2) and education (eight years of schooling, secondary school degree).

Materials

A series of experimental tasks targeting both production and comprehension were developed to assess the morphosyntactic domains traditionally impaired in individuals with agrammatism but not in anomia; see Table 3 below.

[Table 3 here]

Focusing on Relative Clauses and Wh-questions, the character-selection methodology (Friedmann & Novogrodsky, 2004; Arnon 2005) was used to investigate comprehension. See (16) and Figure 1 for an example of experimental item and picture pair used to test the comprehension of SRs and ORs with number match.

(16) Experimenter: Guarda! In queste immagini ci sono un ippopotamo e un pinguino.

'Look! In these pictures there are a hippo and a penguin'

SR: Mostrami l'ippopotamo che sta lavando il pinguino.

'Show me the hippo that is washing the penguin.'

OR: Mostrami l'ippopotamo che il pinguino sta lavando.

'Show me the hippo that the penguin is washing.'

[Figure 1 here]

See item (17) and Figure 2 testing the comprehension of Which- Subject and Object questions.

(17) Experimenter: Guarda! In queste immagini ci sono due elefanti e un coniglio.

'Look! In these pictures there are two elephants and a rabbit'

a. Which-S question: Quale coniglio sta ritraendo gli elefanti?

'Which rabbit is drawing the elephants?'

b. Which-O question: Quale coniglio stanno ritraendo gli elefanti?

Which rabbit are drawing the elephants

'Which rabbit are the elephants drawing?'

[Figure 2 here]

The picture-description methodology was used to explore production. In the task exploring relative clause production (Novogrodsky & Friedmann, 2006), the experimenter describes a picture pair and asks about a character in one of the pictures. The participant has to answer the question by describing the character in question. See (18) for an experimental item and Figure 3 for a picture pair used to elicit SRs and ORs with number match.

(18) Experimenter: Guarda! In queste immagini ci sono due giraffe. In un'immagine la giraffa bacia la scimmia, nell'altra immagine la scimmia bacia la giraffa. Che giraffa è questa? Inizia con: Questa è la giraffa…

'Look! In these pictures there are two giraffes. In a picture the giraffe is kissing the monkey, in the other picture the monkey is kissing the giraffe. Which giraffe is this? Start with: This is the giraffe…'

a. Target SR: Questa è la giraffa che bacia la scimmia.

'This is the giraffe that is kissing the monkey'

b. Target OR: Questa è la giraffa che la scimmia bacia.

'This is the giraffe that the monkey is kissing'

[Figure 3 here]

In the task exploring wh-question production (Guasti et al., 2012), the participant is presented with a picture in which one character is hidden. The experimenter briefly describes the picture and the participant has to ask a third person about the identity of the hidden character.

(19) Experimenter: Guarda! In questa immagine ci sono due ragazze. Le ragazze stanno pettinando qualcuno. Lui sa chi. Chiedigli chi!

Look! In this picture there are two girls. The girls are combing someone. He knows who. Ask him who!'

Target Who-O question: Chi stanno pettinando le ragazze?

Who are combing the girls?

'Who are the girls combing?'

[Figure 4 here]

We refer the reader to the Appendix for the materials testing the remaining conditions in Relative Clauses and Wh-questions.

For the comprehension of Relative Clauses, a total of 45 relative clauses were tested: nine SRs with number match, nine ORs with number match, six SRs with number mismatch, six ORs with number mismatch, six ORs with post-verbal subject, and nine PORs. In the number mismatch conditions, half of the items had a singular subject and a plural object and the other half had a plural subject and a singular object. For the production of Relative Clauses, a total of 30 relative clauses were tested: 15 SRs with number match and 15 ORs with number match. All relative clauses had lexically restricted and animate arguments and transitive verbs, and they were semantically reversible.

A total of 40 Wh-questions were included in the Wh-questions comprehension protocol: 10 Who SQs, 10 Who OQs, 10 Which SQs and 10 Which OQs. A total of 20 Wh-questions

were included in the production protocol: five Who SQs, five Who OQs, five Which SQs and five Which OQs. In all conditions, the subject and the object were animate and mismatched in number so as to avoid ambiguity between a subject question and an object question reading; in half the items the subject was singular and the object plural, while in the other half the inverse was true. Furthermore, the verbs were transitive and the sentences semantically reversible.

All items contained the same number of content words. In all tasks, the order of the items was pseudo-randomized so that there were never more than two consecutive items of the same type. The pictures were also pseudo-randomly ordered, so that there were never three consecutive pictures in which the target character was in the same position.

In summary, this study examined the following categories: comprehension of SRs with number match, comprehension of ORs with number match, comprehension of SRs with number mismatch, comprehension of ORs with number mismatch, comprehension of ORs with a post-verbal subject, comprehension of PORs; production of SRs with number match, production of ORs with number match; comprehension of Who SQs, comprehension of Which SQs, comprehension of Who OQs, comprehension of Which OQs; production of Who SQs, production of Which SQs, production of Who OQs, production of Which OQs. The results on Relative Clauses and Wh-questions were analyzed with the Crawford test for single-case studies (Crawford & Howell, 1998) in the R environment (R Development Core Team, 2014).

2.2 Results

F.G. performed above chance on the majority of the tasks targeting morphosyntax (see Table 4 below). Some difficulties emerged with structures involving object clitics (elicited production of third person object clitic, third person object clitic-past participle agreement, and clitic left dislocation). These structures are known to be particularly hard for developing and impaired speakers, due to both the complexity of the cliticization process and to the possible intervention

configuration present in structures involving an object clitic and a post-verbal subject (we will not address this issue here, but see Belletti & Guasti, 2015, Ch. 3 for a detailed discussion and references therein). The latter is the same configuration found in other object dependencies in which the subject is located post-verbally, such as ORs with a post-verbal subject and Italian Wh-OQs (discussed in section 1). Apart from that, the generally good performance of F.G. in structures involving a post-verbal subject or in passive sentences indicates that his morphosyntactic abilities are relatively unimpaired, as was expected from the clinical diagnosis of anomia.

[Table 4 here]

In the next sections, we will focus on the results on Relative Clauses and Wh-Questions on both comprehension and production.

Relative clauses: comprehension and production

We explored the comprehension of Subject and Object Relatives with number match and mismatch, Object Relatives with a post-verbal subject, Passive Object Relatives, and the production of Subject and Object Relatives with number match. Based on the predictions from fRM described above, we expected ORs with number match (inclusion) to be more difficult than ORs with number mismatch (intersection) and SRs (no intervention). Based on the good performance F.G. showed with passive sentences, we expected PORs (no intervention) to be easier than ORs with inclusion. ORs with a post-verbal subject were expected to be problematic for him, due to the intervention configuration present in the agreement process with the post-verbal subject.

Table 5 reports the results on the comprehension of Relative Clauses. There was no significant difference between the performance of F.G. and that of the controls in the SR

number match condition (*p=.72*), SR number mismatch condition (*p=.11*), OR number mismatch condition (*p=.72*), and POR condition (*p=.72*). In contrast, F.G. performed significantly worse than controls in the OR number match condition (*p<.001*) and in the OR post-verbal subject condition (*p<.001*).

[Table 5 here]

Table 6 reports the results from production. F.G. performed similarly to the controls in the SR number match condition, producing the target SRs (*p=.11*). He performed significantly worse than controls in the OR number match condition (*p <.001)*. Whilst controls produced correct PORs in place of the elicited active ORs as expected, F.G. produced correct PORs and a great amount of incorrect SRs with thematic role reversal.

[Table 6 here]

Wh-Questions: comprehension and production

We tested the comprehension and production of Who and Which Subject and Object questions. Based on the predictions illustrated above, Wh-SQs (no intervention) were expected to be easier to comprehend and produce than Wh-OQs (intervention). Both Which- and Who- Object questions were expected to be difficult because of the intervention configuration present in the post-verbal subject–verb agreement process (intervention of the intermediate object copy).

Table 7 shows the results on the comprehension of Wh-questions. No significant difference emerged between the performance of F.G. and controls in the Who-SQ condition (*p=.43*) and in the Which-SQ condition (*p=.11*). In contrast, F.G. performed significantly worse than controls in the Who-OQ condition (*p <.001*) and in the Which-OQ condition (*p=.033*).

[Table 7 here]

Table 8 reports the results from production. F.G. performed similarly to controls in the Who SQ condition ($p=.72$) and in the Which SQ condition ($p=.72$), producing the target Wh-SQs. In contrast, he performed significantly worse than controls in the Who OQ condition ($p<.001$) and in the Which OQ condition ($p<.001$). Whilst control participants produced the target Wh-OQs in these conditions, F.G. produced incorrect Which-SQs with thematic role reversal and correct POQs.

[Table 8 here]

2.3 Interim Discussion on Relative clauses

Comprehension

A subject-object asymmetry clearly emerged in F.G.'s results on the comprehension of relative clauses. SRs were always successfully understood (both in the number match and in the number mismatch conditions), while ORs were problematic in some circumstances, namely in the OR with number match and OR with post-verbal subject conditions. In contrast, the control participants correctly understood all types of subject and object relatives without any difficulty.

Most of F.G.'s errors in the comprehension of ORs with number match consisted in the selection of the wrong character in the correct picture. In sentences like (20) he chose the subject of the action, the penguin, in the picture in which the penguin washes the hippo.

(20) OR: Mostrami l'ippopotamo che il pinguino sta lavando.

'Show me the hippo that the penguin is washing'

We suggest that F.G. did not process the entire relative clause but only the subject-verb sequence following the relative pronoun (*il pinguino sta lavando, 'the penguin is washing'*). The comprehension of this last part of the sentence indeed results in the selection of the correct

picture and, in the correct picture, of the only argument present (*il pinguino, 'the penguin'*). As a matter of fact, during the task, F.G. often repeated this latest part of the stimulus aloud before answering, whereas he never repeated the entire relative clause.

Interestingly, F.G. performed at ceiling in ORs with number mismatch.

We suggest that the selective difficulties of F.G. with ORs like (20) are due to the presence of an intervention configuration of inclusion between the relativized object (*the hippo* in (20)) and the intervening subject (*the penguin* in (20)), which as we know is particularly hard to compute. Indeed, when intervention is modulated by a (relevant) featural mismatch yielding intersection, as in ORs with number mismatch like (21), F.G. reached a good sentence comprehension.

(21) OR: Mostrami i gatti che il coniglio sta tirando.

'Show me the cats that the rabbit is pulling'

R NP plur NP sing

Similarly, he had no difficulties with PORs, which do not involve intervention (22).

(22) POR: Il pinguino che [$_{TP}$ è [$_{VP}$ lavato <il pinguino>] da [$_{vP}$ l'ippopotamo [$_{VP}$ <V il pinguino>]]

↑_____|

The penguin that is washed <the penguin> by the hippo <V the penguin>

'The penguin that is washed by the hippo'

We trace back F.G.'s difficulties in the comprehension of ORs with a post-verbal subject to the intervention configuration present in the subject-verb agreement process in these structures. The intervention configuration is created by the presence of the object copy (underscored in (23) for clarity) intervening between the lower subject and the inflectional head

(T) in its movement to the relative head, as illustrated in (23) (see section 1 surrounding example (12)).

(23) Il coniglio che [$_{TP}$ stanno tirando $_{T}$ [<il coniglio> [$_{VP}$ i gatti <V> <il coniglio>]]]

The rabbit that are pulling <the rabbit> the cats <V> <the rabbit>

'The rabbit that the cats are pulling'

The type of error that he made supports this hypothesis. In an item like (24a), he pointed to the rabbit in the picture in which the rabbit is pulling the cats. We can thus hypothesize that he interpreted the item as the subject relative in (24b) rather than as the object relative in (24a), as is expected if an intervention effect of the object in subject-verb agreement occurred.

(24) a. Mostrami il coniglio che stanno tirando i gatti.

Show me the rabbit that are pulling the cats

'Show me the rabbit that the cats are pulling'

b. Mostrami il coniglio che sta tirando i gatti.

'Show me the rabbit that is pulling the cats'

To sum up, F.G. failed to comprehend ORs when the preverbal subject, intervening in the dependency between the relative head and the object gap, was in an inclusion relation with the target (OR number match condition). He also failed comprehension when an intervention configuration was present in the subject-verb agreement process with a post-verbal subject (OR post-verbal subject condition). In contrast, he performed very well when inclusion was not involved, as in SRs and PORs, or modulated, as in ORs with number mismatch between the relative head and the subject of the relative clause. We propose that the complexity associated

to intervention can explain F.G.'s results. The extra complexity associated with certain intervention configurations may exceed his computational resources.

Production

The results from production are consistent with those from comprehension, as expected under a grammar-based approach such as featural Relativized Minimality. A Subject-Object Relative asymmetry clearly emerged. F.G. produced the elicited SRs with number match without any difficulty, whereas he never produced the elicited ORs with number match. When ORs were elicited he produced correct Passive ORs and incorrect SRs by reversing the roles of the characters. We extend to production the hypothesis put forth for comprehension. F.G. did not produce any active ORs with number match because the intervention configuration involved in these structures was too hard for him to compute; when answering the elicitation question, he used structures that do not involve intervention, namely correct passive object relatives and incorrect subject relatives. This differed from the performance of controls who only used correct passive object relatives (Belletti & Contemori, 2010; Contemori & Belletti, 2014; Guasti & Cardinaletti, 2003; and section 1 of this paper on the use of passive in the elicitation of active ORs in healthy adults).

2.4 Interim Discussion on Wh-questions

Comprehension

The results of F.G. in comprehension clearly show the Subject-Object Wh-question asymmetry. His performance level was excellent with Wh-SQs, but poor with Wh-OQs. We attribute his selective difficulties with Wh-Object questions to the intervention effect involved in these structures. No intervention is involved in Which- and Who- Subject questions (25-26):

(25) Quale coniglio sta ritraendo <quale coniglio> gli elefanti?

Which rabbit is drawing <which rabbit> the elephants

'Which rabbit is drawing the elephants?

(26) Chi sta ritraendo <chi> gli elefanti?

Who is drawing <who> the elephants

'Who is drawing the elephants?

In contrast, an intervention configuration is involved in the subject–verb agreement process in Italian Which- and Who- Object questions, in which the subject is always post-verbal (27-28). In these structures, the intermediate object copy (underscored for clarity in the examples) intervenes between the inflectional head of the verb and the lower post-verbal subject inducing possible agreement errors (Guasti et al., 2012; Guasti & Rizzi, 2002; Franck et al., 2002, 2006; and section 1, this paper).

(27) Quale coniglio [$_{AgrSP}$ stanno ritraendo [$_{AgrOP}$ <quale coniglio> [$_{VP}$ gli elefanti <V> <quale coniglio>]]]?

Which rabbit are drawing <which rabbit> the elephants <V><which rabbit>

'Which rabbit are the elephants drawing?'

(28) Chi [$_{AgrSP}$ stanno ritraendo [$_{AgrOP}$ <chi> [$_{VP}$ gli elefanti <V> <chi>]]]?

Who are drawing <who> the elephants <V> <who>

'Who are the elephants drawing?'

Errors made by F.G. in the Which- and Who- Object question conditions support this hypothesis. In answering questions like (29), he systematically pointed to the correct character in the wrong picture; for example, in Fig. 5, he indicated the girl who is greeting the kangaroos in the bottom part of the picture instead of the girl in the upper part of the picture.

(29) Chi stanno salutando i canguri?

Who are greeting the kangaroos

'Who are the kangaroos greeting?'

[Figure 5 here]

This type of answer shows that F.G. interpreted the question in (29) as a subject question (*Chi sta salutando i canguri?, 'Who is greeting the kangaroos?'*) rather than as an object question. This error can be attributed to the intervention effect in the subject–verb agreement process just described. He made this error in all items with both Which- and Who- Object questions, disregarding the agreement information present in the verb. Quite interestingly, he only made agreement errors in intervention configurations.

Production

The results from production are perfectly consistent with those from comprehension, as expected under fRM, and with previous literature (Guasti et al., 2012). F.G. successfully produced the elicited Who- and Which- Subject questions, whereas he failed to produce the target Who- and Which- Object questions. In the Wh-Object question conditions, instead of the target structures, he produced correct Passive OQs (30a) and incorrect Wh-SQs (30b). In line with the hypothesis followed so far, we suggest that his selective difficulties in the production of Wh-OQs are due to the intervention effect involved in these sentences. Indeed, when the

problematic configurations were elicited, he resorted to sentences that do not involve intervention, namely subject questions and passive object questions.

(30) Target Wh-O question: Quale bambina stanno pettinando le signore?

Which girl are combing the ladies

'Which girl are the ladies combing?'

a. POQ produced: Quale bambina è pettinata dalle signore?

'Which girl is combed by the ladies?'

b. SQ produced: Quali signore stanno pettinando la bambina?

'Which ladies are combing the girl?'

3. Conclusions and further implications

In this single-case pilot study of anomia, a deficit on both sentence comprehension and production was affirmed. A mild impairment on sentence comprehension was captured by the standard language assessments, but the comprehensive evaluation conducted for this study revealed a syntactic impairment limited to sentences involving an object dependency across an intervening subject whose featural specification is included in the featural specification of the target of movement, as well as to sentences involving agreement with a post-verbal subject across an intervening copy of the object, in both comprehension and production.

We suggested that the cost associated with the computation of an intervention configuration could exceed the computational resources of the individual with aphasia presented in this study. It may indeed be possible that he has reduced computational resources, given the neurological event undergone, and that, although his syntactic abilities are essentially unimpaired, he fails with the most complex structures. This approach to comprehension and production in situations of aphasia, and to grammatical deficit in general, bares on the proper

formulation of a formal theory explicating the grammatical nature of linguistic processing. In many works on sentence processing there is an explicit reference to the concept of complexity (see Just & Carpenter, 1992). To define more clearly what complexity in sentence processing is, reference to syntactic theory is needed. On the basis of the approach proposed in this study, complexity is crucial to the intervention configuration in the syntactic hierarchy and the featural relations in which target and intervener are found.

We want to stress that the investigation of complex sentences revealed difficulties that otherwise would have remained unnoticed in a speaker like F.G. The computation of (certain) ORs and OQs has been described by the linguistic theory as particularly problematic for speakers affected by different types of language pathologies (e.g., specific language impairment, hearing impairment, autism; see section 1). It is therefore reasonable to suppose that in situations of linguistic deficit these structures are the most likely to be impaired. We would like to suggest that the analysis of Object Relatives and Object Questions in the intervention configuration discussed here might thus be a sensitive test for the diagnosis of a language weakness.

We also want to indicate that the kind of tasks used in this case study, based on solid theoretical hypotheses and demonstrably able to explore the morphosyntactic abilities of an impaired speaker, might also be useful in the clinical setting. The experimental designs shown to be valuable in the research area could indeed be of help in eliciting the production of the relevant structures as they successfully do in healthy speakers and, more generally, could train their computation. The success of the work by Friedmann, Olenik & Gil (2000) and Chinellato (2003), for instance, supports this hypothesis.

The findings from this pilot study point towards the need to acknowledge in a more systematic way the syntactic-based impairments in aphasia, developing language assessments informed by linguistic theory. Formal linguistic models, like the approach adopted in this study,

may offer promising tools in view of exploring forms of linguistic deficits, and hopefully inspire new treatment protocols. Further systematic investigation in aphasia would be valuable to support these preliminary findings.

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References

Adani, F. (2011). Rethinking the acquisition of relative clauses in Italian: towards a grammatically based account. *Journal of Child Language, 38,* 141-165.

Adani, F., van der Lely, H. K. J., Forgiarini, M., & Guasti, M. T. (2010). Grammatical feature dissimilarities make relative clauses easier: A comprehension study with Italian children. *Lingua, 120,* 2148-2166.

Arnon, I. (2005). Relative clause acquisition in Hebrew: Towards a processing- oriented account. Proceedings of the 29th BUCLD.

Avrutin, S. (1999). *Development of the syntax discourse interface*. Dordrecht: Kluwer Academic Publisher.

Avrutin, S. (2000). Comprehension of Wh-questions by children and Broca's aphasics. In Y. Grodzinsky, L. P. Shapiro & D. Swinney (Eds.), *Language and the Brain: Representation and Processing* (pp. 295-312). San Diego, CA, USA: Academic Press.

Bastiaanse, R. & van Zonneveld, R. (1998). On the relation between verb inflection and verb position in Dutch agrammatic aphasics. *Brain and Language, 64,* 165–181.

Belletti, A. (2014). Notes on Passive Object Relatives. In P. Svenonius (Ed.), *Functional Structure from Top to Toe* (pp. 97-114). Oxford, UK: Oxford University Press.

Belletti, A., & Contemori, C. (2010). Intervention and Attraction. On the production of Subject and Object Relatives by Italian (young) children and adults. Proceedings of Gala 2009.

Belletti, A., & Contemori, C. (2012). Subjects in children's object relatives in Italian. *Revue Roumaine de Linguistique*, *57,* 117-142.

Belletti, A., Friedmann, N., Brunato, D., & Rizzi, L. (2012). Does gender make a difference? Comparing the effect of gender on children's comprehension of relative clauses in Hebrew and Italian. *Lingua*, *122,* 1053-1069.

Belletti, A., & Guasti, M. T. (2015). *The Acquisition of Italian. Morphosyntax and its interfaces in different modes of acquisition*. Amsterdam/Philadelphia: John Benjamins Publishing Company.

Belletti, A., & Rizzi, L. (2013). Intervention in Grammar and Processing. In C. Cecchetto & I. Caponigro (Eds.), *From Grammar to Meaning* (pp. 294-311). Cambridge, MA, USA: Cambridge University Press.

Bentea, A. (2017). *Intervention effects in language acquisition: The comprehension of A-bar dependencies in French and Romanian*. Doctoral Dissertation. University of Geneva, Geneva, Switzerland.

Berndt, S., & Caramazza, A. (1980). A redefinition of the syndrome of Broca's aphasia: Implications for a neuropsychological model of language. *Applied Psycholinguistics, 1,* 225-278.

Butterworth, B. (1989). Lexical access in speech production. In W. Marslen-Wilson (Ed), *Lexical representation and process*. Cambridge: MIT Press.

Butterworth, B. (1992). Disorders of phonological encoding. *Cognition, 42,* 261-286.

Caloi, I. (2013). The Comprehension of Relative Clauses in patients with Alzheimer's Disease. In E. Servidio (Ed.), *STiL - Studies in Linguistics, Vol. 5* (pp. 5-22): CISCL Press.

Caramazza, A., & Zurif, E. B. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: Evidence from aphasia. *Brain and Language*, *3,* 572-582.

Cardinaletti, A., & Volpato, F. (2015). On the comprehension and production of passive sentences and relative clauses by Italian university students with dyslexia. In E. Di Domenico, C. Hamann & S. Matteini (Eds.), *Linguistik Aktuell/Linguistics Today*, Vol. 223 (pp. 279-302). Amsterdam: John Benjamins Publishing Company.

Chinellato, P. (2003). The Recovery of Subject Clitics in Mild Agrammatism: A generative approach to treatment. *Rivista di Grammatica Generativa, 28,* 31-44.

Collins, C. (2005). A smuggling approach to the passive in English. *Syntax*, *8,* pp. 81-120.

Contemori, C., & Belletti, A. (2014). Relatives and passive object relatives in Italian-speaking children and adults: Intervention in production and comprehension. *Applied Psycholinguistics*, *35,* 1021-1053.

Contemori, C., & Garraffa, M. (2010). Comparison of modalities in SLI syntax: A study on the comprehension and production of non-canonical sentences. *Lingua, 120*, 1940-1955.

Crawford, J. R., & Howell, D. C. (1998). Comparing an individual's test score against norms derived from small samples. *The Clinical Neuropsychologist, 12*, 482-486.

David, C. (1983). *Syntactic competence in agrammatism-a lexical hypothesis*. In S.K. M (Ed.), *Psychobiology of language*. Cambridge: MIT Press.

De Bleser, R., & J, Bayer (1985). German word formation and aphasia. *The Linguistic Review*, *5,* 1-40.

De Vincenzi, M. (1996). Syntactic analysis in sentence comprehension: effects of dependency types and grammatical constraints. *Journal of Psycholinguistic Research, 25*, 117-133.

De Vincenzi, M., Arduino, L., Ciccarelli, L., & Job, R. (1999). Parsing strategies in children comprehension of interrogative sentences. Proceedings of the European Conference on Cognitive Science.

Druks, J. (2016) *Contemporary and emergent theories of agrammatism*. Routledge, Psychology Press.

Durrleman, S., Marinis, T., & Franck, J. (2016). Syntactic complexity in the comprehension of wh-questions and relative clauses in typical language development and autism. *Applied Psycholinguistics, 37,* 1501-1527.

Franck, J., Vigliocco, G., & Nicol, J. L. (2002). Subject-verb agreement errors in French and English: The role of syntactic hierarchy. *Journal of Language and Cognitive Processes, 17(4)*, 371–404.

Franck, J., Lassi, G., Frauenfelder, U., & Rizzi, L. (2006). Agreement and movement: a syntactic analysis of attraction. *Cognition, 101*, 173-216.

Frauenfelder, U., Segui, J., & Mehler, J. (1980). Monitoring around the relative clause. *Journal of Verbal Learning and Verbal Behavior*, *19,* 328-337.

Friedmann, N. (2001). Agrammatism and the psychological reality of the syntactic tree. *Journal of Psycholinguistic Research, 30*, 71-90.

Friedmann, N. (2002). Syntactic tree pruning and question production in agrammatism. *Brain and Language, 83,* 117-120.

Friedmann, N. (2005). Degrees of severity and recovery in agrammatism: Climbing up the syntactic tree. *Aphasiology, 19,* 1037-1051.

Friedmann, N. (2006). Speech production in Broca's agrammatic aphasia: Syntactic tree pruning. In Y. Grodzinsky & A. K (Eds.), *Broca's region* (pp. 63-82). New York: Oxford University Press.

Friedmann, N., Belletti, A., & Rizzi, L. (2009). Relativized relatives: Types of intervention in the acquisition of A-bar dependencies. *Lingua*, *119,* 67-88.

Friedmann, N., & Novogrodsky, R. (2004). The acquisition of relative clause comprehension in Hebrew: a study of SLI and normal development. *Journal of Child Language*, *31,* 661-681.

Friedmann, N., & Novogrodsky, R. (2008). Subtypes of SLI: SySLI, PhoSLI, LeSLI, and PraSLI. In A. Gavarrò & F. M. João (Eds.), *Language acquisition and development* (pp. 205-217). Newcastle: Cambridge Scholars Press.

Friedmann, N., Olenik, D., & Gil, M. (2000). From theory to practice: treatment of agrammatic production in Hebrew based on the Tree Pruning Hypothesis. *Journal of Neurolinguistics, 13,* 250-254.

Friedmann, N., Szterman, R., & Haddad-Hanna, M. (2010). The comprehension of relative clauses and Wh questions in Hebrew and Palestinian Arabic hearing impairment. Proceedings of GALA 2009.

Friedmann, N., Yachini, M., & Szterman, R. (2015). Relatively easy relatives: Children with syntactic SLI avoid intervention. In E. Di Domenico, C. Hamann & S. Matteini (Eds.), *Linguistik Aktuell/Linguistics Today*, Vol. 223 (pp. 303-320). Amsterdam, Netherlands: John Benjamins Publishing Company.

Friedmann, N., Rizzi, L., & Belletti, A. (2017). No case for Case in locality: Case does not help interpretation when intervention blocks A-bar chains. *Glossa: A Journal of General Linguistics, 2(1),* 33.

Garraffa, M. (2007). *Impoverishment of grammatical features in a non-fluent aphasic speaker: The grammatical nature of minimal structures*. Doctoral Dissertation. University of Siena, Siena, Italy.

Garraffa, M. (2008). Minimal structures in aphasia: A study on agreement and movement in a non-fluent aphasic speaker. *Lingua*, *119(10),* 1444-1457.

Garraffa, M., & Grillo, N. (2008). Canonicity effects as grammatical phenomena. *Journal of Neurolinguistics, 21,* 177-197.

Garraffa, M. & Learmonth, G. (2013) Sentence Comprehension and Memory Load in Aphasia: The Role of Resource Reduction. *Procedia - Social and Behavioral Sciences, 94,* 143-144.

Goodglass, H., & Berko, J. (1960). Agrammatism and inflectional morphology in English. *Journal of Speech and Hearing Research*, 257-267.

Gordon, P. C., Hendrick, R., & Johnson, M. (2001). Memory interference during language processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27,* 1411-1423.

Gordon, P. C., Hendrick, R., & Johnson, M. (2004). Effects of noun phrase type on sentence complexity. *Journal of Memory and Language, 51,* 97-114.

Grillo, N. (2005). Minimality effects in agrammatic comprehension. ConSOLE XIII, 107-120.

Grillo, N. (2008). *Generalized minimality: syntactic underspecification in Broca's aphasia*. Doctoral dissertation. Utrecht University, Utrecht, The Netherlands. LOT.

Grodzinsky, Y. (1990). *Theoretical perspectives on language deficits*. MIT Press.

Grossman, M., Kalmanson, J., Bernhardt, N., Morris, J., Stern, M. B., & Hurtig, H. I. (2000). Cognitive Resource Limitations during Sentence Comprehension in Parkinson's Disease. *Brain and Language, 73,* 1-16.

Guasti, M. T., Branchini, C., & Arosio, F. (2009). Agreement in the production of Italian subject and object wh-questions. XXXV Incontro di Grammatica Generativa.

Guasti, M. T., Branchini, C., & Arosio, F. (2012). Interference in the production of Italian subject and object wh-questions. *Applied Psycholinguistics, 33,* 185–223.

Guasti, M. T., & Cardinaletti, A. (2003). Relative clause formation in Romance child production. *Probus*, *15,* 47-89.

Guasti, M. T., Papagno, C., Vernice, M., Cecchetto, C., Giuliani, A., & Burdo, S. (2012). The effect of language structure on linguistic strengths and weaknesses in children with cochlear implants: Evidence from Italian. *Applied Psycholinguistics,* 1-26.

Guasti, M. T., & Rizzi, L. (2002). Agreement and tense as distinctive syntactic positions. Evidence from acquisition. In G. Cinque (Ed.), *Functional Structure in DP and IP: The Cartography of Syntactic Structures, Vol. 1* (pp. 167-194). New York: Oxford University Press.

Hagiwara, H. (1995). The breakdown of functional categories and the economy of derivation. *Brain and Language, 50*, 92-116.

Hakes, D. T., Evans, J. S., & Brannon, L. L. (1976). Understanding sentences with relative clauses. *Memory & Cognition, 4,* 283-290.

Hickok, G., & Avrutin, S. (1996). Comprehension of Wh-Questions in Two Broca's Aphasics. *Brain and Language, 52*, 314-327.

Hickok, G., Zurif, E., & Canseco-Gonzalez, E. (1993) Structural description of agrammatic comprehension. *Brain and Language, 45,* 371–395.

Howard, D., & Gatehouse, C. (2006). Distinguishing semantic and lexical word retrieval deficits in people with aphasia. *Aphasiology, 20,* 921-950.

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 98*, 122–149.

King, J., & Just, M. A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language, 30,* 580-602.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22,* 1-75.

Lin, C.-J. C., & Bever, T. (2006, 2006). Chinese is no exception: universal subject preference of relative clause processing. Proceedings of the 25th West Coast Conference on Formal Linguistics.

Luzzatti C., Willmes K., & De Bleser R. (1996). *Aachener Aphasie Test (AAT). Versione Italiana*, Firenze, Italia: Organizzazioni Speciali.

Martini, K. (2015) *Effetti di località e complessità grammaticale nel comportamento linguistico di un parlante Italiano afasico*. MA Thesis. University of Siena, Siena, Italy.

Martini, K., Belletti, A., Contemori, C., & Rizzi, L. (2018). On the role of lexical restriction and intervention in production: A new angle on the subject-object relatives asymmetry, Proceedings of the 1st SynCart Workshop "From maps to principles". Special Issue of *Generative Grammar in Geneva, 11*.

Miceli, G., Silveri, M. C., Villata, G., & Caramazza, A. (1984). On the basis for the agrammatic's difficulty in producing main verbs. *Cortex*, *20*, 207-220.

Miceli, G., Laudanna, A., Burani, C., & Capasso, R. (1994). *Batteria per l'Analisi dei Deficit Afasici. B.A.D.A.* Roma, Italia: CEPSAG.

Nickels, L. (1995). Getting it right – Using aphasic naming errors to evaluate theoretical models of spoken word recognition. *Language and Cognitive Processes*, *10,* 13-45.

Novogrodsky, R., & Friedmann, N. (2006). The production of relative clauses in syntactic SLI: A window to the nature of the impairment. *Advances in Speech Language Pathology*, *8,* 364-375.

Riches, N. G., & Garraffa, M. (2017) A discourse account of intervention phenomena: An investigation of interrogatives. *Glossa 2(1):*74.

Rizzi, L. (1990). *Relativized Minimality*. Cambridge, MA, USA: MIT Press.

Rizzi, L. (2004). *The structure of CP and IP*. Oxford/New York: Oxford University Press.

Rizzi, L. (2013). Locality. *Lingua*, *130,* 169-186.

Rizzi, L. (2018). Intervention effects in grammar and language acquisition. *Probus, 30(2),* 339-367.

Ruigendijk, E. (2002) *Case assignment in agrammatism: A cross-linguistic study*. Doctoral dissertation. Groningen University, Groningen, The Netherlands.

Ruigendijk, E., & Bastiaanse, R. V. Z. R. (1999). Case assignment in agrammatism. *Journal of Speech, Language and Hearing Research, 42,* 962-971.

Salis, C., & Saddy, D. J. (2011). Comprehension of wh-questions in a case of mixed dementia. *Journal of Neurolinguistics, 24,* 156-162.

Schaeffer, J. (2000). *The Acquisition of Direct Object Scrambling and Clitic Placement*. Amsterdam/Philadelphia: John Benjamins.

Schwartz, M. F., Saffran, E. M., & Marin, O. S. M. (1980). The word order problem in agrammatism. *Brain and Language, 10,* 249-262.

Sheppard, S. M., Walenski, M., Love, T., & Shapiro, L. P. (2015). The auditory comprehension of wh-questions in aphasia: support for the intervener hypothesis. *Journal of Speech, Language and Hearing Research, 58(3),* 781-797.

Starke, M. (2001). *Move Dissolves into Merge*. Doctoral Dissertation. University of Geneva, Geneva, Switzerland.

Terzi, A., & Nanausi, V. (2018). Intervention effects in the relative clauses of agrammatics: The role of gender and case. *Glossa, 3(1):* 17.

Tuller, L., Delage, H., Monjauze, C., Piller, A., & Barthez, M. (2011). Clitic pronoun production as a measure of atypical language development in French. *Lingua, 121,* 423-441.

Vergnaud, J. R. (1974). French relative clauses. Doctoral dissertation. MIT, Cambridge, Mass.

Volpato, F., & Adani, F. (2009). The subject/object relative clause asymmetry in hearing-impaired children: evidence from a comprehension task. In V. Moscati & E. Servidio (Eds.), STiL - Studies in Linguistics, Vol. 3: MIT Working Papers in Linguistics.

Volpato, F., & Vernice, M. (2014). The production of relative clauses by Italian cochlear-implanted and hearing children. *Lingua, 139,* 39-67.

Zingeser, L. B., & Berndt, R. S. (1990). Retrieval of nouns and verbs in agrammatism and anomia. *Brain and Language 39 (1),* 14-32.

Zurif, E. B., Swinney, D., Prather, P., Solomon, J., & Bushell, C. (1993). An on-line analysis of syntactic processing in Broca's and Wernike's aphasia. *Brain and Language, 45,* 448-456.

APPENDIX

Example of experimental item and picture pair testing the comprehension of SRs with number mismatch, ORs with number mismatch, and ORs with post-verbal subject.

SR number mismacth: Mostrami i gatti che stanno tirando il coniglio.

'Show me the cats that are pulling the rabbit'

OR number mismatch: Mostrami i gatti che il coniglio sta tirando.

'Show me the cats that the rabbit is pulling'

OR post-verbal subject: Mostrami il coniglio che stanno tirando i gatti.

Show me the rabbit that are pulling the cats

'Show me the rabbit that the cats are pulling'

[Figure A1 here]

Example of experimental item and picture pair testing the comprehension of PORs.

POR: Mostrami la bambina che è/viene spinta dal gatto.

'Show me the girl that is/get pushed by the cat'

[Figure A2 here]

Example of experimental item and picture pair testing the comprehension of Who-SQs and Who-OQs.

Who-SQ: Chi sta ritraendo gli elefanti?

'Who is drawing the elephants?'

Who-OQ: Chi stanno ritraendo gli elefanti?

Who are drawing the elephants

'Who are the elephants drawing?'

[Figure A3 here]

Example of experimental item and pictures testing the production of Which-OQs.

Experimenter: Guarda! In questa immagine ci sono due gatti grigi, due gatti bianchi e un elefante. L'elefante sta bagnando due gatti. Lui sai quali. Chiedigli quali!

'Look! In this picture there are two grey cats, two white cats and an elephant. The elephant is wetting two cats. He knows which. Ask him which!'

Target Which-OQ: Quali gatti sta bagnando l'elefante?

Which cats is wetting the elephant

'Which cats is the elephant wetting?'

[Figure A4 here] [Figure A5 here]

Table 1. Language performance in both adult speakers and developing and impaired speakers in different featural set specifications (based on Friedmann et al., 2009 and Belletti et al., 2012).

		X Z Y	ADULT SPEAKERS	DEVELOPING AND IMPAIRED SPEAKERS
A	**Identity**	A… A… A	✗	✗
B	**Inclusion**	A,B… A… A,B	✓	✗
C	**Intersection**	A,B… A,C…A,B	✓	✓
D	**Disjunction**	A… B… A…	✓	✓

Table 2. PWA's demographic, medical and language profile details. Language Assessment tests are: BADA (Batteria per l'Analisi dei Deficit Afasici, Miceli et al., 1994) and AAT (Aachener Aphasie Test, Luzzatti et al., 1996).

PWA	F.G.		
Sex	Male		
Age	66		
Education	Eight years		
Lesion	Left TPO		
Post on set	Four months		
BADA	**Correct responses**	**% correct**	
Object naming	21/30	70%	
Action naming	18/28	64%	
Visual word comprehension	38/40	95%	
Auditory word comprehension	36/40	90%	
Non-word repetition	33/35	94%	
Phoneme discrimination	58/60	97%	
Auditory lexical decision	78/80	97%	
AAT	**Correct responses**	**Standard-nine Scores**	**Deficit**
Naming	72/120	5	Moderate
Token test	12	7	Mild
Repetition	128/150	6	Mild
Sentence Comprehension	44/60	6	Mild
Word Comprehension	58/60	9	None
Writing	85/90	9	None

Table 3. List of the morphosyntactic domains investigated in F.G.*

MODALITY	DOMAIN
PRODUCTION	Verb tense, Auxiliaries, Third person reflexive clitic, Third person object clitic, Third person object clitic-Past Participle Agreement, Relative clauses, Wh-questions.
COMPREHENSION	Agreement Determiner-Noun, Agreement Determiner-Adjective-Noun, Verb tense, S-V and V-S agreement, S-V and V-S Past participle agreement, Third person object clitic-Past Participle Agreement, Active sentences, Passive sentences, Relative clauses, Wh-questions.

* For more details on methodology and results see Table 4 of this paper and Martini (2015).

Table 4. Percentage of correct responses in F.G. morphosyntax.*

DOMAIN	% CORRECT (RAW DATA)
	F.G.
Agreement Determiner-Noun	
Forced choice task	100% (40/40)
Agreement Determiner-Adjective-Noun	
Forced choice task	95% (19/20)
Verb tense	
Gap filling task	87% (26/30)
Forced choice task	100% (30/30
Auxiliaries	
Gap-filling task	93% (25/27)
S-V agreement	
Forced choice task	100% (14/14)
V-S agreement	
Forced choice task	
with unaccusative verbs	94% (17/18)
with intransitive verbs	94% (17/18)
with clitic left dislocations	50% (7/14)
S-V and V-S Past participle agreement	
Forced choice task	100% (24/24)
Third person reflexive clitic	
Picture description task	100% (6/6)
Third person object clitic	
Picture description task	50% (9/18)
Third person object clitic-Past participle agreement	
Gap-filling task	54% (7/13)
Forced choice task	47% (7/15)
Active sentences	
Sentence-picture matching task	100% (14/14)
Passive sentences	
Sentence-picture matching task	89% (16/18)

* For more details see Martini (2015).

Table 5. Correct responses in the comprehension of RCs.*

	SR match	OR match	SR mismatch	OR mismatch	OR post-verbal	POR
F.G	9/9	0/9 ***	5/6	6/6	0/6 ***	9/9
Controls N=Six (Means)	8.8/9	9/9	6/6	5.8/6	5.6/6	9/9

* SR match = SR number match condition; OR match = OR number match condition; SR mismatch = SR number mismatch condition; OR mismatch = OR number mismatch condition; OR post-verbal = OR post-verbal subject condition; POR = Passive Object Relative condition.

Table 6. Sentences produced in the elicitation of RCs.*

		F.G.	Controls N=Six (Means)
SR match	**Target**	13/15	15/15
	Other	2/15	0/15
OR match	**Target**	0/15	0/15
	POR	6/15 ***	15/15
	SR	9/15	0/15

* In the SR (number) match condition: target = target response, namely the elicited SR; other = unclassifiable response. In the OR (number) match condition: target = target response, namely the elicited OR; POR = correct Passive Object Relative (expected answer in healthy adults, see section 1); SR = incorrect Subject Relative in which the roles of the characters are reversed.

Table 7. Correct responses in the comprehension of Wh-Qs.

	Who SQ	Which SQ	Who OQ	Which OQ
F.G	9/10	9/10	0/10 ***	0/10 *
Controls N=Six (Means)	9.5/10	10/10	9.1/10	8.3/10

Table 8. Sentences produced in the elicitation of Wh-Qs.*

		F.G.	Controls N=Six (Means)
Who SQ	**Target**	5/5	5/5
Which SQ	**Target**	5/5	5/5
Who OQ	**Target**	0/5 ***	5/5
	POQ	5/5	0/5
Which OQ	**Target**	0/5 ***	5/5
	POQ	2/5	0/5
	Which SQ	3/5	0/5

* In the Who SQ condition: target = target response, namely the elicited Who SQ. In the Which SQ condition: target = target response, namely the elicited Which SQ. In the Who OQ condition: target = target response, namely the elicited Who OQ; POQ = correct Passive Object Question. In the Which OQ condition: target = target response, namely the elicited Which OQ; POQ: correct Passive Object Question; Which SQ = incorrect Which Subject Question in which the roles of the characters are reversed.

Fig. 1 Picture pair used for the relative clause context in (15).

Fig. 2 Picture pair used for the wh-question context in (16).

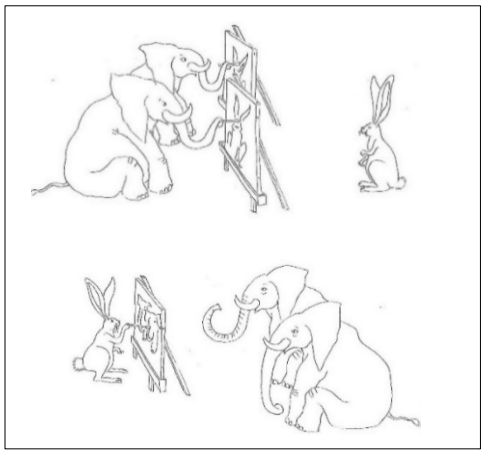

Fig. 3 Picture pair used for the relative clause context in (17).

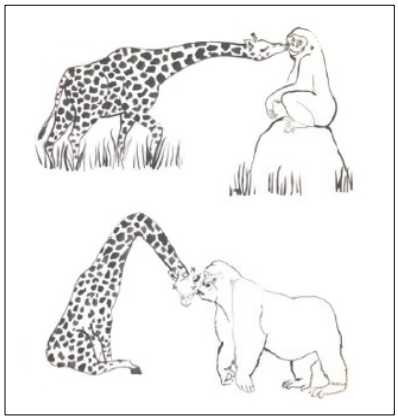

Fig. 4 Picture pair used for the wh-question context in (18).

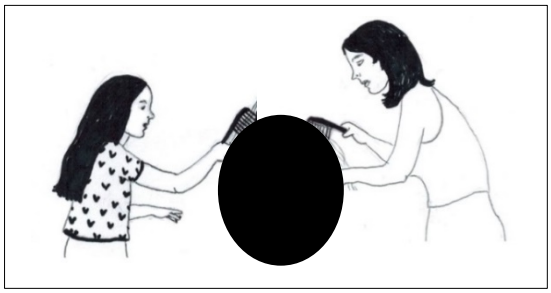

Fig. 5. Picture pair for item (30).

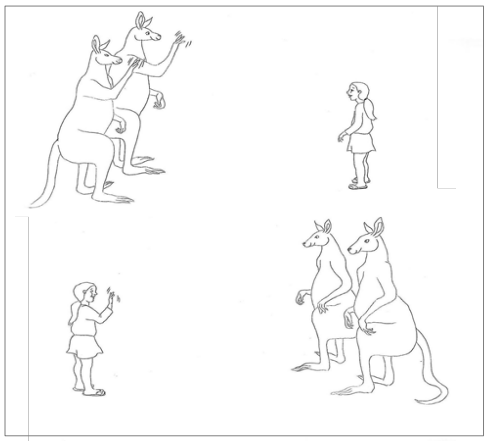

Fig. A1

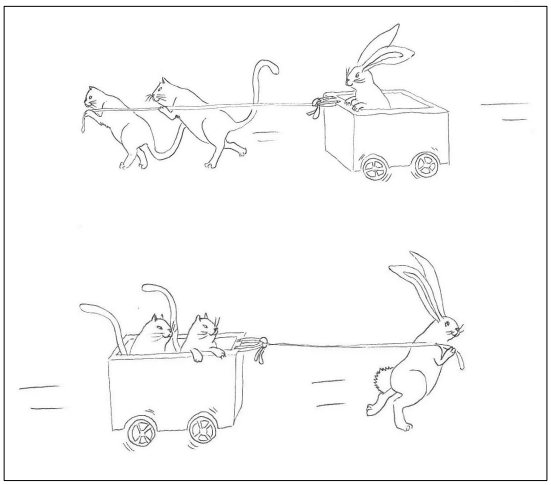

Fig. A2

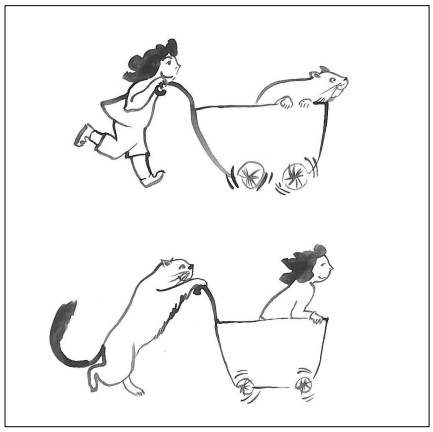

Fig. A3

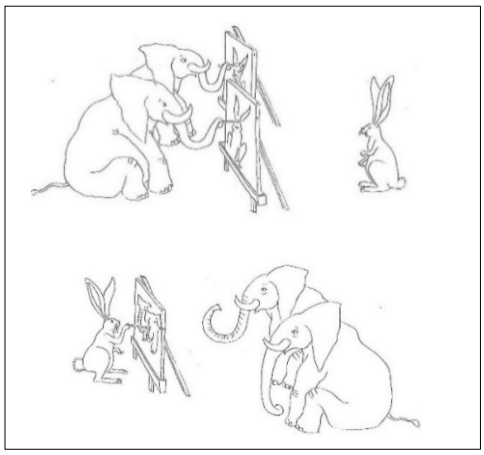

Fig. A4

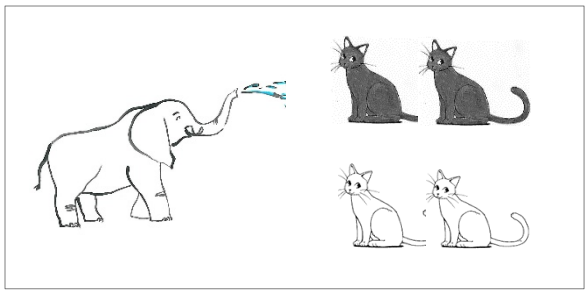
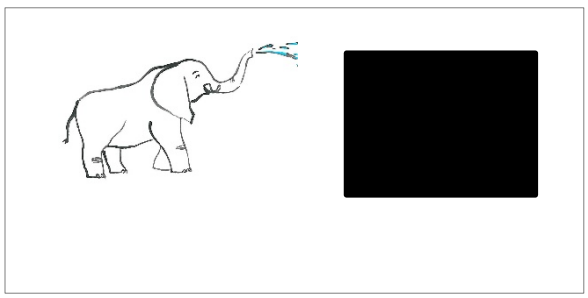
Fig. A5