Linguistic theory and aphasia: An overview.

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Abstract

Background: Aphasia research has been informed by linguistic theory to a great
extent. Conversely, linguistic theory has also been informed by data from people with
aphasia, albeit to a lesser extent.

Aims: This overview to the Special Issue of Aphasiology entitled "Aphasia and
linguistic theory: What we have captured so far" presents a narrative review that aims
to illustrate the contribution of linguistic theory to aphasia research, and of a section
that presents the articles making up the Special Issue. The narrative review, which is
not exhaustive, highlights influential theoretical frameworks and linguistic constructs
that have been central to accounts of language impairment in aphasia.

Main Contribution: The overview illustrates the contribution of linguistic theory to
aphasiology and paves the way for the development of a unified approach to aphasia,
which will incorporate insights not only from theoretical linguistics, but also from
other complementary fields, such as psycholinguistics, cognitive (neuro)psychology,
and neuroscience of language.

Keywords: aphasia, linguistic theory, syntax, generative grammar, usage-based approaches, syntactic movement, derived orders, trace deletion, canonicity, relativised minimality, interpretable vs. uninterpretable features

INTRODUCTION[1]

It has recently been suggested that aphasiology, syntactic theory, and psycholinguistic investigations of language processing in neurologically healthy adults "have generally not moved in tandem" and "findings and theoretical developments in any one of the three often go unnoticed in the others" (Gahl & Menn, 2016, p. 1372). Generally speaking, we endorse this statement. We believe, however, that at least when it comes to syntactic theory—and more broadly, linguistic theory—and aphasiology, they have influenced and informed each other, although it might be argued that this bidirectional relationship is not balanced; it appears that aphasiology has been informed by linguistic theory to a greater extent than the opposite. (Studies illustrating how data from aphasia can inform linguistic theory include Bates & Goodman, 1997; Boye & Bastiaanse, 2018; Grodzinsky, Pierce, & Marakovitz, 1991; among others.)

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[1] List of abbreviations: CP=Complementiser Phrase; DMH=Distributed Morphology Hypothesis; DOP-H=Derived Order Problem Hypothesis; DP=Determiner Phrase; IFIH=Interpretable Features' Impairment Hypothesis; NP=Noun Phrase; OSV=Object-Subject-Verb; OVS=Object-Verb-Subject; PADILIH=Past Discourse Linking Hypothesis; PWA=persons with aphasia; RM=Relativised Minimality; SI=Special Issue; SOV=Subject-Object-Verb; SVO=Subject-Verb-Object; T/INFL=Tense/Inflection; TBI=Traumatic Brain Injury; TDH=Trace Deletion Hypothesis; TPH=Tree Pruning Hypothesis; TUF=Treatment of Underlying Forms; TUH=Tense Underspecification Hypothesis

The aim of the present overview is to illustrate how linguistic theory has informed aphasiology to date. To this end, we provide a non-exhaustive review of influential linguistically informed accounts of language impairment in aphasia (see Druks, 2017, for a more extensive overview). It should be noted that, over the last 35 years, the vast majority of linguistically informed studies on aphasia have been framed within different versions of Generative Grammar, such as the Government and Binding Theory (e.g., Chomsky, 1981) and the Minimalist Program (e.g., Chomsky, 1995a, 2000, 2001). Generative Grammar has provided frameworks, constructs/notions and explanatory tools that have inspired studies on both comprehension and production deficits, and particularly syntactic and morphosyntactic deficits. Some of the "generative grammar constructs" employed in accounts of the observed patterns of performance in aphasia include the notions of *syntactic movement*, *trace*, *chain*, *merge*, *syntactic hierarchy* or *syntactic tree*, *argument structure*, *binding*, *coreference*, and the distinctions between (i) *arguments* and *adjuncts*, (ii) *long* and *short syntactic dependencies*, and (iii) *Logical Form-interpretable features* and *Logical Form-uninterpretable features*, among others. We will return to these terms in the section *Generative Grammar and Aphasia Research*

This overview also functions as an Editorial to the Special Issue (SI), "Aphasia and linguistic theory: What we have captured so far". This SI consists of linguistically informed approaches to aphasia and related disorders, and paves the way for a unifying approach to aphasia, which will incorporate not only different linguistic constructs, approaches or frameworks, but also insights from other complementary fields, such as psycholinguistics, cognitive (neuro)psychology, and neuroscience of language. Ideally, such an approach will lead to a unified theoretical framework integrating knowledge from all the fields above.

We will first review some of the most influential linguistically informed accounts of language impairment in aphasia, and subsequently we will present the papers included in the corresponding SI.

SELECTIVE OVERVIEW OF LINGUISTICALLY INFORMED ACCOUNTS OF LANGUAGE IMPAIRMENT IN APHASIA

In the last 64 years, starting from Jakobson's (1956) investigation of aphasia, many linguistically informed approaches to aphasia have been taken, which aimed at describing and characterizing language impairment in aphasia. In his first theorization, Jakobson proposed that two fundamental operations could be affected in aphasia: the selection of lexical items and the combination of these items in linguistically meaningful units. For example, the meaning of the sentence *She is eating* is computed based on the lexical items selected during a first operation (*she*, not *he*; *eating*, not *eaten*; *is*, not *are*) and, subsequently, based on the relative ordering of these lexical items (*She is eating*; not *She eating is*), which is the second fundamental operation. According to Jakobson's model, selective disorders of these two operations lead to two different types of aphasia: *selection* aphasia and *combination* aphasia. Jakobson's intuition that aphasia can be studied and characterized by making use of insights and concepts/notions from linguistics paved the way for many linguistically informed studies on aphasia.

Generative Grammar and Aphasia Research

Syntactic movement and related constructs in basic research on aphasia

One of the most influential studies on sentence comprehension in aphasia was conducted by Caramazza and Zurif (1976). The authors tested three groups of persons

with aphasia (PWA) (Broca's, Conduction, Wernicke's) with a sentence-picture matching task that included four sentence types: (1) semantically irreversible sentences with center-embedded object-extracted relative clauses (e.g., *The apple that the boy is eating is red*); (2) semantically reversible sentences with center-embedded object-extracted relative clauses (e.g., *The cow that the monkey is scaring is yellow*); (3) implausible sentences with center-embedded object-extracted relative clauses (e.g., *The horse that the girl is kicking is brown*); and (4) control sentences (e.g., *The girl is kicking a green ball*). Note that all object-extracted relative clauses involve *syntactic movement*, a core operation which will be presented and discussed in detail in the remainder of this section. Caramazza and Zurif's most important finding concerned the groups of participants with Broca's and Conduction aphasia. Both groups performed at chance when they had to rely on syntax, that is, on semantically reversible sentences and on implausible sentences. In contrast, they fared near perfectly on sentences where they could rely on semantic information (i.e., semantically irreversible sentences and control sentences). Caramazza and Zurif (1976) interpreted this finding as supporting a neuropsychological dissociation between heuristic and algorithmic processes, which are predominantly based on semantic and syntactic information, respectively. The authors argued that persons with Broca's aphasia and persons with Conduction aphasia are not able to use syntactically-based algorithmic processes. However, they are able to use semantically-based heuristic processes in order "to assign a semantic interpretation to, at best, an incompletely represented syntactic organization" (Caramazza & Zurif, 1976, p. 581). These heuristic procedures are primarily based upon "the semantic plausibility of the arrangement of lexical items [...] and upon a sequential regularity

whereby noun-verb surface arrangements can be mapped as actor-action relations" (op. cit.).

Grodzinsky (1986, 1990, 1995) drew on generative grammar and employed syntactic constructs such as *trace*, *syntactic movement*, and *chain*, to propose one of the most influential accounts of the "asyntactic comprehension" observed in agrammatic aphasia: the *Trace Deletion Hypothesis* (TDH). This hypothesis is a theoretically motivated account of the agrammatic comprehension deficit affecting semantically reversible *non-canonical* sentences, that is, sentences in which the theme precedes the agent, as in the English passive sentence *The boy was kissed by the girl*. As per generative grammar (e.g., Chomsky, 1981, 1993; Pollock, 1989), which provided the framework for the formulation of the TDH, non-canonical sentences such as *The boy was kissed by the girl* are derived from canonical sentences such as *The girl kissed the boy* through the syntactic movement of a determiner phrase (DP) (noun phrase/NP in older terminology), *the boy*, from its theme position (the post-verbal position in which this DP was assigned the theme role) to the preverbal position. This syntactic operation (*movement*) was postulated to create/leave a trace at the extraction site (the original object position). This trace and the element in the new fronted position, the trace *antecedent*, are co-indexed, forming a *chain* (*The boy$_i$ was kissed __$_i$ by the girl*). According to the TDH, however, in persons with agrammatic aphasia, the trace left by the syntactic movement of DPs like *the boy* in the example above is deleted from the syntactic representation of the sentence. This deletion results in the disruption of the connection ("chain") between the trace and the moved phrase and, therefore, in a deficient representation. As a result, persons with agrammatic aphasia are unable to use syntactic means in order to assign thematic roles to DPs that have been moved from their original position. To overcome this

problem, persons with agrammatic aphasia resort to a heuristic process, whereby they assign the agent role to the linearly first DP of the sentence (NP1=Agent). Therefore, when agrammatic speakers process semantically reversible passive sentences with an overt by-phrase such as *The boy was kissed by the girl*, they assign the agent role to the DP *the boy.* However, they also assign the same thematic role (i.e. agent) to the linearly second DP (i.e. *the girl*). This is so because, in by-phrases, it is the preposition *by* that assigns the agent role to the DP that it governs, and, according to the TDH, theta role assignment by prepositions is not impaired in agrammatic aphasia. Hence, when processing reversible passive sentences containing an overt by-phrase, agrammatic speakers build up syntactic representations with two agents and, as a result, they have chance performance on this sentence type (for detailed discussions of the concept of chance performance, see Burchert, Hanne, & Vasishth, 2013; Drai & Grodzinsky, 2006; and Hanne, Sekerina, Vasishth, Burchert, & De Bleser, 2011).

A different interpretation of *asyntactic comprehension* was proposed by Schwartz, Linebarger, Saffran, and Pate (1987), who argued that persons with agrammatic aphasia have a *mapping deficit*. According to the *Mapping Hypothesis*, asyntactic comprehension stems not from failure of persons with agrammatic aphasia to perform syntactic analysis, that is, to parse sentences, but from their difficulty mapping thematic roles onto the parsed constituents. The authors argued that mapping thematic roles onto parsed constituents/NPs involves the transmission of thematic roles from theta positions (i.e. syntactic positions to which thematic roles are assigned; e.g., Chomsky, 1981) to the NPs occupying these positions or to the NPs that have moved out of these positions. Canonical sentences (e.g., active declarative sentences) involve transmission of thematic roles from theta positions to the NPs

occupying these positions. This process is called *direct* transmission. Noncanonical sentences (e.g., passive sentences, sentences including object-extracted relative clauses) involve transmission of thematic roles from theta positions to NPs that have moved out of these positions. This process is called *indirect transmission*. Schwartz et al. (1987) considered thematic role transmission to be a post-parsing operation, which is compromised in PWA showing asyntactic comprehension. The authors also argued that indirect transmission of thematic roles is more demanding than direct transmission. As a result, persons with mild agrammatic aphasia have difficulty only with indirect transmission of thematic roles, whereas persons with more severe agrammatic aphasia have difficulty with both indirect and direct transmission of thematic roles. It should be noted that the Mapping Hypothesis also had clinical implications, as it inspired "mapping therapy" treatment programs for nonfluent aphasia directly targeting either comprehension impairments (e.g., Byng, 1988; Byng, Nickels, & Black, 1994; Schwartz, Saffran, Fink, Myers, & Martin, 1994) or production impairments (e.g., Rochon, Laird, Bose, & Scofield, 2005). (For a review of mapping therapy studies, where the contribution that the Mapping Hypothesis made to aphasia therapy is also discussed, see Marshall, 1995.)

The notion of syntactic movement has also been central to the *Derived Order Problem Hypothesis* (DOP-H), put forward by Bastiaanse and van Zonneveld (2005, 2006) and Bastiaanse, Koekkoek and van Zonneveld (2003), to account for patterns of performance exhibited by persons with Broca's aphasia on tasks tapping into both sentence production and sentence comprehension. Derived orders are orders that result from *any* kind of syntactic movement, that is, both verb movement and movement of maximal projections (e.g., DPs, verb phrases or prepositional phrases). The DOP-H posits that, in Broca's aphasia, movement-derived structures are harder to

produce and comprehend than structures with canonical order where no transformations have been applied.[2] Importantly, according to the DOP-H, the relative difficulty associated with derived orders does not stem from a representational deficit, but from the fact that any syntactic movement is computationally costly for people with aphasia. In other words, the DOP-H is a processing account. In contrast, the TDH was developed as a representational account, as it stated that it was the knowledge about specific parts of grammar that was impaired in agrammatic aphasia (Grodzinsky, 1986, 1990, 1995). The debate on the nature of the deficit in agrammatic aphasia will not be covered here. The reader is referred to Druks' (2017) comprehensive review.

The construct of syntactic movement and related constructs such as *chain*, *specifier* and *head* positions of *Complementiser Phrase* (CP), as well as the distinction between *arguments* and *adjuncts*, have also been central to studies that investigated the ability of PWA to produce and/or comprehend different types of questions (e.g., *wh-questions* vs. *yes/no questions*; *argument questions* vs. *adjunct questions*; *subject questions* vs. *object questions*; *wh-questions* vs. *wh-NP questions*).

For example, wh-questions are classified into argument or adjunct questions depending on whether the moved element is an argument or an adjunct. Argument questions involve movement of an argument to the specifier position of a CP (e.g. *What$_i$ did you eat ___$_i$ yesterday?*), and adjunct questions involve movement of an adjunct to the same position (e.g., *Where$_j$ did you eat ___$_j$?*). Note that, according to generative grammar (Chomsky, 1991, 1993), arguments are strictly selected by verbs, but adjuncts are not. Relatedly, arguments and adjuncts are generated in different

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[2] Note that, unlike DOP-H, the TDH (Grodzinsky, 1986, 1990, 1995) predicts only sentences with movement of maximal projections to be affected.

positions. While the internal argument (grammatical object) is at the same height/level in the syntactic hierarchy as the verb (as they occupy sister nodes), adjuncts are located either at a higher or at a lower position than the verb. Studies on production of argument and adjunct questions in agrammatic aphasia have shown that either question type can be impaired selectively. For example, three French-speaking agrammatic individuals reported in Van der Meulen, Bastiaanse and Rooryck (2005), a Greek-speaking agrammatic individual (GL) reported by Fyndanis, Varlokosta and Tsapkini (2010), and an English-speaking agrammatic individual (agrammatic participant 5) reported by Thompson, Shapiro, Tait, Jacobs, and Schneider (1996) (see baseline data) fared better on the production of argument questions as compared to the production of adjunct questions. In contrast, Friedmann's (2002) Hebrew-speaking and Palestinian Arabic-speaking agrammatic participants exhibited the opposite pattern. As suggested by Fyndanis et al. (2010), the afore-mentioned double dissociation between argument and adjunct questions is consistent with the idea that these two question types are supported by functionally distinct processing mechanisms, and also lends independent empirical support to the theoretical distinction between arguments and adjuncts, which also reflects the theoretical distinction between argument questions and adjunct questions.

Another linguistic concept adopted in studies on interrogative sentences in aphasia is related to the structural distinction between wh-questions (e.g., *What did you eat yesterday?*) and yes/no-questions (e.g., *Did you like your pizza?*). Friedmann (2002) examined both question types on a group of Hebrew-speaking, Palestinian Arabic-speaking and English-speaking individuals with agrammatic aphasia. Her Hebrew- and Arabic-speaking agrammatic participants exhibited an asymmetric pattern, as they performed significantly better on the production of yes-no questions

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than on the production of wh-questions. Friedmann's English-speaking agrammatic participant, however, was unable to produce either question type. Friedmann noted that, just like her English-speaking agrammatic participant, most English-speaking individuals with agrammatic aphasia reported in the literature performed comparably poorly on the production of these two sentence types. Friedmann (2002) accounted for both the dissociation between wh-questions and yes/no-questions exhibited by her Hebrew-speaking and Palestinian Arabic-speaking agrammatic participants and the lack of dissociation (and general poor performance) shown by English-speaking agrammatic individuals by reference to the *Tree Pruning Hypothesis* (TPH) (Friedmann & Grodzinsky, 1997), according to which the highest nodes of the syntactic tree, which are involved in wh-questions in Hebrew, Arabic, and English and in yes/no questions in English, are impaired in agrammatic aphasia. (For more details about the TPH, see section *Syntactic hierarchy and Merge in aphasia research*).

Following up on Friedmann's (2002) study, Burchert, Swoboda-Moll, and de Bleser (2005) investigated the ability of German-speaking individuals with agrammatic aphasia to produce wh-questions and yes/no-questions, and reported a double dissociation. They accounted for this pattern drawing on the generative grammar framework. Burchert et al. (2005) adopted two theoretical assumptions: (1) CPs include an operator position (Spec, CP), which hosts an operator in both wh-questions and yes/no-questions; and (2) wh-questions and yes/no-questions differ in terms of operator movement: while the former involve such a movement (an operator moves from its base-generated position to the specifier position of the CP), the latter do not, as an empty operator is directly generated at the specifier position of the CP. Based on the assumptions above, Burchert et al. (2005) put forward the Operator

Movement Hypothesis and the Empty Category Deletion Hypothesis. The Operator Movement Hypothesis posits that some persons with agrammatic aphasia have difficulty moving the operator, which gives rise to a deficit in wh-questions. The Empty Category Deletion Hypothesis, which is a generalization of the TDH (Grodzinsky, 1995), states that some agrammatic individuals have problems with all empty elements of the grammar. These individuals, thus, have problems with empty operators as well and are, therefore, expected to fare poorly on yes/no-questions.

A last distinction that we will briefly cover here is the distinction between which-NP-questions (e.g., *Which girl chased the boy?*) and who-questions (e.g., *Who chased the boy?*). Both question types are argument questions. It has been argued that which-NP-questions are Discourse-linked questions, whereas who-questions are not (for more details, see Avrutin, 2000, and Pesetsky, 1987). The two question types also differ syntactically, as which-NP-questions involve referential chains, whereas who-questions involve non-referential chains. (Which-NP-questions' chains are referential because they contain a restrictor NP. No restrictor NPs are included in wh-questions.) Furthermore, under Cinque's (1990) analysis, which-NP-questions involve "binding" chains, whereas who-questions involve antecedent "government" chains, which are coreferential chains. While "binding" chains can be established over long structural distances, antecedent "government" chains are subject to locality restrictions (Hickok & Avrutin, 1996). Hickok and Avrutin (1996) tested the ability of two English-speaking individuals with agrammatic aphasia to comprehend subject-extracted and object-extracted who-questions and which-NP-questions (e.g., *Who chased the elephant? Which cat chased the dog? Who did the horse chase? Which cat did the dog follow?*). An asymmetry emerged between subject-extracted wh-NP-questions (above chance performance) and object-extracted wh-NP-questions (chance performance).

Agrammatic participants were significantly more impaired in object-extracted wh-NP-questions. On the other hand, there was no dissociation within who-questions, as agrammatic participants performed above chance on both subject and object questions. Hickok and Avrutin (1996) drew on relevant theoretical distinctions made within the generative grammar framework in order to account for this pattern of performance. In particular, they adopted the assumption that who-questions and wh-NP-questions involve antecedent "government" chains and "binding" chains, respectively, and interpreted their results as suggesting that, in agrammatic comprehension, only binding chains are affected. Furthermore, they accounted for the observed preponderance of antecedent "government" chains over "binding" chains by suggesting that these two chain types are supported by two distinct processing mechanisms, which can be impaired independently, and that antecedent "government" chains are computationally less demanding than "binding" chains. It should be noted that, in light of new theoretical developments within the generative grammar tradition, Hickok and Avrutin (1995) revised their original account outlined above.

Syntactic movement and related constructs in clinical research on aphasia
Importantly, the same framework and theoretical constructs such as *syntactic movement*, *traces*, *argument structure*, and *thematic roles*, as well as theoretical distinctions such as *wh-movement* (A´ movement) vs. *NP-movement* (A movement) and *canonical* vs. *non-canonical* sentences inspired an influential linguistically-based intervention approach to agrammatic aphasia: *Treatment of Underlying Forms* (TUF) (Thompson & Shapiro, 2005). The TUF focuses on syntactically complex structures such as sentences with reversible object-extracted (i.e. non-canonical) relative clauses (e.g., *The man saw the artist who the thief chased*) rather than on simple (canonical)

sentences (e.g., *The man saw the artist*). Several studies by Thompson and colleagues (e.g., Ballard & Thompson, 1999; Thompson, Ballard, &Shapiro, 1998; Thompson, Shapiro, Kiran, & Sobecks, 2003; Thompson, Shapiro, & Roberts, 1993) reported evidence that training structurally complex sentences results in greater generalisation to untrained (but structurally/linguistically related) sentences as compared with training less complex sentences. To explain these findings, Thompson et al. (2003) proposed the *Complexity Account of Treatment Efficacy*, which posits that training structurally complex sentences results in generalisation to less complex sentences only "when untreated structures encompass processes relevant to (i.e., are in a subset relation to) treated ones" (Thompson et al., 2003, p. 602). For example, training very complex sentences such as *The man saw the artist who the thief chased* (i.e. a two-proposition sentence with an object-extracted relative clause) results in generalisation to untreated structurally related less complex sentences such as *It was the artist who the thief chased* (object cleft sentence) and *Who did the thief chase?* (object wh-question). What the three sentences above have in common is that they involve wh-movement (and in particular, who-movement, that is, movement of arguments, not movement of adjuncts) and object extraction. However, they differ in complexity. Sentences with object-extracted relative clauses are more complex than object cleft sentences, because they involve not only wh-movement, but also NP-movement, which occurs in their matrix clause (for details, see Thompson & Shapiro, 2005). In contrast, object cleft sentences involve wh-movement only. Also, sentences with object-extracted relative clauses and object cleft sentences are structurally more complex than object questions because the first two sentence types consist of two propositions, whereas the latter sentence consists of one proposition only. Given the difference above, and since the syntactic process (i.e. wh-movement) taking place in

matrix object questions is identical to the syntactic process occurring in the relative clauses of the two more complex sentences described above, it is clear that the syntactic structure of matrix object questions is a subset of the syntactic structure of sentences with object-extracted relative clauses and object cleft sentences (again, for more details see Thompson & Shapiro, 2005).

Syntactic hierarchy and Merge in aphasia research

Inspired by Pollock's (1989) split inflection hypothesis and Chomsky's (1993) checking theory within the minimalist program, Friedmann and Grodzinsky (1997) put forward the TPH. This hypothesis states that agrammatic aphasia usually arises from a pruning of the syntactic tree at the Tense node, which renders tense and all nodes above (e.g., CP) inaccessible while preserving all materials below (e.g., Agreement Phrase).

Framed within the minimalist program (e.g., Chomsky, 1993, 1995b), Hagiwara (1995) argued that the higher in the syntactic hierarchy a functional category, the more likely it is to be impaired. This is so because the higher the projection of a functional category, the more the times that the operation *Merge*[3] has to be implemented. Hence, the higher in the syntactic hierarchy a functional category, the costlier it is computationally. Since persons with agrammatic aphasia have reduced processing resources (e.g., Caplan & Hildebrandt, 1988), they have difficulty producing or comprehending costly functional categories.

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[3] *Merge* is a "class of highly constrained structure-building operations", which create "phrasal nodes (NP = noun phrase, VP = verb phrase, PP = prepositional phrase) out of merged categories (DETerminer, Noun, Verb, Preposition), which are in turn merged into a 'root', sentence node" (Grodzinsky & Friederici, 2006, p. 242).

The distinction between interpretable and uninterpretable features in aphasia research

Based on the pattern of performance of a group of German-speaking persons with agrammatic aphasia, Wenzlaff and Clahsen (2004, 2005) put forward the *Tense Underspecification Hypothesis* (TUH). This hypothesis was framed within the minimalist program (Chomsky, 1995a; 2000), which posits that the Tense/Inflection (T/INFL) node bears interpretable Tense and Mood features and uninterpretable Agreement (person and number) features.[4] The TUH focuses on the features hosted in the T/INFL node, and states that, while the Agreement and Mood features are well preserved, the Tense feature is underspecified in agrammatic aphasia. Hence, persons with agrammatic aphasia are (expected to be) more impaired in Tense than in Mood and Agreement, in both production and comprehension. This pattern of performance has been reported not only in German (Wenzlaff & Clahsen, 2004, 2005), but also in English (Clahsen & Ali, 2009) agrammatic aphasia. The pattern predicted by the TUH partly rests on the assumption that the Mood distinction between *realis* (indicative) and *irrealis* (subjunctive) is primary and the tense distinction between *past* and *non-*

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[4] Interpretable features are relevant for semantic interpretation, whereas uninterpretable features are not. For instance, in sentences like *Everyday John drinks a beer*, the person and number features of the subject (*John*) are copied from the subject to the verb (*drinks*). The marking of these features on the verb is uninterpretable because it is "redundant" and, therefore, does not contribute to the interpretation of the sentence. In contrast, in sentences like *I went to the movies*, the tense feature +PAST that the verb (*went*) bears is interpretable, as it clearly contributes to the interpretation of the sentence (i.e. the action "going to the movies" took place before the speaking time).

past is secondary. It is clear that, unlike the TPH (Fredmann & Grodzinsky, 1997) or

Hagiwara's (1995) account, the TUH (Wenzlaff & Clahsen, 2004, 2005) attributes

agrammatic speakers' Tense deficits to morphosyntactic processes, not to impaired

projection of the syntactic hierarchy. Importantly, the selective impairment within the

T/INFL node does not directly affect other structural layers, such as that of the CP

(Wenzlaff & Clahsen, 2005). Therefore, the TUH does not rule out the possibility that

persons with agrammatic aphasia may be impaired not only in Tense but also in

(morpho)syntactic categories or structures associated with nodes located higher or

lower than the T/INFL node.

The minimalist distinction between interpretable and uninterpretable features

(Chomsky, 1995a, 2000, 2001) has also been exploited by Fyndanis, Varlokosta, and

Tsapkini (2012), Varlokosta, Valeonti, Kakavoulia, Lazaridou, Economou, and

Protopapas (2006), and Nanousi, Masterson, Druks, and Atkinson (2006). The authors

above proposed the *Interpretable Features' Impairment Hypothesis* (IFIH) to account

for the pattern of performance exhibited by Greek-speaking persons with agrammatic

aphasia (i.e. Aspect/Tense < Agreement, or Aspect < Tense < Agreement). Fyndanis

et al. (2012) argued that categories bearing interpretable features (e.g., Time

Reference/Tense, Aspect, Polarity) are more demanding in terms of processing

resources than categories bearing uninterpretable features (e.g., subject-verb

Agreement), because the former involve processing and integration of information

from two levels of representation (grammatical and extralinguistic/conceptual),[5]

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[5] For example, "interpretable categories" such as Tense require relating the speaking

time to the event time (processing of extralinguistic information), encoding an

abstract prephonological tense/time reference value such as +PAST (processing of

grammatical knowledge), and retrieving the corresponding verb form (e.g., *walked*) or

whereas the latter do not involve integration processes and only require implementation of grammatical knowledge.[6] The view that integration processes are demanding in terms of processing resources (and, thus, challenging for persons with agrammatic aphasia) is shared (explicitly or implicitly) by several scholars (e.g., Avrutin, 2000; Bastiaanse et al., 2011; Hartsuiker et al., 1999; Kok et al., 2007; Yarbay Duman & Bastiaanse, 2009). Although the IFIH gained further empirical support by a recent study on Greek aphasia and healthy aging (Fyndanis, Arcara, Christidou, & Caplan, 2018), Fyndanis, Arfani, Varlokosta, Burgio, Maculan, Miceli et al. (2018), based on cross-linguistic data from Alzheimer's disease, revised the IFIH suggesting that "morphosyntactic categories that involve integration processes are harder to process than those that do not, unless they are instantiated through free-standing morphemes" (p. 22).

Relativised Minimality and aphasia research

Another "generative grammar account" of language impairment in agrammatism was proposed by Grillo (2008). In particular, this account was based on the Relativised

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the corresponding inflectional morpheme (i.e. *-ed*) (processing of grammatical knowledge).

[6] Note that Fyndanis et al.'s (2012), Varlokosta et al.'s (2006) and Nanousi et al.'s (2006) studies adopted the view that, in both null-subject and non null-subject languages (e.g., Greek and English, respectively), subject-verb Agreement is a local feature copying operation from the grammatical subject to the verb (e.g., Chomsky, 1995, 2000, 2001; Spyropoulos & Revithiadou, 2009; but for different views, see Alexiadou & Anagnostopoulou, 1998; Philippaki-Warburton, 1987; and Tsimpli & Dimitrakopoulou, 2007).

Minimality (RM) locality theory (Rizzi, 1990, 2004), which offers a new approach to intervention effects. According to RM, the relations between non-adjacent elements in a sentence are established in minimal configurations, that is, in the smallest structural domains in which this relation can be satisfied. In an abstract configuration $X \dots Z \dots Y$, element Y is in a minimal configuration with element X only if the intervening element Z is not a potential candidate for establishing a local/structural relation with Y. For intervening elements Zs to qualify as potential candidates for establishing local relations with Ys, they should be of the same structural type as Xs. Consider for example sentences (1) and (2) (taken from Rizzi, 2004).

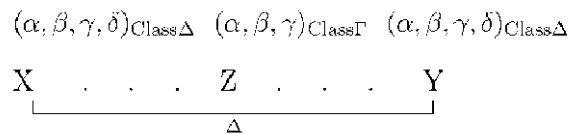(1) **How**$_i$ did you solve the problem ___$_i$?

(2) ****How** do you wonder **who** could solve this problem ___?

In grammatical question (1), a local/structural relation linking the moved element *how* to its trace has been established. The abstract configuration underlying question (1) is $X \dots Y$. This is a minimal configuration, as there is no intervening element Z that could function as a candidate for establishing a local/structural relation with the trace (element Y). In contrast, the abstract configuration underlying question (2) is $X \dots Z \dots Y$, with elements X, Z and Y standing for *how*, *who*, and the trace, respectively. X and Z are of the same structural type, as they are both wh-elements. Thus, not only X but also the intervening element Z is a candidate antecedent of the trace (Y). Hence, the configuration underlying question (2) is not minimal. Because X and Z compete for the same role, *how* fails to form a chain (i.e. a structural/local relationship) with its trace, which renders the question ungrammatical.

More precisely, in configurations $X \ldots Z \ldots Y$, element Y is in a minimal configuration with element X if X and Y are associated with identical sets of morphosyntactic features (e.g., *person*, *number*, *gender*, *case, wh-, focus*), with these feature sets belonging to the same class, and, in addition, if the feature set of the intervening element Z belongs to a different class than that of X and Y (see (3), taken from Grillo, 2009, p. 1432). Therefore, in configurations like that in (3), the intervening element Z is not a potential candidate for establishing a local relation with Y, allowing thus X and Y to establish a local relation.

(3)

$$(\alpha, \beta, \gamma, \delta)_{\text{Class}\Delta} \quad (\alpha, \beta, \gamma)_{\text{Class}\Gamma} \quad (\alpha, \beta, \gamma, \delta)_{\text{Class}\Delta}$$
$$X \quad . \quad . \quad . \quad Z \quad . \quad . \quad . \quad Y$$
$$\underbrace{}_{\Delta}$$

The core idea of Grillo's (2008) approach is that persons with agrammatic aphasia have difficulty processing morphosyntactic information, which in turn compromises the representation of the full array of morphosyntactic features that are normally associated with elements X, Z, and Y in such configurations as (3) above. This feature impoverishment gives rise to minimality effects, as the element Z is not dissimilar from Y and will act as intervener for the relation between *X* and *Y*. For example, in the sentence *This is the boy$_i$ who the girl is pushing <the boy>$_i$*, healthy speakers have no difficulty linking the moved element *the boy* to its trace, because their syntactic parser "sees" that the DPs *the boy* and *the girl* are not associated with identical sets of features (see (4)).

(4)   [NP,Sing,Accusative,wh-]**Q**   [NP,Sing,Nominative]**A**   [NP,Sing,Accusative,wh-]**Q**

*This is **the boy**ᵢ*   *who **the girl***   *is pushing **<the boy>**ᵢ*

However, the morphosyntactic parser of persons with agrammatic aphasia is not as efficient as that of healthy speakers, which results in intermittent failures to maintain activation of the full representation of features normally associated with elements such as DPs. Thus, some of the features needed for the computation of structures involving dependencies over possible interveners may be absent. An example of an underrepresented structure is provided in (5).

(5)   [NP, Sing]**A**   [NP, Sing]**A**   [NP, Sing]**A**

*This is **the boy**ᵢ*   *who **the girl***   *is pushing **<the boy>**ᵢ*

In a similar vein, in a study on wh-questions in agrammatism, Garraffa and Grillo (2008) proposed an account of both comprehension and production deficits in aphasia, which postulated that persons with agrammatic aphasia have reduced resources for processing morphosyntactic information, which results in impoverished morphosyntactic representations.

Grillo's (2008) and Garraffa and Grillo's (2008) approach to agrammatic comprehension is consistent with agrammatic speakers' attested worse comprehension of non-canonical sentences (which involve object movement and crossing of the subject DP) than of canonical sentences (which involve subject movement that does not cross any DPs). This is so because canonical and non-canonical sentences differ in the presence vs. absence of a potential intervener between the moved element and its trace. In canonical sentences, no DP intervenes

between the moved subject and its trace, and thus, even if the syntactic representation is impoverished, no minimality effects are expected to emerge. Within the same linguistic framework, minimality effects have been investigated by Terzi and Nanousi (2018) and Varlokosta, Nerantzini, Papadopoulou, Bastiaanse, and Beretta (2014) for Greek, and by Kljajevic and Murasugi (2010) for Croatian.

Distributed Morphology and aphasia research

Thompson, Fix and Gitelman (2002), Dickey, Milman and Thompson (2008), and Wang, Yoshida and Thompson (2014) proposed the *Distributed Morphology Hypothesis* (DMH), which was inspired by the Distributed Morphology framework (e.g., Halle & Marantz, 1993; Harley & Noyer, 1999). As per this framework, the morphological component operates separately from the syntactic component, but the former takes the outputs of the latter (i.e., feature bundles and phrase structures) as input for its computations. According to the DMH, morphological insertion processes are impaired in agrammatic aphasia, which comparably affects all morphosyntactic categories involving inflectional alternations (e.g., Tense (*walk-walked*) and subject-verb Agreement (*walk-walks*) in English).

Linguistic Usage-based Theories and Aphasia Research

In a recent study, Gahl and Menn (2016) reviewed evidence that supports usage-based and probabilistic approaches to linguistic theory and aphasic sentence processing. The focus of their review was on the role of frequency, lexically conditioned predictability, and contextual predictability of linguistic usage in aphasia. The authors argued that investigations "of probabilistic effects at the sentence level in aphasia are essential because of the gradient nature of aphasic communication difficulties" (Gahl

& Menn, 2016, p. 1373). They also claimed that, if future studies on aphasia adopt frameworks provided by usage-based linguistic theories of syntax and semantics such as Construction Grammar (Bencini, 2013; Goldberg & Bencini, 2005; Kapatsinsky, 2014), the scope of the discussion would possibly be broadened "beyond the patterns of 'agrammatic' deficits that have dominated the study of sentence-level deficits in aphasia in the past" (Gahl & Menn, 2016, p. 1373). Lastly, the authors claimed that usage-based approaches to aphasia research have greater relevance to rehabilitation as compared to alternative approaches. This is so because usage-based approaches to aphasia and current trends in rehabilitation, where life participation is of paramount importance (e.g., Elman, 2011), share "(1) a focus on *preserved* abilities in individuals with aphasia and (2) a focus on communicative needs in contexts specific to an individual and to different situations in which communication takes place" (Gahl & Menn, 2016, p. 1373).

A usage-based linguistic theory adopted by several recent studies on aphasia (e.g., Boye & Bastiaanse, 2018; Ishkhanyan, Sahraoui, Harder, Mogensen, & Boye, 2017; Martínez-Ferreiro, Ishkhanyan, Rosell-Clarí, & Boye, 2019; Nielsen, Boye, Bastiaanse, & Lange, 2019) has been developed by Boye and Harder (2012). In particular, Boye and Harder proposed a functional theory of grammatical status, which provided a theoretical anchor for the grammar-lexicon contrast. According to this theory, lexical items convey foreground or discursively primary information, whereas grammatical items convey background or discursively secondary information. Moreover, grammatical items are always dependent on lexical items, which act as host elements. As a consequence, lexical items can stand alone, whereas grammatical items/elements cannot. In fact, this is one of the diagnostic criteria for distinguishing between lexical and grammatical items. Another diagnostic criterion is

that, while lexical items can be focalised, grammatical items cannot. Importantly, applying these diagnostic criteria sometimes result in classifications that challenge established views in that (1) word classes such as prepositions and pronouns are not treated as homogenous (see Boye & Harder, 2012; Ishkhanyan et al., 2017), and (2) the resultant classifications of words into lexical and grammatical items cut across distinctions between content and function words or between open-class and closed-class words. Boye and Harder's (2012) functional theory has gained empirical support from studies on aphasia (e.g., Boye & Bastiaanse, 2018; Ishkhanyan et al., 2017; Martínez-Ferreiro et al., 2019; Nielsen et al., 2019) and at the same time provided a theoretical framework that, according to its proponents, allowed a precise characterization of the linguistic deficits attested in non-fluent and fluent aphasia.

Integrating Insights from Linguistic Theory, Psycholinguistics, and Neuroscience of Language

In the preceding sections, we illustrated how linguistic theory has informed studies on aphasia thus far. As mentioned in the Introduction, however, the ultimate goal should be the development of a unified theoretical framework that would integrate knowledge provided by complementary fields, such as linguistics, psycholinguistics, cognitive (neuro)psychology, neuroscience of language, and aphasiology. A fruitful integration of insights from syntactic theory, psycholinguistics, and neuroscience of language was provided by Grodzinsky and Friederici (2006), who sketched a brain map for syntactic knowledge (*formal syntax map*) and syntactic processing (*language processing map*). According to their formal syntax map, major (and universally

assumed) syntactic operations such as MERGE, $MOVE_{XP}$[7], $MOVE_V$[8] and BIND[9] are all neurologically *individuated*, that is, they are subserved by distinct brain regions/loci, exhibiting, thus, different spatial patterns. For instance, as the authors pointed out, there is converging evidence from cross-linguistic PET and fMRI studies (e.g., Ben-Shachar, Hendler, Kahn, Ben-Bashat & Grodzinsky, 2003; Ben-Shachar, Palti, & Grodzinsky, 2004; Bornkessel, Zyssett, Friederici, von Cramon, & Schlesewsky, 2005; Caplan, Vijayan, Kuperberg, West, Waters, Breve, & Dale, 2002; Röder, Stock, Neville, Bien, & Rösler, 2002; Stromswold, Caplan, Alpert, & Rauch, 1996), as well as from lesion studies, that $MOVE_{XP}$, a major syntactic operation that is impaired in Broca's aphasia, implicates the inferior frontal gyrus of the left hemisphere, and the superior temporal gyrus bilaterally.

THE SPECIAL ISSUE

The nine studies making up this SI investigated some of the most recurrent language problems in aphasia and related disorders, making use of a variety of linguistic theoretical frameworks. These studies demonstrated that language difficulties encountered in aphasia and related disorders are best explored within theoretical

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[7] $MOVE_{XP}$ is the syntactic operation by which a maximal projection such as DP, verb phrase or prepositional phrase is moved out of a position X to a position Y and establishes a link to the trace it leaves behind.

[8] $MOVE_V$ is the syntactic operation by which a verb is moved out of a position X to a position Y and establishes a link to the trace it leaves behind.

[9] BIND is a "relationship that determines how reflexives and pronouns link to other NPs, on which they depend for reference, in the same sentence" (Grodzinsky & Friederici, 2006, p. 242) (e.g., *Mary looked at herself*; *John asked Mary to help him*).

frameworks based on which falsifiable hypotheses and predictions can be generated and tested. Of the nine studies included in this SI, seven studies focused on aphasia (Adelt, Burchert, Adani, & Nicole, **this issue**; Aziz, Hassan, Razak, & Garraffa, **this issue**; Martínez-Ferreiro, Bastiaanse, & Boye, **this issue**; Martini, Belletti, Centorrino, & Garraffa, **this issue**; Maviş, Arslan, & Aydin, **this issue**; Nerantzini, Papakyritsis, & Varlokosta, **this issue**; Peristeri, Tsimpli, Dardiotis, & Tsapkini, **this issue**) and two studies focused on disorders related to aphasia: *traumatic brain injury* (TBI) (Arcara, Tonini, Muriago, Mondin, Sgarabottolo, Bertagnoni et al., **this issue**) and neglect dyslexia (Abbondanza, D'Imperio, Passarini, Meneghello, Burgio, Laratta, & Semenza, **this issue**). The studies on aphasia included a review paper (Martínez-Ferreiro et al., **this issue**), five studies on syntactic processing (Adelt et al., **this issue**; Aziz et al., **this issue**; Martini et al., **this issue**; Maviş et al., **this issue**; Peristeri et al., **this issue**), and a study on morphosyntactic/morphosemantic production (Nerantzini et al., **this issue**).

Review paper on aphasia

Martínez-Ferreiro et al. (**this issue**) focused on functional and usage-based approaches. In particular, they provided a critical review of research into (1) the role of frequency in aphasic speech and (2) the distinction between grammatical and lexical items and the implications of the conceptualization of this distinction for the characterization of aphasic speech and the understanding of underlying causes of aphasia.

Syntactic processing in aphasia

Using self-paced reading and grammaticality judgment, Peristeri et al. **(this issue)** investigated the ability of Greek-speaking PWA to integrate morphological (case) cues while processing garden-path sentences (e.g, *While s/he was sewing the hats slipped from the chair*). Moreover, they explored the relationship between sentence processing and executive attention/attentional control. The study reported a significant association between domain-general attentional control abilities and sentence comprehension abilities in both PWA and healthy controls.

Adelt et al. (**this issue**) tested the predictions of the RM approach (e.g., Friedmann, Belletti, & Rizzi, 2009; Garraffa & Grillo, 2008; Grillo, 2008; Rizzi, 1990) by investigating the effect of two different grammatical cues, number marking and case marking, on the interpretation of non-canonical sentences (in particular, sentences including object-extracted relative clauses). As the authors noted, the RM framework predicts that dissimilarity between the subject and object in number facilitates the processing of sentences with object-extracted relative clauses in aphasia, whereas dissimilarity between subject and object in case does not facilitate the processing of this sentence type. Adelt et al. tested German speakers with aphasia and healthy controls combining the visual-world eye-tracking methodology with an auditory referent-identification task. Both participant groups showed a general processing advantage for case-disambiguated over number-disambiguated non-canonical sentences, regardless of the timing of disambiguation. The authors concluded that case marking can be used more successfully than number marking to derive sentence meaning. Following Fodor and Inoue (2000), Adelt and colleagues argued that, for reanalysis, the case cue is more informative than the number cue, because the former is provided before the integration of the verb arguments into the

syntactic structure. In contrast, the number cue is provided after the integration of the verb arguments has been completed.

Maviş et al. (**this issue**) and Aziz et al. (**this issue**) contributed data from two underrepresented languages in the aphasia literature, Turkish and Malay. Both languages have free word order.

Maviş et al. (**this issue**) investigated the ability of Turkish-speaking fluent and nonfluent PWA to comprehend declarative sentences presented in four different word orders (Subject-Object-Verb (SOV)/Subject-Verb-Object (SVO)/Object-Verb-Subject (OVS)/Object-Subject-Verb (OSV)) using a sentence-picture matching task. The control group outperformed the group of PWA. The group of fluent PWA performed comparably on all four conditions. The group of nonfluent PWA, however, exhibited a dissociation between object-first and subject-first sentences, performing worse on the former than on the latter. There was no difference between OVS and OSV sentences, nor between SOV and SVO sentences. The authors discussed these findings in light of linguistically informed hypotheses, such as the TDH (e.g., Grodzinsky, 1995), RM (e.g., Friedmann et al., 2017; Garraffa & Grillo, 2008), and DOP-H (Bastiaanse & van Zonneveld, 2005, 2006).

Aziz et al. (**this issue**) investigated the ability of five Malay-speaking persons with non-fluent aphasia to comprehend active and passive reversible sentences. The aphasic participants performed comparably on active and passive sentences, which was at odds with the selective impairment in the comprehension of non-canonical passive sentences reported in many languages. Aziz et al.'s finding, however, was consistent with previous findings on standard Indonesian showing that, in comprehension, there is no dissociation between passive and active sentences. A qualitative analysis of the data showed that thematic role reversal errors

predominantly occurred in passive sentences, whereas lexical errors ("lexical substitutions") predominantly occurred in active reversible sentences. Therefore, error analysis pointed to different sources of difficulty in processing reversible canonical and non-canonical sentences. The authors discussed the results in light of the TDH (Grodzinsky, 1986, 1990, 1995) and Grillo's (2008) approach (see section *Relativised Minimality and aphasia research*), and concluded that the latter accounts for the observed pattern of performance better than the TDH. According to the authors, this is so because, unlike the TDH, Grillo's approach states that the morphosyntactic representation of both active and passive sentences is underspecified in PWA, which leads to a comprehension deficit comparably affecting both sentence types in a free word order language.

Lastly, Martini et al. (**this issue**) thoroughly investigated the (morpho)syntactic abilities of an Italian-speaking individual with anomic aphasia. According to an initial formal assessment, the patient did not reveal any signs of agrammatism or morphosyntactic impairments. However, testing with a series of off-line tasks tapping into comprehension and production abilities revealed a selective deficit affecting only certain object relatives and object questions in both modalities. In these impaired structures, the featural specification of the intervening subject was included in the specification of the displaced object. The authors argued that this finding was consistent with the grammatical Featural RM approach (Friedmann et al., 2009; Grillo, 2008) to the impaired computation of sentences with an intervener.

Verb-related morphosyntactic/morphosemantic production in aphasia

Nerantzini et al. (**this issue**) focused on verb-related morphosyntactic/ morphosemantic production in aphasia. In particular, they investigated the ability of

Greek-speaking individuals with agrammatic aphasia to refer to different time frames (*past*, *present*, *future*) by means of verb morphology. The authors moved beyond the sentence level, as in addition to using a sentence production priming task they also elicited picture description and conducted a semi-standardized interview. Task effects emerged. For example, Nerantzini et al.'s agrammatic participants had greater difficulty referring to the past when tested with the sentence production priming task than in the two narrative tasks. Moreover, the results of the sentence production task showed that the agrammatic participants were impaired in both past and future reference. The authors discussed the results in light of the PAst DIscourse LInking HYpothesis (PADILIH; Bastiaanse et al., 2011) and Chiou's (2014, 2015) analysis, according to which the Greek future tense, and in particular the combination of the particle *θα* and the perfective non-past form of a verb, calls for a "future prospective reading", which arises as an informativeness implicature (see Levinson, 2000). Nerantzini and colleagues attributed the observed deficit in future reference to agrammatic speakers' difficulty processing conversational implicatures. Lastly, they implicitly accounted for the past reference deficit by assuming that only reference to the past involves Discourse-linking (Bastiaanse et al., 2011; Zagona 2003, 2013), which taxes the processing system (e.g., Avrutin, 2000).

Beyond aphasia

Arcara et al.'s (**this issue**) and Abbondanza et al.'s (**this issue**) studies are different from the studies above in that they do not focus on aphasia but on related disorders: TBI (Arcara et al., **this issue**) and neglect dyslexia (Abbondanza et al., **this issue**).

Arcara et al. investigated pragmatic abilities in TBI adopting the framework of Relevance Theory (e.g., Sperber & Wilson, 1995, 2008; Vega Moreno, 2007) and

using a comprehensive and standardized tool: the *Assessment of Pragmatic Abilities and Cognitive Substrates* (Arcara & Bambini, 2016). They found that both pragmatic aspects of discourse production and comprehension of figurative language are compromised in TBI. It should be noted that pragmatics is an understudied linguistic domain in aphasia research. None of the studies on aphasia included in this SI examined pragmatic abilities. We suggest that future research should thoroughly investigate pragmatic abilities of PWA by means of comprehensive and standardized tools such as that of Arcara and Bambini (2016).

In a syntactically informed study, Abbondanza et al. (**this issue**) investigated the reading abilities of nine Italian-speaking individuals with neglect dyslexia. The authors tested the hypothesis that the syntactic structure of the sentence modulates the attention of people with neglect dyslexia. To this end, the participants were administered a reading task that included sentences with topicalised or focalised elements (experimental condition) and sentences with no involvement of discourse-related positions (control condition). Abbondanza et al.'s participants performed better on the experimental sentences than on the control sentences, thus providing empirical evidence for the hypothesis above. This finding may have implications for the treatment protocols for neglect dyslexia.

SUMMARY AND CONCLUDING REMARKS

This overview presented the articles making up the SI of Aphasiology entitled "Aphasia and linguistic theory: What we have captured so far", and also illustrated the contribution of linguistic theory to aphasia research by highlighting influential theoretical frameworks and linguistic constructs that have been central to accounts of language impairment in aphasia. It is our hope that this overview will pave the way

for the development of a unified approach to aphasia, which will incorporate insights from several complementary fields such us theoretical linguistics, psycholinguistics, cognitive (neuro)psychology, neuroscience of language, and speech language pathology.

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