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Language Deterioration in Prodromal Alzheimer's Disease Reveals a Breakdown in Language-Thought Relations: New Study of Null Anaphora in Adjunct Clauses

Barbara Lust [1,2], Suzanne Flynn [2], Charles Henderson [3], James Gair [3], Janet Cohen Sherman [4]

[1] *Cognitive Science, Psychology, Cornell University, Ithaca, NY, USA.* **[2]** *Department of Linguistics and Philosophy, MIT, Cambridge, MA, USA.* **[3]** *In Memoriam, Cornell University, Ithaca, NY, USA.* **[4]** *Department of Psychiatry, Massachusetts General Hospital, Boston, MA, USA.*

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Corresponding Author: Barbara Lust, Cornell University, Psych, Ithaca, NY 14853, USA. E-mail: bcl4@cornell.edu

Abstract

In this paper, we extend an interdisciplinary experimental program in which we study language deterioration in amnestic Mild Cognitive Impairment (aMCI), a period of prodromal Alzheimer's Disease (AD). We report new results which reveal a language deficit in sentences with null arguments in temporal adjuncts, Control structures, replicating previous research with lexical pronouns. The fact that language deterioration in sentences with null pronominals replicates that with lexical pronouns provides evidence that aMCI language deterioration is localized in the anaphoric construal types they share, generalizing over the phonetic variation of their pro form. We argue that the aMCI deficit reflects the architecture of the Language Faculty (LF) as it constrains the creation of language meaning through dual anaphoric construal types. We suggest that our new results are consistent with linguistic analyses of Control structures and motivate integration of Control theory and Binding Theory in a Minimalist approach to the LF. They inform more focused interdisciplinary investigations of the neuroscientific foundations of the Language Faculty and of language impairment such as aMCI (cf. Moro et al., 2001). We sketch possible directions for future research, both theoretical and empirical.

Keywords

anaphora, aMCI, Control, Binding, Coreference, pronouns, AD, Language Faculty

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1 Introduction

In Cognitive Science today, the relations between language and thought, grounded in centuries of philosophical inquiry, continue to be vigorously debated. Decades of theoretical study of the Language Faculty (LF), complemented by empirical study of the LF in language acquisition and language loss, have now advanced this extensive inquiry. Here we will assume a Minimalist approach to definition of the LF, focusing on its core architectural components (Chomsky, 2006, 2016).

These advances have enabled researchers to approach perhaps the most fundamental question of the LF: "is it well designed for interaction with the systems that are internal to the mind?" (Chomsky, 2002, p. 107; cf. Ansaldo & Enfield, 2016; Epstein et al., 2017; Jackendoff, 1997, 2011; Pinker & Jackendoff, 2005). Linguists have recognized that "correctly capturing the interface is the crucial adequacy criterion of any syntactic theory" (Reinhart, 2006, p. 2; cf. Chomsky, 1995). What has been termed a "Conceptual-Intentional Interface (C-I)" (Chomsky et al., 2023), a "semantics-pragmatics interface" (Berwick & Chomsky, 2016, p. 11) or a "Concept System" (Reinhart, 2016), specifically invokes a locus for language-thought relations.

Although fundamental issues of language-thought relations have long been subject to psycholinguistic debate (e.g., Fedorenko et al., 2024; Piattelli-Palmarini, 1980; Watumull, 2024), they have been generally limited by minimal access to definition of precise syntactic components of language knowledge, and limited precision in specification of computation at the LF interface. Current linguistic analyses of the LF invite more focused theoretical and empirical investigation.

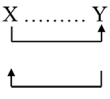
2 This Paper

2.1 Anaphora at the Interface

In this paper, we focus on one example of linguistic computation at the interface between syntax (linguistic computation) and "semantics-pragmatics," i.e., anaphora. We assume "anaphora" defined generally as in 1. We assume "semantics-pragmatics" to refer generally to the creation of meaning through language. We are concerned with "thought" as it "provides for the contents of what we say: thought as manifested in the semantics of human language" (Hinzen, 2013, p. 3)

(1) a. "…any case where two nominal expressions are assigned the same referential value or range" (cf. Reinhart, 1999, p. 20; Reuland, 2011a; Wasow, 1986).

b.



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Although all language production and comprehension reflect an integration of syntax and semantics, and although the multidimensional complexity of both syntax and semantics is vast, especially as it links to pragmatics, study of anaphora allows focus on specific computation which engages specific and well-studied aspects of both syntax and meaning, thus allowing more refined and tractable empirical study.

In a previous paper (Lust, Flynn, Henderson, Gair & Cohen Sherman, 2024, henceforth LFHGS24), part of a larger project studying language in prodromal Alzheimer's Disease (AD), we reported experimental study of sentences such as 2 with adjoined temporal clauses and lexical pronoun subjects. Here anaphoric construal is necessary in order to determine the value of the pronoun 'he'; until that value (or a range of values) is assigned to the pronoun, sentence meaning cannot be fully composed. In sentences like 2, construal can be computed through sentence syntax or through external reference. Our results revealed a systematic deficit in production of these sentence types in an amnestic Mild Cognitive Impairment (aMCI) population. We argued that the source of this deficit lies in the nature of anaphoric construal allowed in these sentences, reflecting deterioration at the CI interface of the Language Faculty.

(2) a. The electrician$_{i}$ fixed the light switch when he$_{i,j}$ visited the tenant.
b. When he$_{i,j}$ visited the tenant, the electrician$_{i}$ fixed the light switch.

In this paper, we extend our research program to ostensibly similar sentence types involving arguments which are phonetically null, traditionally termed "Control" structures, such as 3.

(3) a. The instructor demonstrated the rule when ∅ lecturing the pupil.
b. When ∅ babysitting the infant, the grandmother skimmed the newspaper.

As shown through an extensive history of investigation (Green, 2018; Landau, 2013, 2021, 2024a; Williams, 1992), sentence types such as 3 reflect similar anaphora construal options to those in 2. They allow an option for context dependent as well as sentential syntax determined anaphora, as in 4.

(4) a. When ∅$_{i,j}$ babysitting the infant, the grandmother$_{i}$ advised the teenager$_{j}$
b. A new assistant$_{i}$ has joined the household. When ∅$_{i,j}$ babysitting the infant, the grandmother$_{j}$ skimmed the newspaper
c. When she$_{i,j,}$ babysat the infant, the grandmother$_{i}$ advised the teenager$_{j}$

Pronominal anaphora in sentence types such as 2 have been the source of decades of theoretical study, in philosophy (e.g., Geach, 1962) and linguistics, grounding our inquiry (e.g., Everaert & Reuland, 2023; Heim & Kratzer, 1998; Reinhart, 1983a, 1986, 2006; Reuland 2011a, among many others, explicated under a *Binding Theory* module in

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the LF). Study of language acquisition has complemented this research (e.g., early papers in Lust, 1986 and forward.)

Sentence types such as 3 have also been studied extensively, mainly as a reflection of "a distinct Control module in the theory of grammar" (Chomsky, 1995, p. 110), with debate regarding their representation continuing in current Minimalist approaches to generative theory (e.g., Chomsky et al., 2023, p. 60, section 8.1; Landau, 2024a). In a comprehensive theory of adjunct control (Landau, 2021, p. 199f), two forms of anaphoric construal have been revealed in these Control sentences. In contrast to Obligatory Control (OC), Non Obligatory Control (NOC) interpretations allow reference to context. Both types of control (OC and NOC) can occur in the same domain. "…OC and NOC… readings (of alternating adjuncts) may coexist…" (Landau, 2021, p. 176; 2024a). "NOC does arise under a c-commanding subject" (Landau, 2021, pp. 50, 84, 151). This research adjusts earlier views which assumed that "all or most adjuncts fall under OC [Obligatory Control]" (Landau, 2021, p. 2; see, e.g., Green, 2018; Landau, 2013, 2015, 2021, p. 199f, 2023, 2024b; Williams, 1992, on adjunct control). See also the Appendix to this paper. Control has also been studied extensively in language acquisition (e.g., Cairns et al., 1993, 1994; Gerard & McDaniel, 2025; Landau, 2021, Chapter 12; Sherman, 1983; Sherman & Lust, 1993a, 1993b, 1986).

2.2 Leading Hypothesis

In this paper, we investigate whether sentences such as 3 with null arguments also reveal significant language deterioration in aMCI, as did sentences with lexical pronominals such as 2. If the deterioration in sentences such as 2 is explained by deterioration in anaphoric construal, then it should replicate in sentences which reflect similar anaphoric construal options regardless of phonetic variations in proform, as in 3. By comparing results with null arguments (Control Theory) to those with lexical pronouns (Binding Theory) we not only test for replication of the aMCI deterioration discovered in lexical pronominal anaphora but also seek to refine our understanding of its nature.

2.3 Structure of This Paper

We first (3.1) consider the LF as it provides an architecture for anaphoric construal at the interface between syntax and the semantic-pragmatic dimension of language knowledge. We (3.2) briefly review our previous experimental results reported in LFHGS24 with lexical pronouns in aMCI which revealed selective effects of dual anaphoric construal types in language deterioration. In (3.3) we consider the motivation for and challenge of extending this experimental work to the study of null proforms and in (3.4) we provide our leading experimental hypothesis. In (4) we review the design and method of our new experiment to study sentences with null proforms such as 3 and in (5) report results. (6) provides discussion and (7) conclusions.

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3 The Architecture of the Language Faculty Dissociates Dual Forms of Anaphoric Construal

3.1 Binding and Coreference

As we recognized in LFHGS24, given a long history of linguistic analyses, lexical pronouns, e.g., 2, are essentially ambiguous. Two distinct types of anaphoric construal determine pronominal interpretation in sentences like 2: 'Binding' and 'Coreference' (see, e.g., Evans, 1980; Hust & Brame, 1976; Keenan, 1971; Reinhart, 1983a, 1983b, 1986; Reuland & Everaert, 2001; Reuland, 2011a, pp. 27-30, for review; see Everaert et al., 2010, for studies relevant to their psychological reality). This research has been complemented by an extensive history of study of their semantic representation (e.g., Heim & Kratzer, 1998), and by cross linguistic investigation (e.g., Lust, Wali, Gair & Subbarao, 2000). Accordingly, it has been complemented by continual psycholinguistic inquiry.

Each anaphoric construal type accomplishes a unique form of relation between antecedent and proform, and accordingly between pronoun and reference to context. In construal by 'Coreference,' computation reaches outside of the syntax of sentence composition; a specific reference is determined and assigned to the pronoun in accord with the context of the sentence.[1] (For example, in 2, the pronoun may refer to an "inspector" or someone else who the speaker-hearer has in mind or to the sentence subject, the "electrician.") Pragmatic reasoning must be integrated with sentence syntax. In contrast, in construal by 'Binding' no external reference need be assigned, as in 5. Binding is provided through syntactic configuration; it is derived through the configurational property of c-command of the pronoun by its antecedent.

(5) No one alarms his tenant

Thus, as we assumed in LFHGS24, "…at the C-I [conceptual-intentional] interface pronouns can be translated either as expressions receiving a value directly from discourse storage or as variables to be bound by an antecedent" (Reuland, 2001, p. 447).

Based on the most fundamental property of the LF, structure dependence, Binding and Coreference are in an inverse relation syntactically and semantically.[2] While configuration involving c-command of a pronoun by an antecedent provides the conditions for

1) The distinction between "Binding and Coreference" has been broadened to define a distinction between "binding and non-binding" (rather than between 'binding and coreference') in order to recognize cases of co-valuation where reference is not involved in anaphora (cf. Heim & Kratzer, 1998; Reinhart, 2006, p. 172f; Reuland, 2011a). Here we will maintain the term 'coreference' to reflect non binding, both because it is used in much of the psycholinguistic literature, but also because co-valuation implies some form of cognitive computation external to sentence syntax.

2) In search for epistemological primitives, we assume a simplified, minimal definition of 'c-command,' setting aside issues of locality, which we will assume reflect a distinct component of grammar: "*a* c-commands *b* if *a* is a sister to a category γ containing *b*. Schematically: [a [γ … b …]]" (Reuland, 2011a, p. 29, #23). We assume that structure

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Binding, it also provides the conditions for the inverse. Principle C undoes the Binding construal option. In the domain of a c-commanding pronoun, an independently referring expression, a NP, may not be bound. In 6 it cannot be the electrician who visited the tenant; only extra -sentential reference is possible for this pronoun.[3] Free reference is necessitated.

(6) #He_i visited the tenant when the electrician$_{*i}$ fixed the light switch.

The fact that pronouns may be bound or free (not bound) reflects a fundamental structure dependent dissociation of two forms of syntax-semantics/pragmatics relations.

We assume that this non necessary dissociation of construal types is determined by the architecture of the Language Faculty (LF).[4] The LF carves out the dissociation and facilitation of each construal type. Both types may cooccur within the same sentence, leading to the ambiguities in classic "sloppy identity" type sentences e.g., 7 (cf. LFHGS24, p. 4, #3); and confirming that this structure dependent dissociation is not defined through sentential syntax alone, or through general cognitive necessity, but by the architecture of grammar.

(7) The electrician repaired his equipment and the inspector did too.

Structure dependent access to both Bound and Coreferential ("sloppy" and "strict") readings in pronominal anaphora have been attested from early language acquisition to adulthood (e.g., Foley et al., 2003; Foley, Lust, Battin, Koehne & White, 2000).

Without Binding

When pronouns are not bound, they are free, i.e., their interpretation is in principle limitless and multifaceted, engaging various forms of cognition.[5] Context can be variably provided: through consideration of an existing or possible situation or discourse, through a sentence internal named antecedent, or through conceptualization based on general knowledge or point of view, e.g., logophoricity or topicality (cf. Ariel, 1990; Reuland, 2011a). Reference itself is derivative of internal conceptualization, i.e., of com-

dependence is the most fundamental property of the Language Faculty. The configurational property of c-command is its essential defining property.

3) Although most studies relevant to Binding Theory (e.g., Chomsky, 1986, p. 166) in psycholinguistics, have focused on this division of nominal lexical forms, 'anaphors' and 'pronouns,' and done so in local domains, we move here beyond lexical forms and their locality, to study the essentials of the Language Faculty which provide the foundation for distinguishing Binding and Coreference, i.e., the c-command configuration.

4) Reinhart (2006) makes a distinction between 'syntactic binding' and 'logical binding.' We focus here on 'syntactic binding,' using the term to connote its configurational determination. More fundamentally, we focus on the epistemological primitives which underlie the Binding/Coreference distinction (cf. Reuland, 2011b).

5) The role of pragmatic context in sentence processing of anaphora is long established (e.g., Caramazza et al., 1977; Hankamer & Sag, 1976).

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plex thought; its relation to sentence meaning is indirect (e.g., Chomsky, 2013; Hinzen, 2007; Pietroski, 2021). In communicative use, the dynamics of discourse continually interact to update meaning (Stalnaker, 2014).

In contrast, anaphoric construal by Syntactic Binding obviates context dependence within anaphoric construal.

3.2 Linguistically Based Experimental Study of aMCI

In an ongoing interdisciplinary and inter-institutional project (Cornell University, Massachusetts Institute of Technology, Massachusetts General Hospital), we have begun to assess the role of the Language Faculty and its integration with other systems of the mind in prodromal AD; aspects of thought and neural deterioration have been studied. Language in individuals who are experiencing deficits in various aspects of cognitive functioning, compared to those in whom cognition is preserved, provides a window into the CI-Interface (Conceptual-Intentional) of the Language Faculty, complementing study of the LF in language acquisition (e.g., Cordella et al., 2015; Lust et al., 2015a, 2015b, 2017, 2019, 2024; Sherman et al., 2020, 2021; see also Chapin et al., 2022; Hinzen et al., 2018; Moro et al., 2001; Vasić, 2006).

We focus on the prodromal stage of AD referred to as aMCI, a period between normal aging and progression to AD (Petersen, 2003, 2004). It is characterized by cognitive loss relative to baseline, with predominant decline in memory (particularly the amnestic type of aMCI) although other cognitive areas may be involved. Individuals at this stage maintain the ability to independently manage most activities of daily living.[6] Over the last decades, language deficits have also been found to characterize aMCI, raising issues regarding relations between language and thought in prodromal AD deterioration (e.g., Mueller et al., 2016, 2018; see Sherman et al., 2020, for reviews).

3.2.1 Investigation of Lexical Pronominal Anaphora (LFHGS24)

In a series of experiments, three populations: aMCI, HA (Healthy Aging), and HY (Healthy Young) individuals have been experimentally assessed and compared across varied complex sentence types. Language production is elicited through an Elicited Imitation task (EI) which is well studied and accessible to widely varying populations (see 4.1.4). The results in our present study contribute to our wider research program which has evaluated anaphora in various forms of sentence production in aMCI, i.e., relativization, coordination, temporal clause adjunction; and in language acquisition (Lust et al., 2015a, 2015b, 2017, 2024, 2026; Sherman et al., 2020, 2021; Sherman & Flynn, 2021).

6) MCI is a complex condition which is difficult to diagnose and depends on careful clinical exam. Although it is a "probable" predictor of clinically manifest Alzheimer's Disease, it is not necessarily so. In our current project we focus on aMCI because it has the highest probability among several forms of MCI of progression to AD (Mattke et al., 2023; Petersen, 2003).

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3.2.2 Selectivity of aMCI Deterioration Reflects the Architecture of the Language Faculty

Our previous experimental research investigated lexical pronoun anaphora in temporal adjuncts such as 2, repeated here in 8. Results provided evidence that aMCI individuals, in contrast to healthy adults, aging and young, show a deficit in production of these sentence types which allow anaphoric construal by Coreference as well as by Binding. For example, aMCI individuals significantly failed to successfully produce sentences such as 8a, with a mean of .580 compared to HY (.800) or HA (.729) (See LFHGS24 details of design and results).

(8) (=2) a. The$_i$ electrician fixed the light switch when he$_{i,j}$ visited the tenant.
b. When he$_{i,j}$ visited the tenant, the electrician$_i$ fixed the light switch

At the same time, aMCI individuals were found to resemble Healthy adults in successfully producing sentences of equal length, and general form where Coreference is not involved, i.e., sentences like 9 where Coreference is structurally eliminated by Principle C in Binding Theory. Here aMCI achieve a mean of .818, comparable to HY .958., HA .854. Here the Binding Principle, but not Coreference, applies. In sentences with coordination like 10, aMCI, like HA and HY, productively converted 10a to 10b where Binding is revealed.[7]

(9) #*She*$_i$ answered the telephone when *the receptionist*$_i$ heard the caller.

(10) a. The server provided the menu and she brought the appetizer
b. *The server provided the menu* and ∅ brought the appetizer

In a complementary experiment, aMCI individuals also showed superior performance on sentences with lexical relative clause heads which reflect another type of Binding, WH binding, as in 11a, while failing significantly at sentences where reference is indeterminate and must be resolved through context, e.g., 11b (Lust et al., 2015a, 2017; Sherman et al., 2021). aMCI individuals also achieved relatively high success on production of sentences which arguably involved no anaphora, i.e., repeated NP subjects, e.g., 12, confirming maintenance of basic sentential syntax. For example, as reported in LFHGS24, aMCI individuals successfully produced these sentence types like 12, mean .739 correct, compared to .373 on those with pronouns like 10a.

7) The representation of coordinate structure such as that in 10 is debated. For the purposes of this paper, we assume the VP coordination in 10b reflects a bound null subject setting aside issues of its implementation and its relation to the sentential coordination form in 10a, e.g., through conjunction reduction.

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(11) a. *The attorney* presented the evidence which ∅ freed the defendant
b. The state policeman discovered what troubled the private detective

(12) *The student opened the backpack and the student erased the blackboard*

This cumulative evidence for selective deficit in sentence production suggests that language deterioration in aMCI specifically targets anaphoric construal exemplified in sentences like 2/8, even while leaving Binding, as in 9-11a, and basic sentence syntax, e.g., 12, relatively intact. We argued in LFHGS24 that these previous results reflect the dissociation of two types of anaphoric construal. aMCI maintain core syntactic knowledge allowing anaphoric construal by Binding while evidencing deficiency when sentences allow construal by Coreference.[8]

3.3 Extension to Null Arguments

The non necessary dissociation in sentence production which is revealed in previous experimentation begins to localize the source of an aMCI language deficit, implicating the role of anaphora construal type. It leads us to replicate this deficit and to pursue its nature. We can first ask: to what degree is the lexical pronoun itself a source of deficit on sentences such as 2? If our previous results documenting deficit in sentences like 2/8 could be attributed to some aspect of lexical pronoun usage in aMCI, this would potentially obviate the relevance of anaphoric construal type.

3.3.1 Anaphoric Construal With Null Pronominals

In this experiment, by extending our research program to sentence types such as 3 (repeated here as 13), we test whether our previous findings with lexical pronouns (e.g., 2/8), generalize to Control sentences with null proforms (e.g., 3/13). We ask: Is production of sentences such as 3/13 also deficited in aMCI compared to Healthy Adults?

(13) (=3) a. The instructor demonstrated the rule when ∅ lecturing the pupil.
b. When ∅ babysitting the infant, the grandmother skimmed the newspaper.

This contrast is particularly compelling because a null argument does not in itself carry referential force, as the lexical pronoun does. Phi features of gender, number and person conveyed by a lexical pronoun, which might support a Coreferential interpretation, are not directly available through a null pronominal, which is "phi deficient." Absent of all phi features, the null argument cannot alone initiate independent reference. It cannot invoke a presupposition, as lexical pronouns do. The very existence of a null argument

8) See Sherman et al. (2021, 2020, 2026) for evidence confirming an independence of linguistic results from results of cognitive tests including memory in this aMCI population.

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and its identity is dependent on the sentential syntax in which it appears. Accordingly, sentence types such as 3/13 have been traditionally represented in a distinct Control Theory (CT) module of the LF.[9] A shared deficit in production of sentences across lexical and null forms thus cannot be explained by a particular deficit in lexical pronoun referentiality, and must involve construal computation.

3.3.2 Control

This domain is also particularly compelling because sentences like 3/13, in contrast to those in 2/8, have traditionally been assumed to not only allow but require a Binding type construal, i.e., an obligatory subject antecedent in Obligatory Control (OC), as with sentence complements like 14.

(14) The inspector tried ∅ to fix the light switch

As in Binding, representation of Control critically depends on the fundamental property of c-command of antecedent, defined over configuration. Thus, in the absence of any referential direction from a lexical pronoun, a Binding type construal might be predicted for null arguments, resulting in no significant deficit in aMCI language production of 3/13. Indeed, although there is speaker variation, sentences like 3/13 have a strong subject antecedent preference, overriding an alternative external antecedent.[10]

3.3.3 Pronouns in AD

A contrast between sentences like 3/13 and those like 2/8 are also compelling because lexical pronouns have been implicated in AD and prodromal AD language.

Many analyses of 'connected speech,' mainly resulting from picture description or biographical essay tasks, report an increase in use of pronouns in AD and prodromal AD compared to HA. Many versions of computational modeling now pursue the possible predictive power of pronoun use, e.g., in prodromal diagnosis of incipient AD. However, the explanation of pronoun frequency remains undetermined. Hypotheses vary: memory deficit, lexical access failure, 'empty speech' (e.g., Almor et al., 1999; Berisha et al., 2015;

9) We restrict our focus here to temporal adverbial clause adjuncts. This is in order to eliminate the confound of structural variation as much as possible, and to relate more specifically to our finite clause experimental sentences in LFHGS24. We concentrate on clauses introduced by 'when' or 'while' rather than 'before' or 'after' in order to eliminate the further confound of semantic/cognitive reasoning engaged with time; although we assume that 'before/after'/'when 'clauses may share a similar underlying syntactic configuration.

10) Here and throughout, we use the symbol ∅ to represent the phonetically null expression. The exact nature of the null subject argument in sentences like 3/13 is one of our research questions. Research has questioned whether they reflect a distinct version of the empty null subject, "PRO," opposed to a "pro" pronominal. (See Bresnan, 1982; Landau, 2021, p. 219, footnote 9; McFadden & Sundaresan, 2018; Sundaresan, 2014, for discussion.) We use the term 'pro form' to represent both the empty subject which is interpreted in the adjunct clause, and a corresponding lexical pronoun. We cite examples from published literature veridically except for representing null subjects as ∅.

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Bittner et al., 2022, 2024; Carlomagno et al., 2005; Dijkstra et al., 2004; MacDonald et al., 2001; Ripich & Terrell, 1988). Results vary by task and situation. Cross linguistic evidence does not always replicate an increase in pronoun use, e.g., Bengali (Bose et al., 2021).

More recent analyses begin to resolve this indeterminacy. More specific analyses have confirmed that pronoun frequency varies by pronoun type and related context of use. A German sample studied individuals longitudinally to differentiate a potential difference in populations who did or did not proceed to AD. Results showed that a pre-clinical increase in pronoun usage involved D-pronouns (e.g., 'der,' 'das') but not personal pronouns (Bittner et al., 2024). Some forms of null pronominals which were compared (VP ellipsis and coordination) also did not differ across AD and control populations. Other analyses confirm an overall increase in pronoun use in AD compared to HA, but disconfirm a general increase in third person pronouns. Analyses of context have suggested that problems in perspective taking may underlie variation in pronoun use (cf. Bittner et al., 2022). More extensive analyses of NP types confirm variation may be related to anaphoricity and to specificity of reference in discourse (Chapin et al., 2022; cf. Lofgren & Hinzen, 2022; Kemper et al., 1993).

Our previous experimental research has shown that lexical pronouns themselves do not trigger production deficits simply by their free reference (LFHGS24). For example, high success with sentences including the indeterminate pronoun like 9, and the wide occurrence of 'empty pronouns' in speech of dementia suggest that individuals accept indeterminate reference in general (cf. Sherman et al., 2015). LFHGS24 has confirmed that lexical pronouns are inserted or omitted by prodromal AD individuals in a structure dependent manner; they are retained where they do not involve integration of anaphoric construal in sentence syntax (e.g., the Pr C cases as in 9 (LFHGS24)), and they are eliminated where obligatory Binding results from their omission (e.g., coordination as in 10b).

We assume therefore, based on independent study in the field and in our earlier experimental results in LFHGS24, that the lexical pronoun *per se* is not a direct source of aMCI deficit observed in sentences like 2/8. Pronoun use is determined by the structural context in which a pronoun appears and the anaphoric construal relations it potentially reflects.

3.4 Leading Hypothesis

If, as we have proposed, aMCI deficit lies in anaphoric construal at the LF interface, then we would predict that it would generalize beyond language-specific variation in anaphora representation, such as whether proforms are lexical or null, i.e., beyond the specific morphology or lexical form which construal may involve. If, as research has shown, sentence types such as 3/13 do in fact allow both a Coreferential type and a Binding type, an OC or a NOC, construal and if an option for a non Binding (context dependent) type anaphoric construal is the basis for the selective aMCI deficit discovered in

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LFHGS24, then we would expect aMCI to demonstrate significant deterioration relative to healthy adults, on sentences such as 3/13 with null subjects, Control sentences, as they did on sentences like 2/8 with lexical pronouns.

4 New Experimental Evidence: Null Proform in Adjunct Control Clauses

We apply experimental methods in order to strengthen the scientific basis for hypothesis testing (cf. Blume & Lust, 2017 for contrast of experimental and observational methods).

4.1 Design and Method

Using experimental designs, we compared language production of three groups: amnestic Mild Cognitive Impaired (aMCI) (N = 22), Healthy Aging (HA) (N = 24), Healthy Young (HY) (N = 10). (See Table 1). All data collection was approved by Institutional Review Board regulations at each institution. All completed a 42-question sociodemographic questionnaire.

Table 1

Participants: Temporal Adjuncts With Null Subjects

Group	*N*	Age Mean	Age Range	Males	Females	Years of Education mean	Range of Education
HY: MIT	10	23	21-27	5	5	15.6	14-18
HA: Cornell pooled with MGH Controls	24	74	62-87	11	13	17.15	12-20
aMCI MGH	22	75	68-88	12	10	16.86	12-20
Totals	56	65	21-88	28	28	16.67	12-20

Our test of Control sentences was administered among a series of linguistic tests. The series included temporal Adjoined sentences with lexical pronoun subjects and Coordinate sentences, both reported in LFHGS24, and Relative Clause structures, reported in Sherman et al. (2021) and Lust et al. (2015a, 2017).

In addition to linguistic tests, all groups, MCI, HA and HY, were also tested on two standardized cognitive measures: Addenbrooke's Cognitive Examination-Revised (ACE-R), a multidomain cognitive screen (Mioshi et al., 2006) and Brown Peterson Consonant Trigram task (BP), a test of Verbal Working Memory (Belleville et al., 2007; see Sherman et al., 2021, p. 4298, for details of ACE-R and BP results across groups, and Sherman et al., 2026, for extended cross-experiment analyses). In accord with clinical population

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categorization, MCI scores were significantly lower than both HY and HA for both ACE-R and BP.

4.1.1 Population

Individuals identified as aMCI were recruited from the Massachusetts General Hospital (MGH) Psychology Assessment Center (PAC), a neuropsychological evaluation center within the hospital. These individuals were referred by MGH neurologists for clinical neuropsychological evaluation to address concerns about memory and/or other aspects of cognitive functioning. Diagnosis of aMCI was based on neurological evaluation including Clinical Dementia Rating (CDR) (Morris, 1993) and performance on the Uniform Data Set (UDS), a brief set of cognitive measures developed by the National Alzheimer's Coordinating Center (Morris et al., 2006; Weintraub et al., 2009; see Sherman et al., 2021, p. 4292, for UDS results). They also received additional standardized neuropsychological measures (not reported here). Consistent with consensus criteria, individuals diagnosed with aMCI showed evidence of cognitive decline from estimated baseline on neuropsychological testing and caregiver reported preservation of independence in managing activities of daily living (Johnson et al., 2004).

HA were recruited from two sources: (i) The Cornell Institute for Translational Research on Aging, where subjects ages 60 years and older composed an older adult respondent pool, recruited based on their interest in research participation and screened to determine normal health status. They were categorized as HA based on self-report of no neurological events and no language or memory deficits. (ii) An additional 10 HA recruited at MGH were assessed with CDR and neuropsychological testing replicating that applied to the MCI population. HY were recruited from the MIT student and administrative population, with no reported neurological disorders.

4.1.2 Experimental Design

In this paper, we report results of a test of production of Control sentences where the proform (i.e., the subject in the temporal adjunct clause) is null (∅), shown in Table 2. To test our leading hypothesis, sentences were varied factorially in terms of syntactic and semantic features, controlled to match previously tested sentences in our series of linguistic experiments. In this experiment with null subjects, *Branching Direction (BD) and Pronoun Direction (PD)* are united and confounded (*BDPD*).[11] The design resulted in 8 sentences in 4 conditions, for each of three *Groups,* HY, HA and aMCI. With one replication item for each condition, each participant imitated 8 Control sentences with null subjects in non-finite adverbial subordinate clause adjuncts.

11) This follows from the fact that English disallows null subjects in most finite sentence conditions and disallows lexical subjects in most nonfinite conditions.

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Table 2

Experimental Sentences by Factorial Design: Temporal Adjuncts With Null Subjects

+SEM				
Null	RB	F	A6	The chef assembled the casserole when ∅ instructing the apprentice.
			B4	The instructor demonstrated the rule when ∅ lecturing the pupil.
	LB	B	A5	When ∅ babysitting the infant, the grandmother skimmed the newspaper.
			B1	When ∅ examining the soldier, the medic assessed the injury.
-SEM				
Null	RB	F	A1	The guest jeopardized the violin when ∅ refuting the minister.
			B2	The companion adjusted the device when ∅ tackling the worker.
	LB	B	A4	When ∅ awakening the user, the believer broke the piano.
			B1	When ∅ pursuing the painter, the leader destroyed the binoculars.

Note. RB: Right-Branching; LB: Left-Branching; F: Forward; B: Backward Proform. +/- SEM: plus or minus Semantic Plausibility.

As seen in Table 2, in a 2x2 factorial design, the Control sentences varied in *BD* (as left or right branching/pre or postposing of adjunct), each corresponding to linearity of pronominal, i.e., *PD* (Forward or Backward ∅ respectively), thus providing a uniform *BD/PD* factor with LBBPD and RBFPD values. As in previous experiments, sentences were tested in both positive and negative *Semantic Plausibility (SP)* conditions (Semantically Plausible (+) or Implausible).[12] *Group* provided a Between Groups factor.

Matching the finite sentences with lexical pronouns reported in LFHGS24, all sentences were controlled in length (17 syllables, 9 words), as well as in lexical frequency, lexical semantic associativity, and all other aspects of syntactic structure other than targeted variables. Lexical frequency was determined through logfreq-HAL (Elexicon http://elexicon.wustl.edu/). Variation in Semantic Plausibility was based on University of South Florida Free Association Norms for the lexicon (http://w3.usf.edu/FreeAssociation). Animacy of NPs was controlled and counterbalanced across conditions.

4.1.3 Procedures

The sentences in Table 2 were distributed randomly among the two batteries of finite sentences with lexical pronouns previously reported in LFHGS24 (Batteries A and B

12) As Table 2 shows, sentences varied in Semantic Plausibility (SP) (±), according to whether the sentence can more easily be interpreted to "make sense" intuitively or not. Given that the Elicited Imitation (EI) task requires integration of syntax and semantics in construction of the model, this factor allowed us to evaluate to some degree whether syntactic and semantic effects are independent in our results.

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containing replication items), with +/-*Semantic Plausibility* sets counterbalanced within group.[13] Procedures for administration were standardized (Blume & Lust, 2017).

4.1.4 Task

In conjunction with experimental design and controls, we adopted the Elicited Imitation (EI) task to elicit language production. Essentially, individuals are asked to "say what I say just the way I say it." In our use of the task, standardized methods of administration and data scoring have been applied to support replicabililty.[14]

The task is based on the premise that repetition of a given sentence requires generative analysis and reconstruction of the model. Extensive research has confirmed that performance on this task requires analysis and reconstruction of both syntactic and semantic factors (see, e.g., Blume & Lust, 2017, especially chapter 6; Dye & Foley, 2021; Lust, Chien & Flynn, 1987; Lust et al., 1996, for investigation of the cognitive characteristics of the EI task).

The EI task is accessible to participants from a wide cognitive and developmental range, including those in early periods of dementia (e.g., Miller et al., 2021; Sherman & Flynn, 2021; Whitaker, 1976). Description of previous applications of the EI method in our population include Lust et al. (2015a, 2017, 2024, 2026), Sherman and Flynn (2021), and Sherman et al. (2020, 2021).

Imitation of a modeled sentence under controlled conditions, in combination with experimental design and controls, requires and significantly reveals linguistic computation necessary for sentence formation (both syntactic and semantic and their integration); and it implicates the role of experimental design variables. Both patterns of successful performance (productions which match the model sentence) and "errors" (i.e., reformations, or reproductions which deviate from the model, according to standardized criteria) evidence this computation. Reformations can explicate the representation underlying the participant's behaviors.[15]

The EI task thus provides an essential complement to comprehension tasks, where inference regarding participant's linguistic representations of the model sentences is relatively more indirect (cf. Blume & Lust, 2017, chapters 7 and 11). In contrast to observational studies of spontaneous speech (e.g., picture description or biographical

13) Each participant repeated 24 sentences with temporal adjunct clauses (finite and nonfinite). As part of the larger program, test of sentences with temporal adjuncts (both finite and nonfinite) was administered with other tests in our series of complex sentence formation analyses (previously reported).

14) For example, administrators of the model sentence are asked to provide the model sentence in a normal cadence which is clearly fully audible, not to provide any other speech between the administration of the model and individual's response, to allow one repeat or request for repeat, to approve of any form of attempt at reconstruction of the sentence. Experimental sentences are preceded by pretest practice items.

15) For this reason, we use the term '*error*' in quotes and refer to responses which don't precisely match the model sentences, as "reformations."

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essay), EI, combined with experimental design, allows linguistic specification of factors for hypothesis testing and control for linguistic factors not directly related to hypothesis.

4.1.5 Analyses

As with our previous research reported in LFHGS24, quantitative analyses of language data resulting from our factorial designs were conducted with logistic-linear mixed models with binomial error assumption and a logit link function. Qualitative analyses supplemented quantitative analyses through linguistic examinations of imitation reformations, which were counted as incorrect. We analyzed a series of models to examine the results of each of our tests administered. In the model to examine performance on the nonfinite adjunction task the dependent variable was the proportion of correct responses and included *Group* (3 levels: HY, HA, aMCI) and repeated measures factors resulting from the sentence structure of the task as fixed classification factors; the interactions of these factors; and individuals as levels of a random classification factor. There is a replication on each sentence type, but replication was not included in the model as a classification factor. Incorrect or correct (0 or 1) is the score for each response. Analysis was by logistic mixed models with binomial error (Schall, 1991; Wolfinger & O'Connell, 1993). The logistic specification is chosen because of the dichotomous outcome variable. Mean differences in proportion correct response were examined in a mixed model including fixed classification factors for *Group* and the *Sentence Types*, the interactions among these factors, and individuals as levels of a random factor.

In accord with standardized scoring criteria, any major change in syntax or semantics of the model sentence was scored as incorrect. Participant responses which were scored as incorrect were analyzed qualitatively in terms of the nature of their reformation of the model sentence. For all reformations leading to an incorrect score, qualitative analyses assessed structural, lexical, and morphological factors. In this paper we focus on NP-proform relations reflecting anaphora construal (https://testvcla.cac.cornell.edu/the-vll/experiment-bank/; see "archived scoring materials").

4.1.6 Experimental Hypotheses

i. If our explanation of our previous results with lexical pronouns and our understanding of the nature of the sentence types such as 3/13 is correct, then aMCI should show significant deficit on these Control sentences, as they did for comparable sentences with lexical pronouns. aMCI deficit should occur in sentences in Table 2, as it did in those with lexical pronouns (e.g., 2/8). Specifically, individuals with aMCI should reveal significant deficit on production of sentences on Table 2 relative to Healthy Young (HY) and Healthy Aging (HA), as they did on sentences with lexical pronouns. There should be a

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significant *Group* effect, as there was for previous study of lexical pronoun anaphora. We refer the reader to our companion paper, LFHGS24, for detailed results of test of finite sentences with lexical pronouns.

ii. If anaphoric construal is implicated in this deficit, aMCI should show sensitivity to structure in sentences on Table 2, as they had for those with lexical pronouns. That is, individuals should show evidence of consulting the configurational factor of *Branching direction/Pre and Post posing* of adjunct in anaphoric construal.[16]

iii. Given that semantics is by definition involved in anaphoric construal, a factor of *Semantic Plausibility* would be expected to significantly affect sentence production, but as with lexical pronouns, not to differentiate *Groups* HY, HA, and aMCI and not to significantly interact with *Group*; thus, not in itself to explain the *Group* differentiation of aMCI from Healthy adults.

5 Results

In this section we report results from our repeated measures mixed model in 4.1.5. $\bar{x}_{\Delta}$ denotes mean differences.

Table 3 reports the mean success values for production of the Control sentences in Table 2 across the four design conditions and three groups: HY, HA, and aMCI. Figure 1 displays percent correct production of these sentence types for each group conflated across the *Semantic Plausibility* factor, together with group comparisons across sentence types. Given one replication for each condition, the score range is 0-2 per condition. In presenting statistical results, we assume a $p < .05$ threshold of significance. For the reader's convenience, comparative means with lexical pronominal sentences, as reported previously in LFHGS24, are added in bold to Table 3.

16) There is no *a priori* hypothesis that *(BDPD) branching direction/adjunct pre and post posing* and *proform linearity* should significantly affect anaphoric construal in sentences such as 3/13, where, differently from sentences with lexical pronouns, structure and proform direction are necessarily confounded in English However, as Landau (2021, p. 144) observes, in some cases preposed/clause initial adjuncts have been observed to be more susceptible to context based interpretations (Green, 2018; Kawasaki, 1993; Kortmann, 1991; Landau, 2013; Williams, 1992).

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Table 3

Mean Correct Imitation of Sentences With Temporal Adjuncts With Null and Lexical Subjects Across Healthy Young, Healthy Aging and aMCI (SE in Parentheses)

NULL			LFHGS24 Lexical
Healthy Young: 0.843 *(0.082)*	SEM+: 0.905 *(0.060)*	Right Branching Forward: 0.830 *(0.104)*	**0.800 (0.124)**
		Left Branching Backward: 0.948 *(0.041)*	**0.905 (0.124)**
	SEM-: 0.751 *(0.120)*	Right Branching Forward: 0.537 *(0.170)*	**0.650 (0.123)**
		Left Branching Backward: 0.887 *(0.076)*	**0.800 (0.123)**
	SEM Conflated	Right Branching Forward: 0.704 *(0.133)*	**0.725 (0.108)**
		Left Branching Backward: 0.923 *(0.050)*	**0.853 (0.108)**
Healthy Aging: 0.665 *(0.085)*	SEM+: 0.741 *(0.078)*	Right Branching Forward: 0.713 *(0.091)*	**0.729 (0.079)**
		Left Branching Backward: 0.767 *(0.081)*	**0.646 (0.079)**
	SEM-: 0.578 *(0.099)*	Right Branching Forward: 0.568 *(0.109)*	**0.631 (0.080)**
		Left Branching Backward: 0.588 *(0.108)*	**0.501 (0.080)**
	SEM Conflated	Right Branching Forward: 0.644 *(0.093)*	**0.680 (0.070)**
		Left Branching Backward: 0.685 *(0.088)*	**0.573 (0.070)**
aMCI: 0.415 *(0.096)*	SEM+: 0.513 *(0.104)*	Right Branching Forward: 0.447 *(0.112)*	**0.580 (0.084)**
		Left Branching Backward: 0.579 *(0.111)*	**0.461 (0.084)**
	SEM-: 0.323 *(0.091)*	Right Branching Forward: 0.287 *(0.094)*	**0.386 (0.083)**
		Left Branching Backward: 0.361 *(0.105)*	**0.296 (0.083)**

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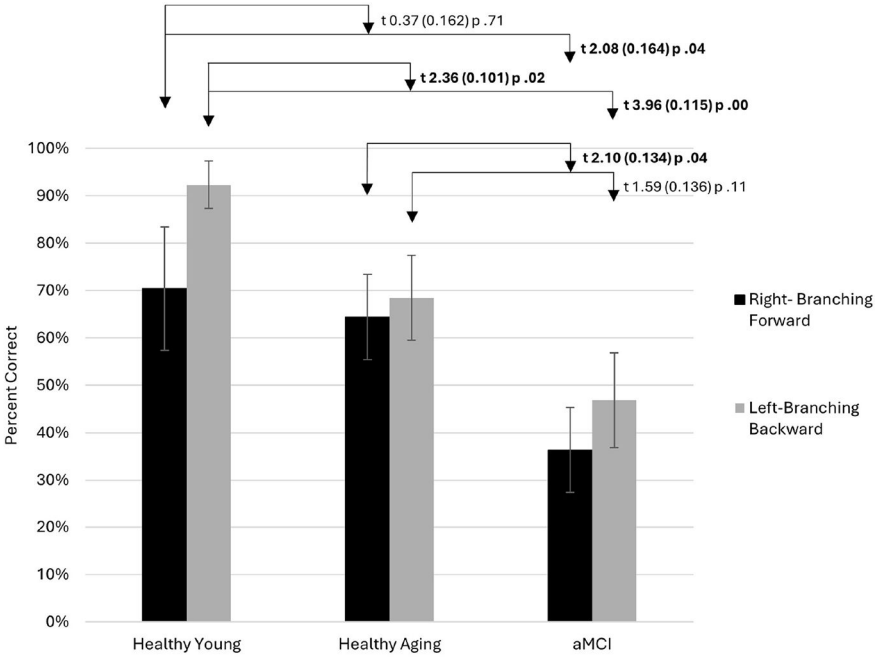
NULL			LFHGS24 Lexical
	SEM Conflated	Right Branching Forward: 0.363 *(0.096)*	**0.483 (0.073)**
		Left Branching Backward: 0.469 *(0.103)*	**0.378 (0.073)**

5.1 Group Comparisons

There was a significant main effect of *Group, F*(2, 810) = 4.17, p = .02, as had been found for sentences with lexical pronouns (LFHGS2024). As shown in Figure 1, successful production of sentences declined in the aMCI group. Overall, across sentences, HY and HA did not differ significantly from each other: $t(810) = 1.50$, p = .134, $\bar{x}_{\Delta}$ = .178. The aMCI group performed significantly lower than HY: HY vs. aMCI, $t(810) = 3.39$, p = .001, $\bar{x}_{\Delta}$ = .428, and tended to perform lower than HA: HA vs. aMCI, $t(810) = 1.94$, p = .052, $\bar{x}_{\Delta}$ = .25).

Figure 1

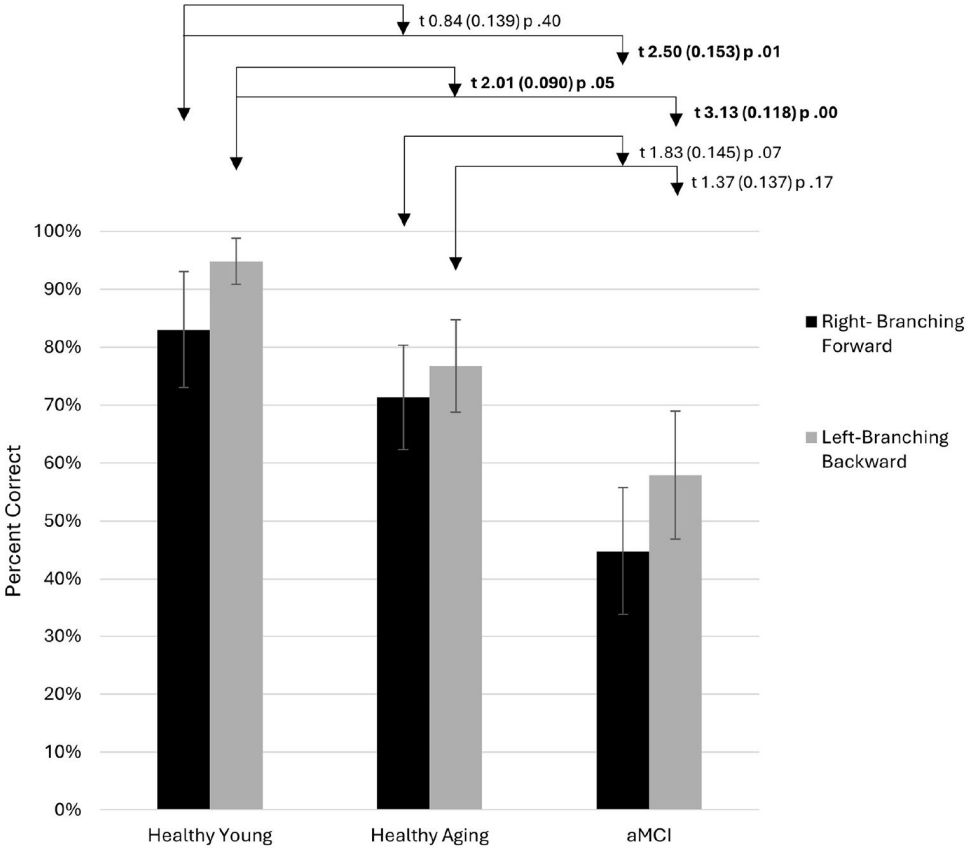
Percent Successful Production of Each Type of Non-Finite Sentence With Null Subjects Across Groups (HY, HA and aMCI), t-Test of Differences Between Group Performance on Each Type, Conflated Over Semantic Plausibility Variation



Also replicating previous results with sentences with lexical pronouns, *Semantic Plausibility* had a significant effect on sentence imitation, significantly depressing performance, $F(1, 810) = 18.01$, $p < .0001$. At the same time, replicating results with lexical pronouns, there was no significant *Group* x *Semantic Plausibility* interaction, $F(2, 810) = 0.26$, $p = .77$, indicating that the *Group* effect was generally independent of plausibility. As Figures 2 and 3 show, a similar pattern of *Group* differences holds across the *Semantic Plausibility* variation.

Figure 2

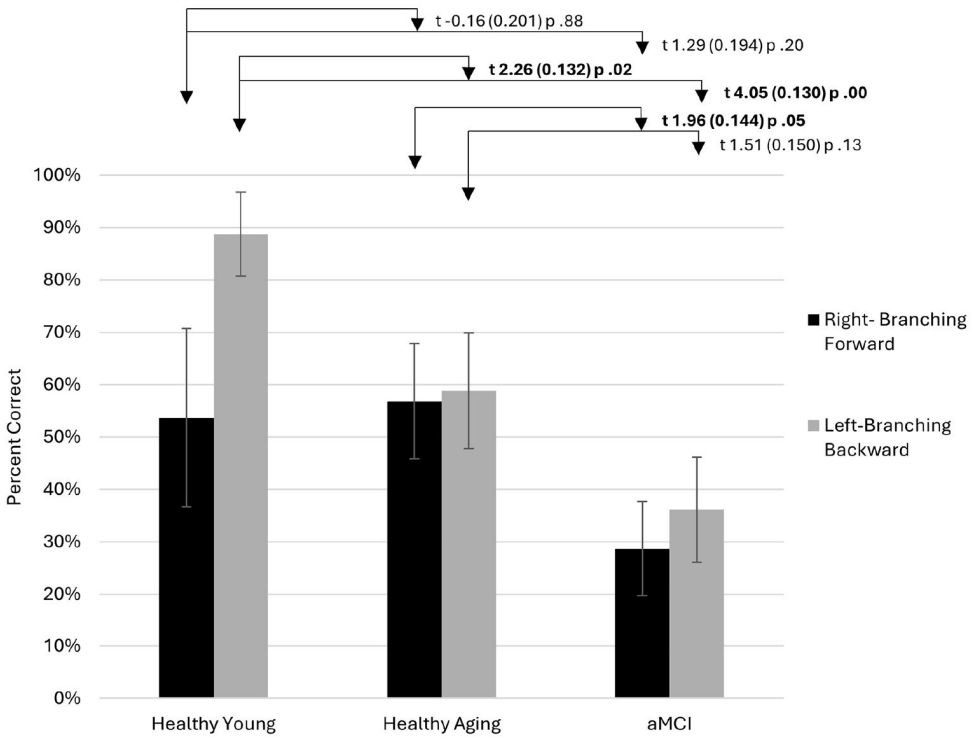
Percent Successful Production of Each Type of Non-Finite Sentence With Null Subjects Across Groups (HY, HA and aMCI), t-Test of Differences Between Group Performance on Each Type, With + Semantic Plausibility



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Figure 3

Percent Successful Production of Each Type of Non-Finite Sentence With Null Subjects Across Groups (HY, HA and aMCI), t-Test of Differences Between Group Performance, Without - Semantic Plausibility



5.2 Structure and Linearity: Directionality Differentiates Null and Lexical Sentence Forms

In this experiment, where BD and PD are united and confounded, the BD/PD factor showed a significant overall effect, $F(1, 810) = 12.28$, $p < .001$ and did not interact significantly with *Semantic Plausibility*, $F(1, 810) = 0.03$, $p = .869$. A *Group* interaction approached significance at the .05 boundary $F(2, 810) = 3.05$, $p = .048$.

As can be seen in Figure 1, across all groups, *Left Branching* with *Backward Proform* (*LBB*) sentence imitations are more successful than *Right Branching with Forward Proform* (*RBF*). This reverses the result found for sentences with lexical pronouns (e.g., 8a and b), where RB sentences like 15a (=8a) were more successfully imitated than those like 15b overall (LFHGS24).[17] In sentences with null subjects, individuals in all groups are to some

17) Conflating over pronun direction variation in sentences with lexical pronouns (LFHGS24).

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degree more successful with the LBB null subject sentences such as 16b than with the RBF such as 16a.

As Figures 2 and 3 show, preference for LBB sentences with null subjects holds across groups both with and without *Semantic Plausibility*. At the same time, production of both RBF and LBB forms with null arguments is below 50% in aMCI across semantic conditions (RBF = .363, LBB = .469).

(15) a. The *electrician* fixed the light switch when *he* visited the tenant.
b. When *she* remembered the orphan, t*he composer* wrote the sonata.

(16) a. The *chef* assembled the casserole when ∅ instructing the apprentice.
b. When ∅ examining the soldier, th*e medic* assessed the injury.

5.3 Reformations in Temporal Adjuncts With Null Subjects[18]

Qualitative analyses of aMCI sentence production confirm an underlying relation between anaphoric construal in null/nonfinite and lexical/finite adjuncts. Examples of types of aMCI reformations are shown in Table 4.

Table 4

Examples of Anaphora Reformations in aMCI Imitation of Temporal Adjuncts With Null Subjects

Reformations of either NP antecedent or Null proform
I. Conversion of NP
NP > NP
(1) R: When examining the soldier, the medic assessed the injury.
P: Ah … when examining the soldier, the um … somebody <laughter> somebody um um uh … examined the injuries. (TS011)
NP > Null
(2) R: When awakening the user, the believer broke the piano.
P: When awakening the user, um … broke the piano? Ok. (TS011)
NP > Pronoun
(3) R: When awakening the user, the believer broke the piano.
P: When awakening receiver, he broke the piano. (TS015)
(4) P: When awakening the believer, they broke the piano. (TS019)

18) We concentrate on aMCI data here since our main focus in this part of our research program is to understand language deterioration in aMCI. We concentrate our analysis on reformations concerning anaphoric construal, and on 'productive' forms of reformation, i.e., those occurring repeatedly, across different sentences, across different participants.

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II. Conversion of Null

Null > Pronoun

(5) R: The chef assembled the casserole when instructing the apprentice.
P: The chef … something the casserole when he was instructing the … something. (TS005)

(6) R: The instructor demonstrated the rule when lecturing the pupil.
P: Lecturer … the lecturer exa>um examined the rule when he … something the lect>and the>lecturer> {laughter}. (TS007)

(7) P: The demonstrator instructed the rule … when she demonstrated the people. (TS019)

(8) R: The guest jeopardized the violin when refuting the minister.
P: The guest damaged the violin when he refuted the minister. (TS008)

Null > NP

(9) R: When examining the soldier, the medic assessed the injury.
P: … When the medic examined the soldier and assessed the injury. (TS007)

Note. R = Researcher model; P = Participant.

As summarized in Table 5, analyses of the components of anaphoric construal in the Control sentences, i.e., the NP antecedent and pro-form, showed that for aMCI, as for all groups, more reformations were made on the NP than on the null pro-form. This result resembles the pattern previously reported for finite sentences with lexical pronouns in LFHGS24 and suggests that, in general, an anaphora relation is being pursued in both cases: an antecedent must be identified for anaphoric construal.

Table 5

Percent of Reformations of Anaphora Components: Proform and NP Antecedent in HY, HA and aMCI (Percent of Items in Parentheses)

Nonfinite clauses with null proforms compared to finite clauses with lexical pronouns				
	Finite Clauses (LFHGS24)		**Nonfinite Clauses**	
	Pronoun	**NP**	**Null**	**NP**
HY	11.43 (2.5)	22.86 (5)	8 (2.5)	28 (8.75)
HA	7.77 (2.08)	32.04 (8.59)	16.07 (4.69)	30.36 (8.85)
aMCI	6.37 (2.84)	28.03 (12.5)	19.57 (10.23)	31.52 (16.48)

Note. Percent of reformations containing two clause errors.

At the same time, as Table 5 shows, there were more changes to the null than to the lexical pronoun subject in both aMCI and HA. aMCI individuals frequently changed the null subject to a lexical pronoun and simultaneously the nonfinite to a finite adjunct,

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as in 17a, b (examples 5–8 in Table 4). aMCI individuals changed the null pronominal in 19.57% of their reformations. This occurred even when individuals showed difficulty maintaining the lexical material in the sentence, as 17b and examples on Table 4 show. Although some conversions of lexical pronouns to null arguments in adjuncts has been reported (LFHGS24), such changes were minimal (contributing minimally to 2.84% of pronoun conversions). The productive conversion from null to lexical pronominals also contrasts with previous findings for coordinate sentences, e.g., 17c, in which aMCI individuals productively reduced the lexical pronoun to a null form; 41% of items, 95% of errors (LFHGS24, p. 33).

(17) a. R: The chef assembled the casserole when ∅ instructing the apprentice.
P: The chef in>assembled the casserole when he encountered the apprentice. (TS007)
b. R: The chef assembled the casserole when instructing the apprentice.
P: The chef…something the casserole when he was instructing the… something. (TS005)
c. R: The server provided the menu and she brought the appetizer.
P: The server provided the menu and ∅ brought the appetizer. (TS026)
(LFHGS24, Table 6)

Changes from a null subject to a lexical pronoun mainly occurred in the RBF adjuncts, as in 17a or b, accounting for 22.4% of aMCI errors on these RBF sentences. 90% of these conversions appropriately converted a nonfinite clause to a tensed clause, indicating a link between clause finiteness and pro-form type (null or lexical pronoun[19]), e.g., examples 5-8 on Table 4. In LBB sentences, by contrast, conversion to a backward pronoun with a finite clause was nearly completely absent (2.7%).[20]

Notably, although there were few errors overall in the Healthy Young group, pronoun insertions were also observed in this group, as in 18.

(18) R: The guest jeopardized the violin when ∅ refuting the minister.
P: The guest jeopardized the violin when **he** refuted the minister. (AD88)

Through these conversions in RBF cases such as 17 or 18, individuals demonstrate a directionality effect consistent with lexical pronouns. A forward anaphora preference is well-known and well-studied in association with lexical pronouns. In this experiment we

19) Although we do not pursue this issue here, explanation of the difference in left branching/preposed sentences may be assumed to involve the representation of left branching/preposed structures in general (e.g., Kayne, 1994), and to the nature of an anaphoric 'forward directionality' preference linked to lexical pronouns in right branching.

20) In LFHGS24, left branching/preposed adjoined clauses with backward lexical pronouns, e.g., "When she remembered the orphan, the composer wrote the sonata" were found to be the most difficult of all constructions with lexical pronouns in all conditions (i.e., lowering mean correct to .296 in -Semantic condition).

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see a complementary relation with null subjects: production of sentences with forward null arguments is reduced in favor of forward pronoun production in adjunct domains.

These reformation data confirm a relation between null and lexical pronominal anaphora in temporal adjuncts, as well as a tendency toward generalization to a lexical pronominal and a finite domain. The correlation of pronominal form and clause finiteness confirms that this relation is grammatical and structure dependent. The apparent contrast in the role of directionality in Control sentences with null subjects is due to selective reformation in nonfinite RB sentences (not LB) towards a forward lexical pronoun and rightward finiteness. Thus, the finite/lexical pronoun and nonfinite/null pronominal results cohere.

5.4 Anaphoric Construal Type Affects aMCI Language Production Within Individuals

Table 6 exemplifies production by three aMCI participants across different sentence types, contrasting their performance on the Control sentences in this current study to that across experiments in our wider program. Production success within each individual varies across anaphoric construal types.

Table 6

Within Participant Comparisons in aMCI Production of Sentences with null and lexical arguments in Adjunct Clauses and Coordinate Clauses

aMCI Participant *(TS005)*
A. Adjunct Clauses (LFHGS24)
Lexical Pronominal
The dressmaker mended the costume when she encountered the actress [RBFPron]
P: The dressmaker…uh mended the…uh…no
Null pronominal
The chef assembled the casserole when instructing the apprentice [RBFNull]
P: The chef…something the casserole when he was instructing the…someth
B. Adjunct Principle C (LFHGS24)
She answered the telephone when the receptionist heard the caller
P: She answered the telephone when the receptionist heard the caller
C. Coordinate Clauses (LFHGS24)
Null Argument
The mechanic replaced the transmission and repaired the suspension
P: The mechanic replaced the transmission and repaired the…suspension

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NP Argument

The postman sorted the mail and the postman delivered the package

P: The postman sorted the mail and the postman delivered the package

Pronoun

R: The server provided the menu and she brought the appetizer

P The server provided the menu and brought the appetizer

aMCI Participant *(TS011)*

A. Adjunct Clauses (LFHGS24)

Lexical Pronominal

The electrician fixed the light switch when he visited the tenant [RBFPron]

P: The elec…lectrician a um inspected the light switch…am I close?

Null Pronominal

The chef assembled the casserole when instructing the apprentice [RBFNull]

P: The chef ah…um…the chef um…something with the casserole, and the student

B. Adjunct Principle C (LFHGS24)

She measured the artifact when the storyteller paid the boyfriend

P: Um could you repeat that one

P: Ah, she, ig>ah examined the artifact while the somebody paid the boyfriend

C. Coordinate Clauses (LFHGS24)

Null Argument

The babysitter emptied the bottle and prepared the formula

P: The babysitter emptied the bottle and prepared the f>formula

NP Argument

The student opened the backpack and the student erased the blackboard

P: The student opened the backpack and the student erased the blackboard

Pronoun

R: The firefighter organized the equipment and he started the pump.

P: The firefighter ah s > sorted the …

R: I'll read it again. R: The firefighter organized the equipment and he started the pump.

P: The firefighter ah organized the equipment and started the pump

aMCI Participant *(TS202)*

A. Adjunct Clauses (LFHGS24)

Lexical Pronoun

The dressmaker mended the costume when she encountered the actress [RBFPron]

P: The dressmaker something the costume when she encountered the actress

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Null Pronominal

The instructor demonstrated the rule when lecturing the pupil [RBFNull]

P: The instructure>the instructor demonstrated the rule while he did the c-call..probably when he demonstrated the…

B. Adjunct Principle C (LFHGS24)

He triggered the alarm when the ambassador saw the intruder

P: He triggered the alarm when the ambassador saw the intruder

C. Coordinate Clauses (LFHGS24)

Null Argument

The babysitter emptied the bottle and prepared the formula

P: The babysitter emptied the bottle and prepared the formula

NP Argument

The plumber damaged the book and the plumber requested the apple

P: The plumber damaged the book and the plumber requested the apple

Pronoun

R: The firefighter organized the equipment and he started the pump.

P: The firefighter organized the equipment and he started the pump.

Each individual's production is compared on (6A) null and lexical pronominal sentences in temporal adjuncts, where both Binding/Control and Coreferential/NOC construals are possible, on (6B) Binding Principle C sentences where anaphoric construal is disallowed, and on (6C) Coordinate Sentences where only Binding is available in the null forms in contrast to lexical pronouns. As the examples suggest, temporal adjunct conditions (both null and lexical) where both types of construal are possible (6A), both provoke incorrect productions, in contrast to success with the 6B and 6C sentence types, conforming with Group statistics.[21]

As the examples show, production of both the temporal adjuncts (lexical and null) is exceptionally difficult for these aMCI individuals. See for example participants' poor sentence production in null and lexical pronominal conditions in adjuncts, compared to their successful performance on the Principle C sentence and Coordinate sentence with null argument. Productive reduction of the lexical pronoun in Coordinate Sentence to a null argument (where Binding results) contrasts with the conversion of the null form to a lexical pronoun in temporal adjuncts (where both CR and Binding/OC and NOC construal types are options). Since all sentences across all conditions were equally

21) Statistical analyses are based on Group populations, assuming and correcting for variance within Group. Not all individuals reflect within themselves the patterns reflected in significant *Group* differences; however, some do. We have demonstrated this in 3 individuals in Table 6.

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controlled in factors such as length and lexical frequency, these results provide evidence that both language production success and reformations are modulated by anaphoric construal possibilities of the model sentence. They do so both within group statistics and within individuals.

5.5 Summary of Experimental Results: Control Sentences

In this experiment, aMCI production of Control sentences, i.e., nonfinite temporal adjuncts with null subjects, is significantly depressed compared to HY and HA, as it was for comparable finite sentences with lexical pronouns (LFHGS24). This confirms our leading hypothesis that temporal adjuncts with null subjects would also challenge aMCI, given their shared option for dual anaphoric construal types (Coreference and Binding, NOC and OC).

This shared deficit contrasts with sentences in our wider program which reflect Binding, e.g., Principle C or Coordinate VP ellipsis without dual construal options, where aMCI individuals are relatively successful in sentence production (LFHGS24).

Qualitative analyses confirm that participants related lexical pronominal (finite) and Control (nonfinite) sentence types. aMCI productively represented the nonfinite sentences with null arguments by converting them to lexical pronominalization and finite adjunction; according with shared construal types across these sentence types. Conversion of null to lexical pronoun would appear to reflect recognition of Coreference possibilities in the control domain. Comparison to results from our wider program confirms that this productive conversion from null to lexical pronominal forms distinguished the temporal adjunct domain.

Semantic Plausibility does not significantly interact in determining *Group* effects, suggesting that, as with lexical pronouns, the source of aMCI deficit in Control sentences lies, at least in part, in the syntactic factors involved in anaphoric construal, over and above their general semantic plausibility. A significant sensitivity to the *(BDPD)* factor in nonfinite sentences, independent of Semantic Plausibility, confirms that construal is structure dependent, as it was in the finite sentences in our previous study.

These results confirm that an aMCI language deficit selectively targets sentences involving an option for context- dependent anaphoric construal, generalizing across the differences between Control structures and finite adjuncts in their syntactic and phonetic/morphological representation. This deficit is thus not specifically linked to the pronominal form (lexical or null) in the clausal adjunct. Rather, it is linked to the computation of anaphoric construal which underlies both Control and lexical pronominal anaphora.

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6 Discussion

If a dissociation of anaphoric construal types between Obligatory Control and Non Obligatory Control (in terms of Control Theory), or between Binding and Coreference (in terms of Binding Theory), is structured by the architecture of the Language Faculty (LF), then aMCI language deterioration appears to specifically indicate weakening at the LF interface, where syntactic computation confronts the external context of thought, and dual modes of anaphoric construal are possible. While HY and HA fluently navigate the ambiguity of two forms of construal across the interface (syntax internal and context external), the aMCI population is significantly challenged.

While these results documenting a language deficit in aMCI implicate a space in the linguistic-cognitive architecture of the mind, viz., the interface structured by the Language Faculty, they lead to a fundamental issue: what is the nature of the knowledge which underlies the specific interface deficit?

6.1 Leading Question

Given the existence of two forms of anaphoric construal, why are sentences with the option for Coreference/NOC selectively deficited?

Although aMCI deficit has been found to involve computation of anaphora, this deficit is not due to a general deficit in syntax. As we saw, while deficited on sentences like 2/8 or 3/13, individuals with aMCI are not similarly deficited on comparable sentences with no anaphoric construal, e.g., 12; as we saw, or on sentences reflecting Binding, as reflected in Principle C effects, e.g., 9 (LFHGS24, 2017; Sherman et al., 2021).

Cognitive limitations of aMCI such as memory also are not a general explanation for our linguistic results (Sherman et al., 2021, 2020, 2026). As we noted, tests of memory (i.e., ACE-R, or Brown-Peterson) have not shown significant correlations with aMCI linguistic performance.

Given the complexity of computation of reference in 3.1, it would appear to follow that deficit in Coreferential and context- dependent computation must be involved in an explanation of the aMCI deficit. However, there is no general indication of a correlated failure in specific reference required by nominals. Independent tests of Naming or Semantic Fluency measured on the ACE-R (Sherman et al., 2021, 2020, 2016, 2013, 2026) have failed to predict the observed language deficit. Significant success on lexically headed relatives (in contrast to free relatives), e.g., 11 (Lust et al., 2017; Sherman et al., 2021), also suggests that deficit does not lie simply at the level of specific reference. Principle C sentence, e.g., 9, production is highly successful although these sentence types include indeterminacy of pronoun reference. Success with Principle C sentences does not require integration of the pronoun in anaphoric construal, suggesting that source of deficit does not lie in the referential properties of the pronoun in particular, but relates specifically to integration of anaphoric construal in sentence syntax.

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"Reference Set" Challenge: Dual Anaphora Options

As we noted in our previous paper LFHGS24 (p. 17), it is possible that the deficit we have observed is not simply due to the challenge of Coreferential or context dependent construal itself but to the challenge of the availability of dual modes of construal at the interface; (Binding/OC) and (Coreference/NOC). This would reflect what has been called a "reference set" challenge at the interface of the Language Faculty with general cognition (Reinhart, 2006). Our experimental sentences, e.g., 2/8 or 3/13, allow both types of construal equivalently in the same sentence.

As we argued in LFHGS24, while our data may reflect an interface challenge involving dual anaphoric construal types, they do not support current representations of proposed mechanisms for 'reference set' computation. For example, they do not support memory of, and choice between, two distinct potential interpretations of pronominal reference in a given sentence (e.g., Reinhart, 2006). Since there was no discourse context presented in the EI task, there was no necessity for determination of specific discourse referents and no evidence that speakers did so or tried to do so. Thus, there is no evidence for competing construal options based on their specific reference. Critically, the EI task on which our language data are based continually reflects participants' creative integration of meaning and form, as seen in their reformations, but does not require, and does not reflect, generation of specific reference in representation of sentence meaning.[22] This fact is compatible with linguistic analyses which recognize the computation of reference to be distinct from computation of essential syntactic and semantic form (e.g., Chomsky, 2013). It is also consistent with studies of sentence processing where reference to pronoun context has been discovered to be delayed (e.g., Karimi & Ferreira, 2016, p. 1024; LFHGS24; Nagano et al., 2020; Mak & Sanders, 2010; Stevenson & Vitkovitch, 1986) where "… in an initial syntactic parse pronouns function as uninterpreted variables, supporting an abstract linguistic representation in initial sentence parsing…" (LFHGS24, p.18). It is also consistent with neuroscientific analyses of sentence processing which recognize syntax-semantics integration as a later stage in the course of sentence processing (Friederici, 2002).

Thus, while our results confirm that an interface challenge exists, they suggest that this challenge is not based on referential properties of lexical pronominal forms. Our current results which involve null pronominals in Control structures accentuate the need to recognize, but redefine, this interface challenge.

Tentative Resolution

Although it is not possible to resolve our leading question without further research, our data lead us to pursue the architecture of the Language Faculty as it both invites and constrains the interface of language with thought. While the architecture of the LF structures two possible forms of anaphoric construal, i.e., two ways in which language

22) These results support the shift from the original "Coreference" construal type label to "covaluation."

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integrates with thought, it does not resolve choice between the two. It does not determine specific behavior; it does not resolve optional construal type.

Given our results, we assume that the Binding Theory module of the LF determines construal by Binding and its inverse equivalently, and is always available. The structure dependence of Binding defines both what is possible and what is not. aMCI individuals, like cognitively normal adults, show continuous structure dependence. At the same time, the capacity for external reference is also always available, providing the competence for Coreference or NOC.[23] This means that the mind at the interface can and must continually toggle between two potential construal types, equally available, one allowing infinite extension to thought in the external world and countless possible relations between antecedent and proform in anaphora construal. This ambiguity is the "unmarked" state.

Cognitive weakening in aMCI may lie in weakened ability to associate these cognitive extensions to the linguistic structure of anaphoric construal. aMCI language deficit may lie in weakening of inter-modular association, not in language itself, not in syntactic Binding, not in cognitive reference itself.

Binding resolves a potential conflict between internally and externally determined anaphoric construal types; non Binding conditions do not. When a Binding structure provides a potential for obligatory binding, that option is taken, as in pronoun reduction in VP ellipsis, e.g., 16c. When it does not, as in temporal adjunctions, both options remain. Non Binding construal engages a weakening cognitive competence attested in cognitive impairment. When the structure of Binding (as in Principle C) prevents anaphora construal, e.g., 9, the language production deficit is avoided (See Table 6).

This tentative proposal recognizes the empirical reality of a 'reference set' challenge at the LF interface (Reinhart, 2006). However, it suggests that the challenge is solved at the level of the architecture of the interface, not at the level of processing of individual construal types, or of 'efficiency' principles to resolve choice between them. Current clinical study in the area of aMCI coheres with this approach; it suggests that cognitive deficit in MCI may reflect weakening of inter-modular cognitive associations more generally (Sherman et al., 2020, 2026). We suggest that 'reference set ambiguity' is in fact not an exceptional instance to be resolved at the LF interface but is in fact a reflection of the essential nature of the architecture of the Language Faculty.

6.2 Linguistic Knowledge: Binding and Control

Given this approach to explanation of aMCI deficit, further analyses of the clinical deficit we have discovered in language production now requires further linguistic analyses of the language we measure.

23) The inverse function of Binding necessitates free reference. These results also motivate renaming of the 'reference set' challenge.

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We may first ask what the knowledge is that underlies the dissociation which both Control Theory and Binding Theory recognize, i.e., that between OC and NOC, in Control Theory, and Binding and Coreference, in Binding Theory (see Landau, 2013, pp. 54-58; 2021, pp. 183-84).[24]

If these dissociations both reflect an essential design feature of the Language faculty which is structure dependent and which overrides language-specific phenomena such as morphology (of pronominal form) and inflection (finiteness), then we are led to pursue the representation of a grammatical core; one which provides fundamental constraint on knowledge, acquisition and loss. As Landau (2021, p. 184) summarizes, our challenge is "to highlight the similar ways in which competition between two strategies – one syntactic or at least LF [Logical Form]-visible, and the other pragmatic, related to reference tracking in discourse plays out both in the binding module and in the control module… Finding such parallels across empirical domains is a promising sign that a fundamental design feature of language is at work" (cf. Landau, 2021, 199f; see Landau, 2024b, for review and discussion in terms of a general Control Theory).

As sketched in Figure 4, both BT and CT reveal the fundamental dissociation between two types of dependency: syntactically determined and context dependent. Both integrate some form of c-command in this dissociation; both involve a variable differentiated as bound or free accordingly. Both engage a range of contextual effects in long distance domains, i.e., non local Binding, or NOC. Both apply over both lexical and null proforms.

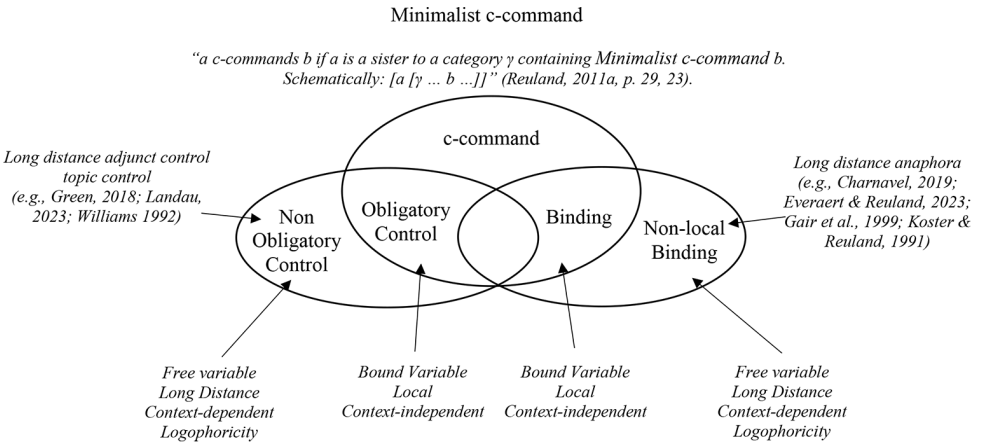
Syntactic factors distinguish adjunct Control as they do Binding. In OC, the controller "must be an argument of the clause immediately dominating the adjunct" (Landau, 2021, p. 21). In Binding Theory, structural locality determines lexical anaphor Binding. In this way, both Binding and Control distinguish long distance (cross clausal) dependencies.

24) In early work, Manzini (1983, p. 421) argued that "…control is an essentially configurational phenomenon and control theory an essentially configurational theory: in particular, control theory is constructed on essentially the same notions on which binding theory is constructed…" (see also Koster, 1984; Manzini & Roussou, 2000; McFadden & Sundaresan, 2018).

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Figure 4

Binding Theory and Control Theory: The Epistemological Structure



6.3 Open Questions and Future Research

Given the epistemological framework in Figure 4, any one or more of factors 6.3.1-6.3.6 may be crucial in determining the nature of the selective aMCI language deficit our experimental work has revealed.

6.3.1 Configuration

To what degree and how does Configuration explain the fundamental Dissociation between two types of dependencies: Binding and Coreference, or OC and NOC? If c-command configuration is essential to defining both Binding and Control, as in Figure 4, what c-command representation is at work? To what degree is locality determinate? In general, how is CP structure critical to construal type dissociation?

Our research in this paper concerns a single configurational domain, e.g., 2 and 3 (which allows both syntax-determined Binding or OC and Context-dependent Coreference or NOC) in temporal adjuncts. Our results across experiments have shown that the default option for lexical pronominals in these domains is structure dependent (e.g., LFHGS24). What then about the structure of these sentences triggers this default to lexical pronominals? While all of the sentences in our experiment with lexical pronouns in temporal adjuncts allowed Binding, this is structural Binding in long distance domains. Similarly, in all of the experimental sentences with null arguments the potential Control dependency is long distance.

To investigate the role of configuration in informing contrasting behaviors, further empirical research can now consider other Binding type and Control type dependencies.[25] For example, sentences with lexical pronominals can be constructed with non

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c-commanding antecedents, e.g., sentence internally or in discourse, thus disallowing Binding and testing the existence of Coreference in isolation. (See Burkhardt et al., 2008; Koornneef, 2010, for examples). Future research can distinguish types of 'logical binding' in distinction from 'syntactic binding' (e.g., Reinhart, 2006, p. 207).

Varied sentence forms with null arguments can be tested comparing forms of OC to NOC; for example, subject purpose clauses such as "Mary invited John ∅ to help with the cooking" (Landau, pc, 2021) which do not allow a context dependent option. Sentences with "partial control," which reflect both syntax-dependent and context-dependent dependencies within the same sentence, e.g., 19, can be tested as another 'reference set' challenge.

(19) It was humiliating to the chair$_i$ [$\emptyset_{i+}$ to disperse so abruptly] (Landau, 2024b, p. 14: 27d).

Future research can now pursue the issue of configuration in coordinate sentences, e.g., 10a and b. In what way are dual anaphora construal options available in 10a, what is the relation between 10a and b, and why is a Binding option (10b) chosen in this case in contrast to that in temporal adjuncts.[26] What configurational factors distinguish coordinate and adjoined clause structures, and how are they involved in determining contrasting anaphoric construal types?

6.3.2 Finiteness

What explains the productive conversion of the nonfinite form of temporal adjuncts to a corresponding finite form with a lexical pronominal?

More generally, why is finite sentential anaphora with lexical pronominals the apparent default for sentences with temporal adjuncts in our experiments? As we noted, the opposite conversion, from lexical pronoun to null non finite sentences, was barely existent in these adjuncts. This conversion to lexical pronouns would appear to recognize the Coreferential or NOC construal option in these finite sentences, given the phi features of the lexical pronoun and their invitation to reference. But why is this true when an alternative option for nonfinite Control with null subjects, exists? Why is this true if reference to context (enabled by lexical pronouns) provides a critical explanation for the observed deficit?

Notably, our comparison of lexical and null pronominals in this study is based on viewing sentence types such as 2/8 and 3/13 as comparable structurally. This dismisses

25) Direct test of NOC in sentences such as 3/13 is not possible given the absence of "strict NOC' in such adjuncts (Landau, 2021, 2024a, p. 51); however, other NOC complex sentence forms can now be tested in future research.

26) This question is suggested by one of our reviewers.

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the distinction in finiteness between them, and makes the productive conversion from the nonfinite to the finite form even more puzzling.

We may consider that a Coreference or NOC type construal invokes cognitive factors including logophoricity, as Figure 4 sketches. In Control Theory, a "Propositional variant" reflects a "perspectival center" (Landau, 2024b, p. 34); the controller is identified by "logophoric" antecedence; the construal is 'logophorically anchored" (Landau, 2021, p. 17; 2024b, section 2.2, for summary; cf. Williams, 1992). In Binding Theory, a conceptual anchor of 'logophoricity' is proposed to underlie long distance pronominal anaphora (Charnavel, 2019, 2020; Clements, 1975; Everaert & Reuland, 2023; Koster & Reuland, 1991; Reuland, 2006; see also Sundaresan, 2018, for study of the syntactic role of a "mental or spatio-temporal perspective holder" in differentiating anaphora types).

We can assess a hypothesis that finiteness may provide "logophoric anchoring." That is, "clauses with a finite (indicative) verb form… are anchored directly to the Speech event…," in distinction from infinitival control clauses (Bianchi, 2003, p. 26). The conversion to a lexical pronominal form and a finite clause may reflect an attempt to achieve logophoricity in order to begin to resolve the indeterminacy of the null argument in this adjunct structure. Given the variation in representation of finiteness across languages (e.g., Gair, 2005), cross linguistic work will be essential to pursue this issue.

Future research can further consider the syntactic role of finiteness in establishing clause boundaries in the syntax of pronominal binding (Grano & Lasnik, 2018; Newman & Branan, 2026).[27]

6.3.3 Syntax-Semantics Integration

To what degree and how is semantic conceptualization involved in the aMCI deficit in anaphoric construal?

All anaphoric construal reflects an integration of syntax and semantics. Varius semantic and pragmatic factors are involved in determining the wide range of possible control dependencies, e.g., "…argument structure, event decomposition, and attitude ascription…" (Landau, 2024a, p. 54). In a comprehensive theory of Control, OC has been argued to be determined through predication, where the control relation denotes a property; in contrast, NOC denotes a proposition as complement. A "Propositional variant criterion" reflects a predicative vs propositional distinction between Control types: adjuncts without a propositional variant, e.g., 20a, are predicative and require strict OC, in contrast to a propositional type, e.g., 20b which hosts a lexical pronoun (Landau, 2024a, p. 51).

27) We thank Elise Newman for suggesting this line of inquiry.

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(20) a. The electrician **failed** ∅ to fix the light switch > *The electrician failed that he fix the light switch"
b. The electrician **promised** ∅ to fix the light switch> The electrician promised that he fix the light switch.

In this theory, different classes of verbs/predicates correspond to different semantic types: e.g. attitude (e.g., *promise, want,*), vs. non attitude verbs (e.g., *dare, fail…*). This semantic type distinction predicts a "propositional variant" as a determinative indicator of NOC (Landau, 2024a, pp. 36-37).

While our experimental designs varied lexical semantic associativity, they did not vary predication type. To evaluate the relation of semantic selection to the propositional, finite clause option which individuals demonstrated in our study, further empirical research can now test for the effects of predication types.

6.3.4 Lexical vs. Null Pronominal Forms

What is the nature of the null argument and in what ways does it resemble or dissemble the lexical pronoun?

Our results have confirmed that both null arguments and lexical pronouns are accessible to both Binding/OC and Coreferential/NOC construal relations; "phonological nullness" is not a defining feature of anaphoric construal type (cf. Landau, 2015, p. 80). However, lexical and null pronominals are not equivalent in our results, as the asymmetric structure dependent productive conversion of one to another (null to pronominal) shows. These results accentuate issues in the representation of null arguments in a sentence where either type of anaphoric construal can apply. A null argument, like a pronoun, must be allowed to take the form either of a bound or a free variable, depending on construal type.

Given the structure dependence which our data has shown in both lexical and null pronoun generation, we may hypothesize that "we need contextual binding principles for determining what anaphoric status must be assigned to pronouns…," i.e., pronouns that "are not lexically marked as 'anaphor' or 'pronominal…'" (Everaert, 1991, p. 114). This hypothesis that syntactic context is determinative of lexical pronominal categorization can be extended to null as well as lexical arguments (see, e.g., McFadden & Sundaresan, 2018; Sundaresan, 2014).

Current approaches to the syntactic representation of Binding in terms of degrees of phi-specificity of lexical anaphors begin to address the challenge of relating null (necessarily phi deficient) and lexical (phi specified) arguments in a uniform Binding Theory of anaphoric construal (Everaert & Reuland, 2023; Reuland, 2006; Reuland & Zubkov, 2022).[28] Given the fact that languages differ in their relations between null and lexical proforms (e.g., Gómez et al., 2022), cross linguistic evidence will be critical to a general theory[29] (cf. Landau, 2015, p. 80). In studying aMCI language, future research can

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further evaluate contextual variation of both null and lexical proforms within and across languages.

6.3.5 Directionality

What explains the directionality effects in conversion to finite sentential structures?

In our data, conversions from null to lexical pronominal forms occurred selectively in the right branching postposed adjunct forms and install a forward lexical pronoun accordingly. What explains these directionality effects involving clausal location? What explains the relatively superior maintenance of backward null dependencies in preposed structures?

Further investigation of this finding will require further study of 'backward control' a relatively understudied phenomenon (e.g., Landau, 2024a, p. 54; see Subbārāo, 2012, for study of South Asian languages; see Jayaseelan, 1999; Gair, 2005, for relevant research). It is possible that this directionality effect implicates fundamental parametric variations of the specific language (see Gair et al., 1998; Haddad & Potsdam, 2009; Lust, Chien & Mangione, 1983; Lust, Mangione & Chien, 1984; Oshima & Lust, 1997, for initial cross-linguistic study).

6.3.6 Context

If an option for construal by Coreference or Non Obligatory Control is a source of deficit in aMCI anaphora computation, then what is problematic about context-dependent construal?

The aMCI population may be afflicted by mild impairment in a variety of cognitive dimensions (Petersen, 2003, 2004). When anaphoric dependencies are not resolved through internal syntax, a wide range of lexical, semantic and syntactic factors may interact in determining them, each a dimension of potential cognitive deficit. See Appendix. It has long been recognized that not only do adjunct dependencies possibly refer to discourse-based referents, but to 'implicit,' or 'thought based' antecedents, e.g., 21.

(21) a. While ∅ in a coma, it seemed to me that the world was on fire (Williams, 1992, p. 301, 12a).
b. ∅ Having just arrived in town, the new hotel seemed like a good place to stop (Williams, 1992, p. 300, 8).

28) On the issue of categorization of nominals see Heim and Kratzer (1998), Reuland (2011a, pp. 239-248; 2006), Everaert (1991). In language acquisition, see study of the notion of lexical 'anaphor' in Japanese language acquisition by Mazuka and Lust (1994) and Lust et al. (1989) for proposal for context dependent characterization of anaphoric forms.

29) See Gómez et al. (2022, p. 9) for evidence of asymmetric null/pronominal contrast in Colombian Spanish. Here a referential (strict) interpretation is possible for the lexical pronoun, but not for the null.

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For example, if logophoricity is impaired, this would challenge integration of context with the syntax of language, since "Logophoric antecedents" reflect a point of view by "sentient individuals whose mental perspective is involved in the reported situation" (Landau, 2021; 2024a, p. 32) and provide a cognitive "center of deixis" (see Bianchi, 2003; Landau, 2023, for discussion).

Empirical studies can now pursue experimental designs which manipulate semantic and pragmatic context as variables; and include controlled assessment of cognitive and linguistic factors (e.g., Sherman et al., 2021, 2026). Although early studies of language deficit in aMCI have assessed the role of discourse access in AD and prodromal AD (e.g., Chapin et al., 2022; Kemper et al., 1993; Kempler et al., 1999) there has been little assessment, to our knowledge, of the role of specific factors involved in the cognitive relation between thought and language relevant to computation of anaphoric dependencies such as logophoricity. Initial studies of Theory of Mind in Alzheimer's disease may provide relevant evidence (e.g., Moreau et al., 2016)

6.4 Limitations of This Study

Empirically, given the wide variance in any population of normal Healthy Aging, or of MCI (e.g., Corbo & Casagrande, 2022; Ganguli et al., 2004; Mattke et al., 2023), larger populations must be studied now in order to validate and generalize our program results. Longitudinal study is necessary to evaluate their predictiveness. Comprehension tests can provide converging evidence to our production tests. If there is in fact a Language Faculty substrate for selective deficit in aMCI language as we have hypothesized, then comparative cross linguistic research must be conducted, as well as comparative studies of language acquisition.

Theoretically, while our interpretation of our results has been framed in terms of the architecture of the LF, specifically its interface, it leaves undefined the implementation, linguistic and/or psychological, by which anaphora type resolution is selectively weakened in MCI. We leave to future research the draft of a comprehensive model of cognitive language-thought relations, structured by specific constraints of the Language Faculty CI Interface.

In the end, an essential mystery remains regarding the essential deficit which our experimental program has revealed to date. An option for a Coreferential or NOC anaphoric construal selectively depresses success in sentence production in aMCI. It does so even when an actual referential interpretation of the sentence is not attempted. The architecture of the Language Faculty simply provides the structure dependent possibility for it. Future study is necessary for resolving this mystery.

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7 Conclusions

In general, our results confirm that linguistic analyses of language in aMCI, and potentially in other pathologies (e.g., Chapin et al., 2022; Hinzen et al., 2018; Moro et al., 2001; Vasić, 2006, and others), are important in two ways: (i) they bear evidence on the linguistic content of the Language Faculty and its empirical manifestation, and (ii) they allow us to refine hypotheses regarding the underlying nature of aMCI and its behavioral manifestation. With further research, they can contribute to our linguistic as well as our clinical knowledge.

In particular, our project results confirm that assessment of sentence level language can advance explanation of observed language deficit in aMCI. Precision in analysis of deficit, targeting specific forms of linguistic computation, strengthened by continuing research, can bring more sensitivity and validity to standard cognitive testing platforms, which are most often focused on cognitive factors such as memory and word level investigations. Supplemented by experimental research, the clinical significance of pronoun use can be understood as an epiphenomenon of deeper aspects of language knowledge concerning language-thought relations.

Discoveries concerning the nature of aMCI language deficit which we report in this project, can advance current neuroscientific investigations of the biological substrate underlying AD and prodromal AD (e.g., Callahan, 2008; El Ouardi et al., 2023; LeDoux & Camblin, 2008; McMillan et al., 2012).[30] Neuroscientific studies of pronoun resolution can be developed in terms of the wider architecture of the Language Faculty (e.g., Friederici, 2012).[31]

Finally, our results suggest that the relation between linguistic theory and the empirical and experimental study of language is not only productive but symmetric. In our experimental work, advances in linguistic theory (both Binding Theory and Control Theory) have allowed the discovery of empirical results which inform the clinical area of cognitive deterioration in prodromal AD. At the same time, our empirical results have informed the linguistic theory which led them. In general, they have provided evidence of the nature of the Language Faculty, specifically of its C-I interface, providing evidence that the architecture of the Language Faculty structures the interaction between

30) For example, we conducted an early pilot study (Lust et al., 2016, 2017) to investigate the neural foundations of integration of language and thought in terms of the default network (e.g., Andrews-Hanna et al., 2014, Buckner et al., 2008; Spreng & Turner, 2013) and of an articulated sentence processing model (Friederici, 2002). Volumetric analyses (Voxel Based Morphometry (VBM)) of brain images of six aMCI subjects, in comparison to 18 healthy aging scans (ADNI) revealed a hypothesized cross-group difference in pattern of grey matter integrity; according with a processing dissociation between the computation involved in syntactic analyses and that in syntax-semantics integration; providing promise for more extended and refined investigations.

31) For example, recent study of pronoun processing through single unit neuronal recording recognizes pronoun variation across sentence contexts but leaves to future research "how brain networks implement such syntactic computations..." (Dijksterhuis et al., 2024, p. 1483; see also Nieuwland & van Berkum, 2008).

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language and thought. Specifically, they have supported advances in the study of Control Theory, confirming OC/NOC variation in control, and supporting challenges to the traditional view of adjunct control (Landau, 2021). Together they have spawned directions for effective new research both theoretically and empirically.

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Appendix

It has now been recognized that sentence types such as 1 below (sentence 3/13 in the text) do not require obligatory subject control (Landau, 2013, 2015, 2021, for review; see also Green, 2018, 2019. For early work, see also Bresnan, 1982; Mohanan, 1983, p. 650; Williams, 1980, and preliminary discussion in Lust et al., 1986, e.g., p. 274, Footnote 4, 5, 9 in early study of language acquisition.)

(1) a. The instructor demonstrated the rule when ∅ lecturing the pupil.
b. When ∅ babysitting the infant, the grandmother skimmed the newspaper.

For example, they can reach into internal sentence contexts to allow object construal as in 2 seemingly regardless of the subject c-command relation.

(2) a. The instructor$_i$ demonstrated the rule to the teaching assistant$_j$ when $\emptyset_{i,j}$ lecturing the pupil.[32]
b. The chef$_i$ assembled the linecooks$_j$ when $\emptyset_{i,j}$ composing the menu.
c. Emilia$_i$ studied Picasso's$_j$ facial composure when $\emptyset_{i,j}$ lecturing at the museum.

These sentence types also allow external contextual reference (Green, 1982; Landau, 2021). In cases like 3, the ∅ is often represented as PRO$_{arb}$ to reflect its arbitrary reference dependent on indeterminate context. Both subject antecedence and reference to context can occur in the same sentence, as in 3a (cf. Green, 2018, p. 144).

(3) a. The pool$_i$ was the perfect temperature [after $\emptyset_{i/\,arb}$ being in the hot sun all day] (Landau, 2021, p. 3; 2024a, p. 48, after Green, 2018, p. 40).
b. All preparations were made before $\emptyset_{arb}$ inviting the senator to the hearing (Green, 2019, p. 2).
c. The night sky can be an unforgettable spectacle while/when $\emptyset_{arb}$ camping in the desert (Landau, 2021: 5).

Interpretation of these sentence types can reach into discourse or other related contexts as in 4 or 5:

32) Throughout we represent example sentences from cited references as reported, except that in most cases we will represent a null subject as ∅ rather than labeling it as *PRO* or *PROarb* or *pro* for example; in order not to predetermine the nature of the null in these sites; which is in fact part of our empirical question. Where we use indices in connection with ∅ it is to graphically explicate potential construal relations between arguments, not to reflect an assumed form of linguistic computation for that construal.

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(4) Hermione is looking after the birds. Hermione takes out the food.
Ron tapped Hermione while ∅ feeding the owl (Landau, 2021, p. 4, after Janke & Bailey, 2017, p. 545).

(5) In the assistant's lectures the instructor kept criticizing the assistant.
The instructor$_i$ criticized the assistant$_j$ when $\emptyset_{i,j}$ lecturing the pupils.

Contextual effects such as topicality, logophoricity and other semantic and/or pragmatic properties of potential antecedents (e.g., +/- human) affect interpretation of the null pronominal in these sentences (Landau, 2021, p. 25; see also Green, 2018, 2019). These effects in Non Obligatory Control (NOC) are consistent with anaphoric construal options with lexical pronouns in finite adjunctions, and consistent with a potential Coreferential form of construal, one which crucially involves reference to context.

As with finite adjunctions with lexical pronouns, the same sentence can allow multiple interpretations resulting from both construal types. Multiple interpretations can arise in the (VP ellipsis, 'sloppy id') test; corresponding to either binding or coreferential interpretations.

(6) The instructor criticized the assistant when ∅ lecturing the pupils and the principal did too.
- Principal criticized the assistant when the assistant lecturing
- Principal criticized the assistant when the instructor lecturing
- Principal criticized the assistant when the principal lecturing

Here the completion of the VP ellipsis can invoke a variable binding type construal, i.e., both instructor and principal lecturing the pupils, or potential referential (strict) readings.

Finally, if dissociation of two types of anaphoric construal constitutes a design feature of the Language Faculty, cross linguistic evidence is essential. Cross-linguistic comparison productively involves null forms of pronominals. Although substantial systematic cross linguistic investigation exists for lexical pronouns and anaphors (e.g., Lust et al., 2000), comparable systematic study of structures including ellipsis have not been conducted (to our knowledge). However, as noted (e.g., Gair in Lust et al., 1986, p. 273; cf. Mohanan, 1983), initial cross linguistic evidence does not support universal obligatory subject control in adverbial adjuncts with null subjects. Discourse antecedents are seen in Sinhala (Gair pc, Lust et al. 1986) as in 7; see also Landau, 2021, pp. 105f, especially chapter 11, for assessment of nine languages which are "systematically ambiguous" between anaphoric construal types in purported control domains. See also Lust, Wali, Gair, and Subbarao (2000) in which in 14 South Asian languages across four language families, lexical forms are studied in a principled typology guided by Binding Theory, and complemented by tests of VP ellipsis/sloppy identity (See p. 777 section C-10).

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(7) yudde ivərə unaamə rajjuruwo maaligaawəTə aawa.
War over became-when king palace-DAT came
Ø enəkoTə maaligaawə lassənəTə sarsannay
Ø come-when palace beautifully decorate
kiyəla bisoo waeDəkaarəyanTə kiwwa
COMP queen workers-DAT said.
(The war having ended, the king returned to the palace. When ∅ coming, the queen told the workers to decorate the palace beautifully.)

Thus, we assume that like the finite adverbial adjuncts with lexical pronouns, non-finite adjunctions with null subjects such as 1 structurally allow free reference, although they generally have a strongly preferred sentence subject antecedent. Effects of pragmatic context are consistent with properties of a Coreference construal. In this way, in spite of their strong subject antecedent preference, nonfinite adjuncts like 1 resemble finite adjuncts like 8 where both a Binding and a Coreferential anaphora construal are possible. They do so regardless of phonetic form of the clausal subject, as lexical pronoun or null.[33] We assume that sentences like 1 and 8 are similar in anaphora construal possibilities, *modulo* language-specific variation in finiteness and the phonetic form of the adjunct subject.

(8) a. The$_{i}$ electrician$_{i}$ fixed the light switch when he$_{i,j}$ visited the tenant.
b. When he$_{i,j}$ visited the tenant, the electrician$_{i}$ fixed the light switch.

The pro-form functions in both cases (lexical or null) as an open variable free to be construed through externally determined reference and Coreference, or through Binding, i.e., as a bound variable, depending on construal type. Both 1 and 8 structurally support indeterminacy between external reference and internal syntactic determination through Binding. Both 1 and 8 implicate two possible forms of construal, one explicitly integrating pragmatic computation through context, both implicating the language-thought interface, each reflecting one of two possible interface strategies.

The evidence reviewed above allows us to test our hypothesis regarding sentences such as 1 in this paper's study of language deterioration in aMCI.

33) Note that these results confound the distinction in representation of the null subjects in control sentences, most frequently differentiated as PRO, or PROarb, vs. pro (a minimal pronominal). See McFadden and Sundaresan (2018) for discussion.

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