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Canonicity in argument realization and verb semantic deficits in Alzheimer's disease*

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1. Introduction

In this paper we argue that argument realization requires different types of information and that the mapping from meaning-to-form may be disrupted when knowledge necessary for its fulfillment breaks down as a result of brain damage. More specifically, we discuss the performance of a population suffering from a semantic deficit (i.e. Alzheimer's patients), in a sentence completion task with predicates that involve non-canonical argument realization.

The study of thematic (or semantic) roles is one of the most challenging topics in linguistic investigations, bringing together lexical, syntactic and semantic issues. Thematic roles label the ways in which entities are involved in, or related to, predicates. Their main function is to mediate between syntax and semantics, and to guide the mapping of semantic representations to syntactic structures. In other words, thematic roles are in part responsible for transferring meaning to the level of form. However, despite the general agreement on their crucial role in the syntax-semantics mapping, the way this mapping is achieved varies according to different approaches. Part of the problem lies in the fact that there is no general consensus as to how many, and what kind of, thematic roles exist. The majority of researchers working on thematic roles use labels such as *Agent*, *Theme*, *Patient*, *Goal*, *Instrument*, *Source*, *Location*, *Benefactive*, and *Experiencer*. Theories that make use of thematic roles target the interpretation of any noun phrase (NP) in a sentence, according to its syntactic position (*thematic hierarchy,* e.g. Fillmore, 1968; Grimshaw, 1990; Jackendoff, 1990), its general semantic content (*proto-roles,* e.g. Dowty, 1991), and its properties of animacy and definiteness (*animacy hierarchy,* e.g. Croft, 2003)[1]. These approaches are not mutually exclusive but often overlap.

In this paper we explore the effects of "canonicity" in argument realization, as stemming from the requirements of hierarchical relations (i.e. *thematic* and *animacy* hierarchies as well as proto-roles) in syntax-semantics mapping by examining how patients with Alzheimer's disease (AD) interpret sentences. We discuss experimental evidence (mostly from Manouilidou, de Almeida, Schwartz, and Nair, 2008) from patients' performance with verbs whose argument re-

alization follows canonical thematic hierarchy compared to their performance with verbs whose argument realization deviates from canonical hierarchy (*psych* verbs; e.g. *fear*, *frighten*). The study we discuss provides evidence for the role of canonicity in sentence processing and stresses the difficulties associated with structures deviating from canonical argument realization for brain-damaged populations, such as AD patients.

The paper is organized as follows: In section 2, we provide an overview of the role of various hierarchies in canonical argument realization. In section 3, we briefly describe the linguistic structures we investigated (i.e. psychological verbs and passive voice) and we show that they demonstrate non-canonical argument realization. Our experimental evidence from patients with AD is described in section 4. Finally, in section 5, we discuss our findings with respect to canonical argument realization and the semantic deficits of AD patients; we suggest that AD patients are sensitive to deviations from canonicity not only in terms of thematic hierarchy but also in terms of the [+/– agentive] verb feature.

2. Linguistic canonicity in argument realization

In this section, we describe some crucial issues on the principles that guide argument realization. We focus on the hierarchical relations of canonical argument realization based on the prerequisites of thematic and animacy hierarchies as well as proto-roles.

2.1. Thematic hierarchy

Proponents of the role of *thematic hierarchy* in argument realization claim that meaning-to-form mapping is based on hierarchical relations between thematic roles. Thematic hierarchy is the most widely used method to explain the mapping between an ordered list of semantic roles and an ordered list of grammatical relations, thus allowing for a particular argument of a verb to be referred to in terms of its function (e.g. subject or object), instead of in terms of its semantic role (e.g. *Agent* or *Patient*) (Levin and Rappaport Hovav, 2005: 155). For instance, Fillmore (1968) suggests that in a verb predicated of an *Agent*, an *Instrument* and a *Theme* argument, the preferred choice of subject is *Agent* > *Instrument* > *Theme/Patient*, meaning that whenever there is an *Agent* in the sentence, it occupies the subject position (e.g. *The boy opened the door*), and, in the absence of an *Agent*, it is the *Instrument* that occupies the subject position (e.g. *The key opened the door*); otherwise the subject is the *Theme* or *Patient* (e.g. *The door opened*).

Table 1. Sample thematic hierarchies.

Study	Thematic hierarchy*
Fillmore (1968)	*Ag > Ins > Th*
Jackendoff (1972)	*Ag > G/S/L > Th*
Givón (1984)	*Ag > Ben > Pat > L > Ins*
Belletti and Rizzi (1988)	*Ag > Exp >Th*
Baker (1989)	*Ag > Ins > Th/Pat > G/L*
Grimshaw (1990)	*Ag > Exp > G/S/L > Th*
Van Valin (1990)	*Ag > Eff > Exp > L > Th > Pat*
Jackendoff (1990)	*Act > Pat/Ben > Th > G/S/L*

** Ag (Agent), Exp (Experiencer), Ins (Instrument), Pat (Patient) G (Goal), S (Source) L (Location), Ben (Benefactor), Th (Theme), Eff (Effector).*

For Levin and Rappaport-Hovav (2005), thematic hierarchies emerge as the result of embedding relations among arguments in an event structure. These relations are always respected in argument realizations. Thus, it appears that more embedded arguments usually receive less prominent syntactic realizations. More recently, other thematic roles, such as *Goal, Source*, and *Location*, have been taken into consideration, resulting in multiple ways of forming thematic hierarchies (e.g. Baker, 1989, 1997; Givón, 1984; Grimshaw, 1990; Jackendoff, 1972, 1990; Van Valin, 1990; see Table 1 for a sample of thematic hierarchies). Although there is considerable variability in the ranking of various thematic roles, the only point of agreement found among them is the fact that whenever there is an *Agent*, it occupies the subject position. This observation leads us to the notion of *canonicity in argument realization* and deviations thereof.

In a *canonical* thematic hierarchy, then, the *Agent* thematic role occupies the most prominent position in the sentence. In the absence of an *Agent*, *atypical* argument realization emerges. Deviations from canonical argument realization can be observed at two levels: when the default *Agent* argument is missing such as in (1) and when there is a *mismatch* between the thematic hierarchy requirements and the actual argument realization, such as in (2). Thus, we will be using the term "non-canonical" to refer generally to two distinct levels of deviations from thematic hierarchy, calling the former case *atypical* argument realization, and the latter *non-canonical* argument realization proper.

(1)	The key opened	the door	
	⟨*Ins*⟩	⟨*Th*⟩	*atypical* argument realization
(2)	The door opened with	the key	
	⟨*Th*⟩	⟨*Ins*⟩	*non-canonical* argument realization

Although thematic hierarchies may provide an appealing way to describe various linguistic phenomena and regularities across languages, it seems to be impossible to formulate a thematic hierarchy which will capture all generalizations involving the realization of arguments in terms of their semantic roles. For instance, in a sentence such as (3), it is not clear whether *Agent* or *Instrument* should be assigned to the first NP. In order for the proper role to be assigned, one would need to know the actual nature of the event – e.g. whether the victim was dead or alive, whether or not an agent used the victim's hands as instrument, etc.

(3) The victim's hand opened the door

In addition, it is not clear which semantic and perhaps "world-knowledge" factors should enter into the determination of the proper characterization of thematic roles. It seems clear that, beyond the syntactic information about the number and the grammatical class of the arguments, more semantic information will be recruited for the realization of each argument. Thus, specific semantic properties of the arguments such as *sentience* and *causal order* also appear to become relevant. The crucial role of these properties in argument realization is assumed by proponents of animacy hierarchy and thematic proto-roles, which are discussed next.

2.2. Animacy Hierarchy

Hierarchical relations between arguments also appear to be regulated by animacy constraints. A hierarchy of animacy has been proposed by various authors to account for different grammatical phenomena. For instance, Morolong and Hyman (1977) use such a hierarchy to determine the object status of arguments, and Silverstein (1976) uses it in a typology of split ergativity systems. The exact characterization of the hierarchy varies from author to author. Animacy hierarchy involves several distinct but related grammatical dimensions, such as *person hierarchy*, in which first and second person outrank third person, *NP-type hierarchy*, in which pronouns outrank common nouns, and finally what Croft (2003: 130) calls the *animacy hierarchy proper*. In this last type of hierarchy, for SVO languages such as English, humans outrank nonhuman animates, which in turn outrank inanimates. Animacy hierarchy is not an ordering of discrete categories, but rather a more or less continuous category ranging from "most animate" to "least animate". In most languages, the animacy of NPs is closely related to particular thematic roles normally assigned by particular verbs. For instance, the thematic properties of the verb *to eat* dictate that it must assign the role of

Agent to an animate NP, while the role of *Theme* would more likely be assigned to an inanimate NP. The role of animacy has been observed both in language acquisition (e.g. Diessel, 2007; Ozeki and Shirai, 2007) as well as in language processing of adults (e.g. Kuperberg et al., 2007; Lamers, 2007) suggesting that animacy constraints on verbs' arguments are computed online and can affect verb processing. Thus, we should consider any structure consisting of an inanimate noun in the subject position and an animate noun in the object position, such as in (4), as deviation from the animacy hierarchy.

(4) The question amazed the journalist

Closely related to animacy hierarchy is Dowty's (1991) proposal about proto-roles, which is outlined below.

2.3. Proto-roles

Proponents of the importance of proto-roles in argument realization assume the existence of only two generalized thematic roles, labeled *macroroles* (Foley and Van Valin, 1984) or proto-roles (Dowty, 1991) – one for the *Agent* and one for the *Patient* (proto-*Agent* and proto-*Patient*). According to this view, thematic roles are not discrete categories, but rather are "cluster concepts" (Dowty, 1991: 571) drawing from a pool of basic semantic properties such as *sentience*, *volition*, and *movement*. No single thematic role necessarily has all of these properties, and some have more than others. Using a series of diagnostics, Dowty has suggested that each of these properties (or "entailments"), listed in Table 2, can be isolated from the others, and so should be treated as distinct. When the predicate of an active sentence takes two arguments, the one with more proto-*Agent* properties appears as the subject, even if both arguments could make good *Agents*. When

Table 2. Proto-*Agent* and proto-*Patient* properties from Dowty (1991)

Proto-Agent properties	**Proto-Patient properties**
Volitional involvement in the event or state	Undergoes change of state
Sentience (and/or perception)	Incremental theme
Causing an event or change of state in another participant	Causally affected by another participant
Movement (relative to another participant)	Stationary relative to movement of another participant
Exists independently of the event named by the verb	Does not exist independently of the event, or at all

a predicate takes three arguments, the non-subject argument with the fewest proto-*Patient* properties appears as the oblique or prepositional object, while the one with the most proto-*Agent* properties appears (as usual) as the subject.

Dowty's proto-roles proposal has several appealing qualities; most important among them is a decrease in the number of thematic roles. Arguments identified as true *Agents* have all or most of the Proto-agent properties and few or none of the proto-*Patient* properties; other thematic roles have few Proto-agent properties, or mixed proto-*Agent* and proto-*Patient* attributes. For example, the only Proto-agent property of a subject *Experiencer* verb, such as in *John admires the statue,* is sentience. Another attractive quality of the proto-roles proposal is that it captures all event properties that are of particular interest to humans in order to interpret the specific event. For instance, when confronted with an event, we tend to care a great deal about the volition of the participants in that event; about who caused what to happen; about participants' perception of, and attitude towards, an event; about whether an event was completed; and about what changes, if any, took place as the result of an event. Thus, canonicity in terms of proto-roles would be defined in a manner similar to canonicity in terms of animacy hierarchy, with the argument carrying more proto-*Agent* properties figuring in the subject position and the argument carrying more proto-patient properties occupying the object position.

There are, however, some potential problems with this theory. One concerns the *ontology* of the features that give rise to the proto-roles. Dowty treats these properties or features as "entailments" of the predicates, i.e., he treats them as the types of information that predicates entail about the nature of their constituent arguments. To put it simply, a predicate such as *kick* would select for an agent role which entails some of the properties listed in the first column of Table 2; for instance, it would entail *volition* and *causation* of the agent. It is not clear how these entailments work in the representation of the predicates – i.e., whether or not they are represented as part of the concept that a particular verb labels – nor is it clear what is the function of these entailments in the representation of the sentence formed by a particular predicate.[2] Another potential problem for understanding the nature of proto-roles is their function in language use, that is, what role they play in interpreting a sentence during linguistic perception. We defer some of these issues for later discussion in light of the data on AD patients' sentence processing.

Thus far, we outlined three basic principles for guiding the form-to-meaning mapping. These approaches suggest that there is a variety of factors that affect argument realization. A central question is how these different types of information come together to form a representation of meaning as we process language and what happens when some of the knowledge that is required for argument

realization breaks down as a result of brain damage. Some of these questions are addressed below, when we discuss a study on the performance of AD patients on linguistic structures that deviate from canonical argument realization. Since ADs are supposed to have difficulties with semantic – but not syntactic – aspects of language processing, we investigated how their alleged deficit interacts with the processing of non-canonical sentences. We compared sentences with *psych* verbs to sentences with agentive verbs, in both active and passive voice. More specifically, we used non-reversible sentences where the *Experiencer* is always an animate entity and the *Theme/Causer* an inanimate one, such as *the statue fascinated the public / the public admired the statue.* We now turn to a discussion on the nature of argument realization in *psych* verbs and in passive structures, which constitute the main type of materials employed in our study with AD patients.

3. Non-canonical linguistic structures

3.1. Psych Verbs

Psychological predicates have constituted one of the most fertile testing grounds for understanding the nature of the mapping between argument structure and thematic roles. According to Belletti and Rizzi (1988), *psych* verbs are divided in three distinct categories:

a. Class I: Nominative experiencer, accusative theme.
John loves Mary.
b. Class II: Nominative theme, accusative experiencer.
The show amused Bill.
c. Class III: Nominative theme, dative experiencer.
The idea appealed to Julie.

In formulations of the hierarchies that include an *Experiencer* (e.g. Belletti and Rizzi, 1988; Grimshaw, 1990; Van Valin, 1990), this role is ranked higher than the *Theme.* Hence, subject-*Experiencer* verbs, as in (5a), demonstrate *atypical* argument realization – with *Experiencer* rather than *Agent* assigned to the first NP – , whereas object-*Experiencer* verbs, as in (5b), demonstrate non-canonical argument realization, in the sense that there is a mismatch between thematic hierarchy and argument realization (i.e., *Theme* appearing before *Experiencer*). Thus, it appears that the two types of psych verbs described above provide us with two distinct cases of thematic hierarchy violations.[3]

(5) a. John loves Mary
b. The show amused Bill

Most interestingly, one can find minimal pairs of *psych* verbs sharing similar semantic content but differing in the way their thematic roles are realized, such as the *fear-frighten* pair. Both *fear* and *frighten* refer to a "fright" situation seen from two different perspectives: from the perspective of the person who is in this mental state (the *Experiencer* in examples 6–9a), and from the perspective of the causer of the mental state (the *Theme* in examples 6–9b). Hereafter, we will be referring to subject-*Experiencer* verbs as "*fear*-type verbs" and to object-*Experiencer* verbs as "*frighten*-type verbs".

(6) a. Jane *fears* the thunder.
b. The thunder *frightens* Jane.

(7) a. The public *admires* the statue.
b. The statue *fascinates* the public.

(8) a. The children *enjoy* the music.
b. The music *amuses* the children.

(9) a. The class *ponders* the equation.
b. The equation *perplexes* the class.[4]

Although the classification of psych verbs proposed by Belletti and Rizzi (1988) has been widely adopted in the literature (e.g. Pesetsky, 1995; Baker, 1997; Landau, 2002; 2005), this has not been done without essential modifications. Belletti and Rizzi call the thematic roles involved in psychological predicates *Experiencer* and *Theme.* However, Pesetsky (1995) suggests that the subject argument of the object-*Experiencer* class bears the role *Causer*[5]. For the same class of psych verbs, Landau (2005: 5) also claims that they are transitive, projecting a little v and an external argument, a *Causer*[6]. The analysis treating the subject *frighten* as *Causer* has been widely adopted and it is now considered as standard. Thus, following this analysis, pairs like *fear* and *frighten* do not differ only in the way their arguments are realized, but they essentially bear different kinds of arguments. This has further implications regarding their predictions with respect to thematic and animacy hierarchy violations.[7]

That is, while Belletti and Rizzi's (1988) model suggests that object-*Experiencer* verbs produce a mismatch between the requirements of thematic hierarchy and their argument realization (with the *Theme* preceding the *Experiencer* argument), the analyses of Pesetsky (1995) and Landau (2005) do not allow us to make the same statement. In contrast, it appears that there is no violation,

since the *Causer* argument, being closer to an *Agent* proto-role, precedes the *Experiencer.* This approach thus claims that psych verbs do not really violate the thematic hierarchy; they just demonstrate atypical argument realization (no *Agent*) in the subject-*Experiencer* constructions.

When it comes to psych verbs, Dowty (1991: 579–80) points out that pairs such as *fear-frighten* represent arbitrariness in argument realization. Both *fear* and *frighten* have equal Proto-agent entailments: the sentience of the *Experiencer* and the causation of *Theme/Stimulus*. Thus, the two arguments are not distinguished by other entailments, and, therefore, it is not clear which one will occupy the subject and which one will occupy the object positions. Either realization at the subject position does not violate any Proto-agent principle. However, *fear* and *frighten* have different entailments when it comes to the Proto-patient role. These entailments are related to the eventive reading of object-*Experiencer* verbs extensively observed in the literature. The eventive reading of this verb class is associated with a change of state on the part of *Experiencer,* which is a Proto-patient property. Thus, although the two arguments are equal in terms of proto-agent properties, it is their difference in the Proto-patient properties that determines their realization. Therefore, in Dowty's terms, causation outranks sentience in determining canonical argument realization.

In terms of animacy hierarchy, while the subject of *fear*-type verbs is most of the time an animate *Experiencer,* the subject of a *frighten*-type verb could be either animate (*John frightened Mary*) or inanimate (*the thunder frightened Mary*). Thus, the only case we may consider as a deviation from canonical animacy hierarchy is related to *frighten*-type verbs when an *inanimate* NP occupies the subject position and an *animate* NP occupies the object position, such as in the sentence *the thunder frightened the children*.

3.2. Passives

In an investigation of non-canonical argument realization, passive voice cannot be left aside. The process of passivization, as described below, results in the externalization of internal argument, which is usually a *Theme*, and the suppression of the original external, usually *Agent,* argument. The sentences in (10) and (11) describe the same basic event with the same semantic participants:

(10) Philip bit the dog

(11) The dog was bitt**en** (by Philip)

Sentences in (10) and (11) describe a biting event. The *biter* (*Agent*) is *Philip* and the *bitee* (*Theme*) is *the dog.* At least on the surface, then, these two sentences

seem to involve the same thematic information. However, on closer examination, one would notice that in (11) the *Agent* is represented by an optional prepositional phrase headed by the preposition *by.* This turns the *Agent* from an argument into an adjunct and as such it is not included in the basic thematic grid of the verb and it is therefore not subject to the theta criterion (Chomsky, 1981). It thus seems that the sentences in (10) and (11) have different thematic properties. The active sentence in (10) has an *Agent* and a *Theme*, while the passive sentence in (11) lacks the *Agent* argument in its thematic grid. This theory of the passive does not however claim that the *Agent* argument is not totally deleted. It is instead supposed to be absorbed or suppressed by the passive morpheme *-en.* This morphological operation thus triggers the surfacing of the *Theme* in the subject position in order to satisfy the EPP (external projection principle).

In the case of psych verbs, the issue of their passivization has generated much controversy in the literature and it is beyond the scope of this chapter to discuss the details of this controversy. We adopt Landau's (2002, 2005) proposal that it is *eventiveness* and not *agentivity* that is a determining factor in the passivization of *psych* verbs (2005: 49). In psych passives, the suppressed argument is the *Experiencer/Theme* (as in *The statue was admired*/*The sculptor was threatened).* Thus, the fact the *psych* verbs passivize cannot be taken as evidence for being agentive.

Defining canonicity is a fairly straightforward task for agentive structures, for all approaches discussed above share the same assumption as to what constitutes a canonical argument realization. Passives of agentive verbs result in non-canonical argument realization, with the *Theme* figuring in the subject position and the *Agent* being suppressed and represented by an adjunct *by*-phrase. It is more difficult to determine canonicity with passives of *psych* verbs. Passives of *fear*-type verbs bear the *Theme* argument at the subject position, thus resulting in a non-canonical argument realization. Passives of *frighten* verbs normally externalize the *Experiencer* argument and canonicity depends on whether the second argument is a *Causer* or a *Theme.* In the former case, non-canonical argument realization emerges, while in the latter case, there is no deviation. Table 3 summarizes the structures that result in non-canonical argument realization.

4. Non-canonicity in brain damaged populations

The role of canonicity in terms of thematic hierarchy as a determining factor for sentence comprehension in patients with Broca's aphasia was addressed by Piñango (e.g. Piñango, 2006). The main language syndrome of Broca's aphasia is impaired sentence production and comprehension when it comes to the interpretation of complex syntactic structures. For instance, agrammatic aphasics have

Table 3. Non-canonicity in *psych* verbs and in passives

Sentence Type	Example	Belletti and Rizzi (1988) Thematic Hierarchy	Pesetsky (1995) Thematic Hierarchy	Dowty (1991) Proto-Roles	Croft (2003) Animacy Hierarchy
Fear-active	The children feared the thunder	+ <Exp, Th>	– <Exp, Caus>	– <Exp, Caus>	+ <An, In>
Fear-passive	The thunder was feared by the children	– <Th, Exp>	+ <Caus, Exp>	+ <Caus, Exp>	– <In, An>
Frighten-active	The thunder frightened the children	– <Th, Exp>	+ <Caus, Exp>	+ <Caus, Exp>	– <In, An>
Frighten-passive	The children were frightened by the thunder	+ <Exp, Th>	– <Exp, Caus>	– <Exp, Caus>	+ <An, In>
Agent-active	The gang stole the car	+ <Ag, Th>	+ <Ag, Th>	+ <Ag, Th>	+ <An, In>
Agent-passive	The car was stolen by the gang	– <Th, Ag>	– <Th, Ag>	– <Th, Ag>	– <In, An >

\+ = *canonical argument realization*
– = *non-canonical argument realization*

been found to have difficulties both with *psych* verbs (e.g. Piñango, 1999, 2000) and passives (e.g. Grodzinsky, 1995; but see Berndt, Mitchum, and Haendiges, 1996). More specifically, agrammatics have problems with *frighten*-type verbs (12), and also with passives of agentive (13) and *fear*-type verbs (14).

(12) The noise frightened Mary.

(13) Mary was pushed by John.

(14) Mary is admired by John.

Piñango (2006), adopting Belletti and Rizzi's (1988) analysis of object-*Experiencer* verbs, postulates that agrammatic patients experience difficulties with passives and *psych* verbs due to these structures' deviations from canonical argument realization. Piñango suggests that these specific constructions violate the principle of linking between semantic representation and syntactic structure (along the lines of Levin and Rappaport Hovav, 2005). The basic principle is that prominent structural positions are occupied by elements which are also prominent in other dimensions, such as. semantic role and animacy, leaving the less prominent items for the non-subject position. That is why *Agent* and *Experiencer* arguments precede *Patients/Themes* and *Recipients*[8] Thus, when syntactic representation violates the canonical order of arguments, agrammatic aphasics perform poorly. However, Piñango's reasoning holds only within Belletti and Rizzi's analysis of *psych* verbs, which treats the non-*Experiencer* argument as *Theme,* and does not explain the pattern of results when this argument is treated as *Causer.*

We examined effects of canonicity in argument realization in terms of both thematic and animacy hierarchy by looking at the performance of AD patients, a brain-damaged population that is supposed to have retained their syntactic abilities, but generally, to have lost their semantic skills (Manouilidou et al., 2008). This combination of preserved syntax and impaired semantics allowed us to examine a different aspect of argument realization and thematic-role mapping, one that mostly relies on semantic resources. A general description of how AD affects linguistic and cognitive abilities of patients is provided in the following section.

4.1. Clinical and linguistic description of patients with AD

Alzheimer's disease (AD) is a progressive neurodegenerative condition characterized by neuropathological changes in the cortex and marked neuronal loss. The observation of excessive quantities of neurofibrillary tangles and senile plaques, formed by increased tau phosphorylation, is sufficient for a diagnosis of AD. Furthermore, hippocampal atrophy, often detected before dementia onset by MRI studies (Fox, Warrington, Stevens, and Rossor, 1996; Visser et al., 1999), is believed to result to clinically identifiable dementia (Fox et al., 1996). Individuals with AD also manifest alterations in various cognitive domains. Deficits are seen in episodic memory (Chen et al., 2001), executive function (Chen et al., 2001), perceptual speed (Fox, Warrington, Seiffer, Agnew, and Rossor, 1998), visuospatial skill (Chen et al., 2001) and attention (Levinoff, Saumier, and Chertkow, 2005; Perry and Hodges, 2000; Pignatti et al., 2005).

AD patients often manifest deficits in language processing very early in the disease course. Deficits are seen in verbal fluency (for a review, see Henry, Crawford, and Phillips, 2004), naming (Laiacona, Barbarotto, and Capitani, 1998), particularly of biological items (Zannino et al., 2006) semantic knowledge (Mauri, Daum, Sartori, Riesch, and Birbaumer, 1994; Garrard, Patterson, Watson, and Hodges,1998), and discourse-level processing (for a review, see Caramelli, Mansur and Nitrini, 1998). Syntactic and phonological abilities, on the other hand, are relatively preserved (Bayles, 1982; Schwartz, Marin and Saffran, 1979 etc.).

Taking into account the claim that AD patients have preserved syntactic but impaired semantic abilities, we studied their performance in a sentence completion task involving *psych* verbs. Based on data from this study, we will discuss the evidence for these hierarchies in language processing by brain damaged populations and argue for their psychological reality.

4.2. The Experimental Data

In a recent study investigating the verb deficit in AD, Manouilidou et al. (2008) tested the performance of 10 AD patients in a sentence completion task by using two types of *psych* verbs, in active and passive voices. Our strategy was to test AD patients' ability to assign thematic roles to the various NPs associated with verbs in different thematic-grid configurations. Based on the fundamental role that hierarchical relations appear to play in the mapping between semantic participants and syntactic structures, we predicted that patients would have difficulty with predicates that require non-canonical argument realization, given the pervasive semantic deficits in AD. The focus of our investigation was patients' performance in sentences that required subject-*Experiencer* (*fear*) verbs, which call for *atypical* argument realization (no *Agent*), and object-*Experiencer* (*frighten*) psych verbs which entail *non-canonical* argument realization (mismatch between the thematic hierarchy and the actual realization of the arguments, with *Theme* preceding *Experiencer*).

In this study we presented participants with the sentences with the verb missing marked by a blank line (e.g. *The boy____the thunder*). They had to choose the correct verb from a list of four verbs, which included the two main alternatives (e.g. *fear* and *frighten*), one syntactically anomalous (e.g. *sleep*) and one semantically unrelated (e.g. *cook*). In total, patients were required to complete 72 active and passive written sentences (see Appendix). All verbs used in the study were controlled for frequency Kucera and Francis (1982) Materials were divided into 6 conditions, with 12 sentences in each of them: (1) subject-*Experiencer* verbs (e.g. *fear*); (2) the reverse equivalent of subject-*Experiencer* verbs, i.e. object-*Experiencer* verbs (e.g. *frighten*); (3) and (4) were the passive equivalent of (1) and (2), respectively (e.g. *was feared* and *was frightened*); (5) subject-agent verbs (e.g. *kick*); (6) the passive equivalent subject-*Agent* verbs (e.g. *was kicked*). Patient performance was compared to that of 11 healthy controls, matched for age, education, and demographics, and to that of 49 young controls.

We scored correct verb selection and analyzed the data taking into account participants and materials (sentence types) as random variables. Our analyses first contrasted the performance of the three groups (AD patients, matched elderly controls, and young controls). The analyses of the three groups revealed significant differences between them. The young controls, however, performed at ceiling, so all our other contrasts were made taking into account only the performance of the other two groups. For these analyses we focused on two main variables, the predicate type (distinguished by subject thematic role) (*Agent*, *Experiencer* subject, and *Experiencer* object) and voice (active and passive).

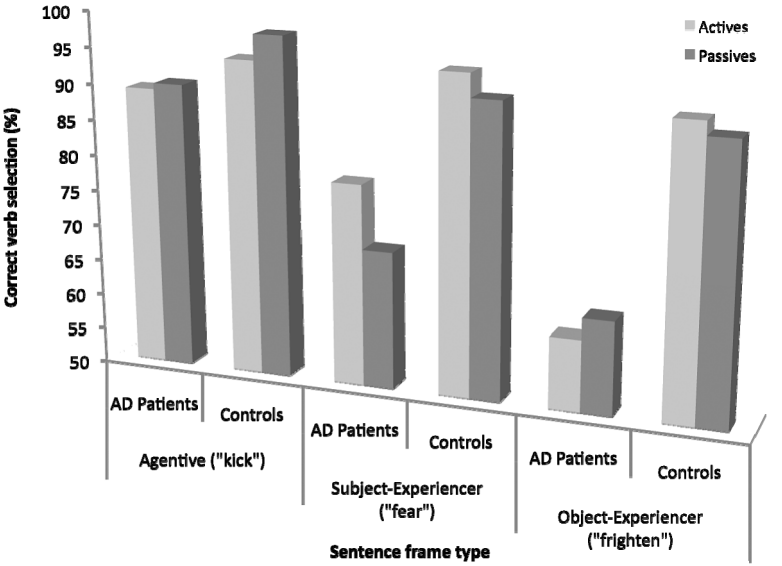

Figure 1. Correct verb selection by Alzheimer's patients and age-matched controls

There were no significant differences between AD patients and controls in the performance of agentive sentences. The differences between the two groups were in the performance of sentences with *psych* verbs. We plotted the performance of the two groups across all conditions in Figure 1.

As can be seen, AD patients committed many more errors than their controls in both *psych* verb sentence types in both active and passive constructions. More importantly, in the analysis of the AD patient data there was a main effect of subject thematic role, which was independent of voice, suggesting that the effects are due to thematic role, not syntactic frame. Taking into account only the AD patient data, we also found a significant effect of subject thematic role. Given that patients performance in sentences with *Agent* roles was not significantly different from that of their controls, we analyzed only the two *psych*-verb frames. Here too we found a significant difference – with more errors in the object-*Experiencer* (*frighten*) frame than in the subject-*Experiencer* (*fear*) frame.

The differences observed in the subject-*Experiencer* and object-*Experiencer* constructions – together with the lack thereof in the case of agentive frames – highlight the difficulty AD patients have with the non-canonical argument realization projected by *psych* verbs. In order to better understand the nature of the difficulty AD patients have with these verbs, we looked at the errors they

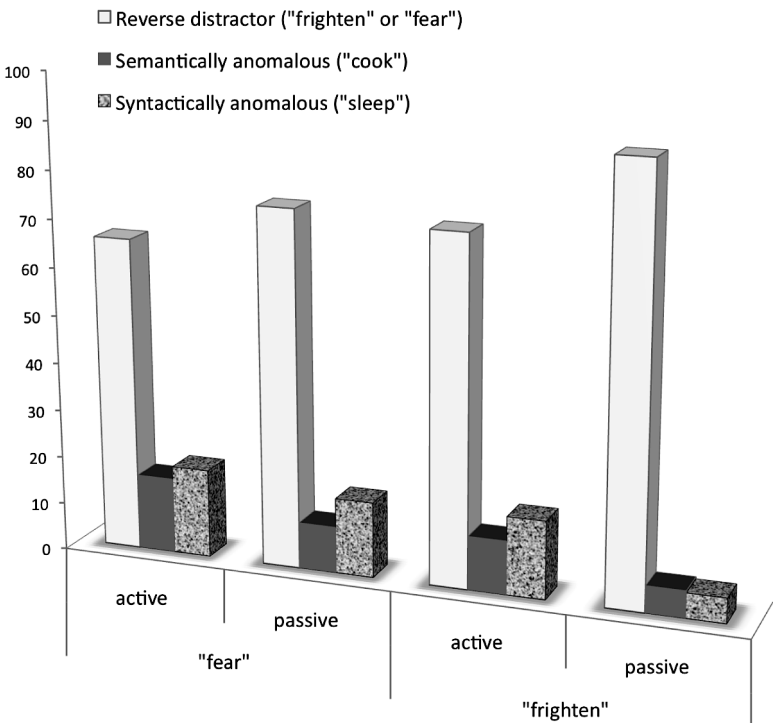

Figure 2. Distribution of errors (%) committed by AD patients when selecting a verb for a sentence frame (e.g. percentage of times in which the reverse distractor *frighten* was chosen in place of the correct *fear* in active and passive frames).

committed when choosing a verb for each frame. The distribution of these errors is shown in Figure 2.

When AD patients opted for an incorrect *psych* verb, they most often selected the verb with the reverse thematic roles (e.g. when the target verb was *fear*, they often chose *frighten*). They very rarely selected the unrelated distractors in both active and passive voice sentences. We suggest that AD patients had no difficulty determining the semantic content of the verbs, for they clearly made their selection between the two competing verbs. The pattern of data supports the view that their deficit is in the assignment of verb thematic roles.

5. Argument Realization and Canonicity

The primary goal of the present study is to discuss different views on argument realization in light of the performance of brain-damaged populations supposedly suffering from a semantic deficit, such as AD patients. Patients' performance was examined with verbs whose argument realization deviate from canonical (*Agent* first) structure, such as psychological predicates. We started off by briefly presenting three main views on argument realization (thematic hierarchy, animacy hierarchy and proto-roles), and outlined their assumptions of canonicity in hierarchical relations between arguments. In order to shed light on the potential role of hierarchical relations in sentence representation, in the present section we discuss the results of our empirical study from the perspective of the theories that have been put forth to account for argument realization.

As we have seen, the results of Manouilidou et al. (2008) show that patients have difficulties with non-canonical structures, as evidenced by the errors they made when they had to complete a sentence with a *psych* verb of either subject-*Experiencer* or object-*Experiencer* type. In contrast, their performance was similar to that of healthy controls when confronted with agentive verb sentences, either in active or in passive voice. A closer look at the pattern of results – which are summarized in Table 4 – allows us to observe that the findings do not entirely support any of the hierarchical theories of argument realization discussed. Instead, it seems that both thematic hierarchy and animacy hierarchy should be considered in a complementary way in order to account for the results.

Table 4. AD patient performance against the predictions of different thematic/animacy hierarchies

Sentence Type	AD Performance Compared to controls	Belletti and Rizzi (1988) Thematic Hierarchy	Pesetsky (1995) Thematic Hierarchy	Dowty (1991) Proto-Roles	Croft (2003) Animacy Hierarchy
Fear-active	*Impaired*	+ <Exp, Th>	✔ – <Exp, Caus>	✔ – <Exp, Caus>	+ <An, In>
Fear-passive	*Impaired*	✔ – <Th, Exp>	+ <Caus, Exp>	+ <Caus, Exp>	✔ – <In, An>
Frighten-active	*Impaired**	✔ – <Th, Exp>	+ <Caus, Exp>	+ <Caus, Exp>	✔ – <In, An>
Frighten-passive	*Impaired*	+ <Exp, Th>	✔ – <Exp, Caus>	✔ – <Exp, Caus>	+ <An, In>
Agent-active	*Normal*	✔ + <Ag, Th>	✔ + <Ag, Th>	✔ + <Ag, Th>	✔ + <An, In>
Agent-passive	*Normal*	– <Th, Ag>	– <Th, Ag>	– <Th, Ag>	– <In, An >

\+ = *canonical argument realization (predicted to be sparred in AD)*

– = *non-canonical argument realization (predicted to be impaired in AD)*

✔ = *predictions supported by the results*

* = *performance also worse than* fear-*active constructions*

Moreover, the results point to the importance of the *Agent* argument, albeit not necessarily at the subject position, emphasizing the complexity of sentence interpretation for AD patients in terms of factors that come into play.

More specifically, thematic hierarchy, under Belletti and Rizzi (1988)'s analysis fails to account for participants' impaired performance in *fear*-actives, *frighten*-passives, and agentive passives. The same holds for animacy hierarchy. However, Pesetsky (1995)'s thematic hierarchy and the theory of proto-roles correctly predict patients' performance in the above structures, but fail to account for their performance in *frighten*-active and *fear*-passive sentences. Finally, none of the proposals for argument realization accounts for patients' ceiling performance with agentive passives. Thus, we cannot maintain that non-canonicity, as strictly defined by hierarchical relations, affects patient performance to a decisive degree. In contrast, AD patients are sensitive to deviations from canonicity in argument realization, when canonicity is not defined in terms of thematic hierarchy but mostly in terms of *agentivity.* The pattern of results seems to suggest that there is a dissociation between [+agentive] verbs (relatively preserved) and [–agentive] verbs (significantly more impaired). This pattern was consistent for both active and passive voice constructions.

In relation to the lack of voice effect, we should emphasize patients' performance on passives. Patients performed normally completing semantically non-reversible passives with agentive verbs, while their performance with non-reversible *psych* passives was impaired. This result casts doubt on the hypothesis of impaired mapping procedures and difficulties in assigning verb arguments in non-canonical sentences. Note that non-reversible passives typically involve animate and inanimate entities whose role in the sentence is easily predictable. For instance, in the sentence *The public was fascinated by the statue* there is only one way to interpret the thematic role of the NPs. However, AD patients were clearly impaired when confronted with these types of *psych* sentences. In contrast, when confronted with non-reversible agentive passives, e.g. *The car was stolen by the gang* there was no confusion as to the selection of the correct verb based on the position of the NPs in the sentence. Even though this sentence is non-canonical in terms of thematic hierarchy, animacy hierarchy and Proto-roles, AD patients had no difficulty selecting the correct verb. It seems that the AD patients could use the syntactic cues – e.g. the *by* phrase – to determine the correct position of the *Agent.*[9] Thus, regardless of how non-canonical – in terms of hierarchical relations – the output is, because the verb calls for an agentive interpretation, AD patients show no difficulty understanding that the *Agent* position in the sentence is after the verb, in the *by*-phrase. The normal performance of AD patients on this type of sentences is perfectly in line with their spared abilities on [+agentive] verbs and [+agentive] sentences. One could argue, then,

that the difference in the type of thematic roles [+agentive] and [–agentive] verbs can take is responsible for AD patients' pattern of performance. Thus, AD patients' performance would be impaired only when the subject of the verb maps onto a thematic role different from that of *Agent*.

Another way of accounting for the pattern of performance of the Manouilidou et al. (2008) study is that AD patients suffer from a category-specific semantic deficit related to *psych* verbs. Their spared abilities would be sufficient to allow access to the meaning of agentive verbs and of all verbs used as distractors. However, the subjects' performance fails when confronted with a *psych* verb. According to this account, AD patients would perform worse on *psych* verbs simply because they have a selective impairment in this verb category. In fact, naming of subject-*Experiencer* perception verbs (*smell, listen*) was found to be impaired in another group of AD patients (Mobayyen, de Almeida, Kehayia, and Schwartz, 2008). These patients performed better at naming events using lexical causatives and motion verbs. Perception verbs also lack the *Agent* argument. Thus, impaired naming on perception verbs also supports our claim about impaired [–agentive] verbs. If this is the case, then it strongly suggests that a range of factors may affect AD patients' performance in the sentence completion task, and one of them is the presence or absence of the *Agent* argument in the sentence. Hence, it seems that AD patients suffer from a semantic deficit restricted to [–agentive] verbs and [–agentive] sentences. This deficit occurs in the context of spared abilities in active and passive agentive sentences. We cannot at this point determine if the AD patients' deficit involves thematic roles that are different from that of *Agent* or if it simply involves the [–agentive] verb feature per se. If they have a deficit with thematic roles that are not *Agent*, patients should have difficulty with thematic roles assigned to the object of agentive sentences.[10] The pattern of results of our study, however, does not support this hypothesis. Thus, a [–agentive] verb feature deficit seems to be the best way to account for our data.[11]

Most interestingly, the above finding does not cancel out any possible effects of hierarchical relations in argument realization and sentence interpretation by AD patients. Before concluding on the defining role of *agentivity* in guiding AD patients' sentence interpretation, we should account for the difference between *fear* and *frighten* active sentences. Patients performed better on *fear*-actives than on *frighten*-actives. This finding suggests a sensitivity of AD patients to argument realization that deviates from animacy hierarchy and from canonical thematic hierarchy for subject-*Experiencer* verbs, following Belletti and Rizzi's analysis. That is, because *frighten* actives have an argument realization with a *Theme* figuring before *Experiencer*, these verbs present greater difficulty than *fear* verbs, which have an atypical but still canonical argument realization. While

agentivity appears to be a defining factor in leading AD patients' performance, canonicity stemming from thematic hierarchy also appears to play a role. Thus, sentence interpretation by AD patients appears to be subject to multiple constraints, with first among them the presence of an *Agent* followed by the presence of an animate entity in the subject position. Evidently, these constraints are subject to different degrees of violability, which could be described in a, practically, optimality theory way, as applied in syntax by Aissen (2003).

This finding allows us to argue for the existence of thematic hierarchy as a linguistic entity that guides argument realization and to address certain issues pertaining to the nature of thematic roles. The role of hierarchical relations in argument realization has been put into question by various researchers (e.g. McCarthy, 2002; Newmeyer, 2002) mostly because of a lack of agreement regarding its formulation and also because of an inability to be proven as "innate and functionally motivated" (Newmeyer, 2002: 60). The results of the study we discuss cannot argue for the innateness of hierarchical structures, but they do argue for the functional motivation of these hierarchies. Sensitivity to their violations by brain-damaged populations provides support for the psychological reality of such structures. The mapping from meaning to form is not random, but it complies with hierarchical regularities related to semantic properties of each argument. This observation together with the selective impairment of AD patients in [–agentive verbs] gives further support to the existence of thematic roles as entities that are not merely labels (Rappaport and Levin, 1988) for lists of arguments of a predicate, but also crucially assist in the mapping of form to meaning. While we can argue for the existence of thematic hierarchy based on this specific study, we cannot argue that argument realization can be fully accounted for in a theory that relies on proto-roles (Dowty, 1991). In the proto-roles approach, *causation* outranks *sentience,* while we have shown evidence for the opposite realization.

In conclusion, we have shown that deficits arising from neurologically impaired individuals provide us with the opportunity of observing how a particular domain of knowledge can be selectively affected. Although the performance of AD patients cannot be taken as the only – nor necessarily the best – evidence for the nature of thematic hierarchy and argument realization, it does provide us with a window into how these patients unravel the phrase structure rules of their native language and sheds light on the nature of the mapping between arguments and their thematic roles. We have evidence that AD patients are sensitive to deviations from canonicity in linguistic structures. This canonicity is mostly defined in terms of *agentivity* with the role of thematic hierarchy still being significant. It is the presence of the *Agent* argument that leads comprehension. When there is no agent, then thematic hierarchy seems to guide sentence comprehension.

Thus, it appears that the semantic properties of a verb's arguments cannot exhaustively account for argument realization. In contrast, mapping from form to meaning requires different types of information, which may be disrupted when some of the knowledge that is required for argument realization breaks down as a result of brain damage.

Appendix

This appendix contains sample materials used in the experiment by Manouilidou et al. (2008)

Sentence frames were presented for verb selection, and participants had to choose the correct alternative among four verbs presented in random order. The verb options for each sentence below are the following: the first verb represents the correct answer, the second is the main distractor, the third is the semantically inappropriate distractor and the forth is the syntactically inappropriate distractor. Passive versions employed the same verb materials as in the active sentences but with passive frames presented to participants (e.g., The statue was *admired/fascinated/rode/slept* by the public).

fear active

1) The public *admired/fascinated/rode/slept* the statue.
2) The children *feared/frightened/melted/bloomed* the thunder.
3) The scientist *liked/pleased/froze/smiled* the fossil.
4) The minister *pitied/saddened/saved/screamed* the poverty.
5) The spectators *enjoyed/amused/licked/lived* the performance.
6) The class *pondered/perplexed/cooked/coughed* the equation.
7) The students *dreaded/intimidated/brushed/whispered* the exam.
8) The actress *envied/tempted/poured/chatted* the singer's voice.
9) The elderly *hated/bothered/danced/agreed* the hospitals.
10) The author *resented/disappointed/sipped/frowned* the editor's remarks.
11) The community *tolerated/disturbed/murdered/existed* the differences.
12) The listeners *detested/disgusted/hit/stood* the commentator's opinion.

frighten active

1) The exam *intimidated/dreaded/brushed/whispered* the students.
2) The singer's voice *tempted/envied/ poured/chatted* the actress.
3) The hospitals *bothered/hated/danced/agreed* the elderly
4) The editor's remarks *disappointed/resented/sipped/frowned* the author
5) The differences *disturbed/tolerated/murdered/existed* the community.

6) The commentator's opinion *disgusted/detested/hit/stood* the listeners.
7) The statue *fascinated/admired/rode/slept* the public
8) The thunder *frightened/feared/melted/bloomed* the children.
9) The fossil *pleased/liked/froze/smiled* the scientist.
10) The poverty *saddened/pitied/shaved/screamed* the minister
11) The performance *amused/enjoyed/licked/lived* the spectators.
12) The equation *perplexed/pondered/cooked/coughed* the class.

agent active

1) The teacher *accompanied/arrived/grew/yawned* the students.
2) The gardener *cultivated/sprouted/decided/babbled* the carrots.
3) The company *fired/resigned/concurred/drifted* many employees.
4) The hostess *illuminated/glittered/divorced/gossiped* the room.
5) The hunter *killed/died/descented/sneezed* the deer.
6) The lifeguard *saved/survived/expressed/snored* the swimmer.
7) The king *expelled/departed/moaned/wrinkled* the poets.
8) The policeman *chased/fled/kissed/spoke* the criminal.
9) The thief *stole/vanished/helped/stuttered* the painting.
10) The cleaner *pushed/fell/mopped/barked* the bucket.
11) The mom *tickled/giggled/cured/revolved* the kid.
12) The movie *bored/yawned/carved/nodded* the audience.

Notes

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1. Hierarchical relations are especially important for SVO languages which do not allow free word order, such as English, the language under investigation in the present paper. While the mapping from meaning to form for other languages is marked by inflectional morphology, in English it depends heavily on the position of the NP in the sentence.
2. Dowty assumes that these roles are compiled as "prototypes", much like the prototype theory in psychology (e.g. Rosch and Mervin, 1975). However, Dowty's use of the term "prototype" is slightly different. The term "proto-roles" refers to higher-order generalizations about lexical meanings without suggesting that individual lexical meanings themselves are prototypes (Dowty, 1991: 577).

3. We will use the term "violation" to refer to both cases of deviation although we do not consider an atypical argument realization a violation, but a deviation from the most typical case of argument realization.
4. We are not claiming that the verbs constituting these minimal pairs are synonymous with reversed thematic roles. It is beyond the scope of the present paper to determine the content properties of these verbs or to account for the notion of content similarity between the members of the pairs. The strategy used in our study was to employ verb pairs that allow for the reverse thematic roles while keeping the nature of the state predicated by the verbs as close as possible.
5. Pesetsky (1995: 55) also renames the object argument with the subject-*Experiencer* class either as *Target of Emotion* or *Subject Matter.* This difference is not relevant for the purposes of our study and we will not further elaborate on it.
6. Notice that the majority of object-*Experiencer* verbs are ambiguous between stative and eventive readings. However, there are some verbs that are unambiguously stative, such as *interest* and *concern*. Following Landau (2002) we assume that only these verbs lack a "causer" argument in their thematic grid.
7. It should be noted that this analysis also runs into problems if *Causer* is somewhat taken as part of the semantic representation of the object-*Experience* sentence. Fodor (1970) has long observed that constructions such as (ia) and (ib) are not synonymous, for their distributional properties are not the same. Compare (ii) and (iii).
   (i) a. The article angered Bill
       b. The article caused Bill to become angry
   (ii) a. The article angered Bill and it surprised me that it did so
       b. The article caused Bill to become angry and it surprised me that it did so
   (iii) a. *The article angered Bill and it surprised me that he did so
       b. The article caused Bill to become angry and it surprised me that he did so
8. This applies to all languages in which subject precedes object (such as SVO).
9. The preposition *by* is lexically ambiguous, introducing a NP that can be assigned the thematic role of an *Agent* or *Location* among others (*found by the river*). However, discourse expectation, verb bias, and mostly a frequency bias from the preposition itself favor the role of *Agent*. A bias for interpreting the *by* argument as an *Agent* is also found in on-line experiments of sentence processing by using eye-tracking (Tanenhaus, Spivey-Knowlton, and Hanna, 2000) indicating that a *by* phrase following a passive verb provides overwhelming support for the agentive interpretation. In the same study Tanenhaus et al., 2000 found effects of individual verb biases. Agent-biasing verbs strengthened the preference for an agent completion in all conditions.
10. Even though we only have two arguments, we are still in position to judge whether incorrect responses stem from the subject thematic role and not from the object thematic role, simply because a difficulty with the object thematic role would equally affect agentive and non-agentive sentences.
11. Deficits affecting only [–agentive] verbs were found with aphasic patients as well (Finocchiaro, (2002).

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