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Thematic roles in Alzheimer's disease: Hierarchy violations in psychological predicates

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Abstract

The nature of the verb deficit in Alzheimer's disease (AD) was investigated with a special focus on thematic-role assignment, employing verbs whose argument realization follows canonical thematic hierarchy, with *Agent* and *Theme* as main roles (e.g., *The hunter killed the deer*), and verbs whose argument realization deviates from canonical hierarchy, such as *psych* verbs (e.g., *fear*, *frighten*). Subject-*Experiencer* verbs (e.g., *fear*) do not assign an *Agent* role to the subject position of the sentence, but instead assign the role of *Experiencer* to that position. Object-*Experiencer* verbs (e.g., *frighten*) deviate from canonical thematic hierarchy in two ways. Like *fear* verbs, the *frighten* verbs do not assign the role of *Agent*. Moreover, they assign the role of *Theme* to the subject position and the role of *Experiencer* to the object position, thus resulting in the non-canonical *Theme* < *Experiencer* argument realization. Ten AD patients, 11 matched elderly controls, and 49 young controls performed a sentence completion task in which they had to choose a verb that would render the sentence grammatical and meaningful. AD patients showed no problems with canonical structures, but performed worse than controls in *psych* verb sentences, demonstrating greater difficulty with object-*Experiencer* sentences. Results suggest that AD patients may have an impairment in more fine-grained aspects of verb-semantic representation, such as thematic roles.

Keywords: Psychological verbs; Thematic roles; Thematic hierarchy; Alzheimer's disease; Sentence processing

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1. Introduction

Deficits of verb-specific information are pervasive in brain-damaged populations, particularly in patients with aphasia (e.g., Bastiaanse & Jonkers, 1998; Berndt, Haendiges, Mitchum, & Sandson, 1997; Berndt, Mitchum, Haendiges, & Sandson, 1997; Kemmerer, 2000; Kemmerer & Tranel, 2000a, 2000b; Marshall, Pring, & Chiat, 1998; Miceli, Silveri, Villa, & Caramazza, 1984). Studies with agrammatic patients, for instance, have shown that both syntactic and semantic attributes of verbs are affected in tasks involving sentence production (e.g., Thompson, Lange, Schneider, & Shapiro, 1997), as well as in those involving comprehension (e.g., Caplan, Waters, DeDe, Michaud, & Reddy, 2007). In Alzheimer's disease (AD), however, the investigation of verb knowledge has received less attention. Although AD patients have deficits affecting diverse linguistic functions (e.g., Ullman et al., 1997), most studies have shown that these deficits usually involve dissociations related to nouns associated with diverse semantic categories, such as natural kinds and artefacts (e.g., Zannino, Perri, Carlesimo, Pasqualetti, & Caltagirone, 2002; Zannino, Perri, Pasqualetti, Carlesimo, & Caltagirone, 2006; see Whatmough & Chertkow, 2003, for a review).

Moreover, many studies have explored the question of whether or not language deficits in AD can be clearly dissociated from deficits affecting other cognitive resources, such as working memory and attention. Results appear to be controversial. Several of the studies report a strong association between the patients' declines in specific linguistic tasks and their working memory capacity (Bayles, 2003; Kemper, 1997; Small, Andersen, & Kempler, 1997; Small, Kemper, & Lyons, 1997). Other investigators have argued for the independence of linguistic abilities and working memory resources (McDonald, Almor, Henderson, Kempler, & Andersen, 2001; Rochon, Waters, & Caplan, 2000; Waters & Caplan, 2002). For instance, Bayles (2003) has shown that poor performance on language production and comprehension tasks results mainly from difficulties in focusing attention, encoding, and activation of long-term knowledge rather than from loss of linguistic knowledge. Similarly, Small et al. attempt to prove that the sentence-processing difficulties of AD patients originate from their working memory limited capacities and reflect patients' difficulties with non-linguistic memory demands. In the opposite camp, Rochon et al. (2000) argue against the view that working memory is involved in all aspects of sentence comprehension. In contrast, they claim that working memory processes are at least ''partially independent of those involved in syntactic processing'' (p. 398). This is in accordance with Caplan and Waters (1999), who have posited a ''separate-sentence-comprehension-resource'' hypothesis in which verbal working memory is composed of subsystems, at least one of which is specialized for assigning syntactic structure and its use in sentence interpretation. Thus, while working memory deterioration is the hallmark of AD patients' impairments, it seems that syntactic aspects of sentence comprehension are not affected by it. A similar approach to the relationship between linguistic abilities and linguistic working memory has been adopted by McDonald et al. (2001) who argue that, although linguistic representations, linguistic processing and linguistic working memory are ''intertwined'' (p. 18) there is no dependence relationship between linguistic abilities and working memory, such that a deficit in one of these areas does not trigger a deficit in the other. The independence of working memory and linguistic processing, as described by Rochon et al., and McDonald et al., is particularly significant for our study which targets the linguistic performance of patients with working memory difficulties.

2. Verb processing in AD

Results concerning AD patients' ability to compute *verb-related* information are inconclusive. The majority of the studies targeting verb performance in AD have focused on both the semantic and the grammatical information related to verbs (e.g., Cotelli et al., 2007; Kim & Thompson, 2004; Waters, Rochon, & Caplan, 1998). Most of these studies have shown that verb computations are near those of unimpaired adults, essentially ruling out the existence of a syntactic/structural deficit affecting verb representation. Nevertheless, these same studies have identified a sentence processing deficit usually stemming from an inability to deal with semantic aspects of verb related information. For instance, Waters et al. (1998) showed that the performance of AD patients was not affected by verb syntactic complexity, but, rather, by the number of propositions that sentences convey. Similarly, the patients tested by Cotelli et al. (2007) mostly demonstrated difficulties with semantic coherence, rather than with structural aspects of sentences. Similar conclusions, supporting a semantic rather than a syntactic deficit, are drawn by a variety of studies focusing on verb performance (Grossman, Mickanin, Onishi, & Hughes, 1995, 1996; Grossman & Rhee, 2001; Grossman & White-Devine, 1998; Kim & Thompson, 2004; Rhee, Antiquera, & Grossman, 2001; Schwartz, Marin, & Saffran, 1979). A comparable pattern—preserved syntactic knowledge accompanied by marked semantic deficits—affecting sentence processing has been found in other forms of dementia (e.g., Bayles, 1982; Cotelli et al., 2007; Kavé, Leonard, Cupit, & Rochon, 2007).

Despite the general acceptance of the existence of a semantic deficit in AD, there have been a few attempts to delineate the nature of the impairment by attributing it to a specific aspect of verbs: their thematic roles and their realization at the sentence level (Small, Kemper, & Lyons, 2000; Grossman & White-Devine, 1998; Price & Grossman, 2005). In the present study, we investigate thematic role assignment, a process that underlies both production and comprehension, in the performance of AD patients. In particular, we investigate whether or not AD patients have difficulty mapping verb thematic roles to grammatical roles, especially when this mapping violates the default thematic hierarchy of argument realization. This is the case of verbs denoting psychological states (such as *fear* and *frighten*), which do not have the typical *Agent–Patient/Theme* mapping to the subject and object positions, respectively, but instead assign either the role of *Experiencer* (as in *fear*) or the role of *Theme* (as in *frighten*) to the subject position.

The notion of *canonicity* in verb-argument relations has been reported to influence sentence processing in normal young and old adults (Ferreira, 1994; Kemper, 1997; Kemper et al., 1993; King & Just, 1991; Miyake, Carpenter, & Just, 1994), in aphasic patients (Caplan & Hildbrandt, 1988), and in dementia (Kemper, 1997; Kemper et al., 1993; Lyons et al., 1994; Small, Andersen, et al., 1997; Small, Kemper, et al., 1997; Small et al., 2000). However, in these studies, canonicity in verb-argument relations is usually described in terms of non-canonical thematic role assignment as a result of syntactic manipulations. For instance, Small et al. (2000), using a sentence repetition task, investigated the performance of AD patients in a variety of structures, including sentences in active and passive voice and also in four types of embedded clauses. They considered as non-canonical sentences in the passive voice (e.g. *The motorist was stopped by the highway patrol*), Object–Object relative clauses (e.g. *The angry parent disciplined the student who the teacher sent home*) and Subject–Object relative clauses (*The job that the woman wanted required college education*). In all these cases, the *Theme* argument precedes that of the *Agent*. However, in all three cases, non-canonical argument realization is the result of syntactic movements, and thus, its effect cannot be considered

independent of the effect of syntactic structure complexity. Hence, non-canonical thematic role assignment and its processing cost cannot be dissociated from other factors that affect sentence processing, such as syntactic movement. For this reason, we cannot be certain that the observed difficulties arise exclusively from *non-canonical argument realization*. It could be the case that patients' difficulties are associated with memory and cognitive resources—something that Small et al. (2000) also point out. Thus, the question of non-canonical thematic role assignment in the performance of populations suffering from dementia still needs to be delineated in terms of verb-specific requirements and not as a side effect of syntactic manipulations.

In one of the previous attempts to investigate sentence comprehension difficulties in AD, Grossman and White-Devine (1998), addressed the issue of thematic roles and verb argument structure among other questions. They used two types of verbs, simple transitives (e.g., *eat*, *kiss*) and what they call lexical causatives (e.g., *awaken*, *drown*) in both active and passive sentences (e.g., *Gary ate the chicken/The chicken was eaten by Gary* and *The mother awakened the baby/The baby was awakened by the mother*). They employed a sentence comprehension task with probe questions which were either about the *Agent* or about the *Theme/Patient* of the sentence (e.g., *Did Gary eat?/Did the chicken eat? – Did the mother awaken?/Did the baby awaken?*). Grossman and White-Devine hypothesized that patients will have more difficulties with lexical causatives, because lexical causatives allow for ''*atypical* syntactic–thematic relations'' that, according to Grossman and White-Devine, require a variety of cognitive resources in order to be processed accurately. Indeed, the main finding of the study, which is relevant to the present investigation, is that patients made fewer mistakes in sentences with simple transitives than in sentences with lexical causatives. The authors attributed this finding to a higher demand of cognitive resources due to the fact that thematic roles associated with lexical causative verbs are mapped onto grammatical roles in an ''atypical fashion'' (p. 189). More specifically, they assert that the object of the transitive verb is the actual *Agent* when this verb is used intransitively. For instance, in a sentence such as *Daniel drowned the swimmer*, the corresponding intransitive sentence is *The swimmer drowned* and not **Daniel drowned*. Grossman and White-Devine (1998) regard this as atypical syntactic–thematic mapping, which is associated with lexical causatives and which is not signalled explicitly at a surface level. Overlooking the fact that the object of the causative verb does not become an *Agent*, but remains an *Experiencer* occupying the subject position, the main issue with Grossman and White-Devine's study is their definition of *atypicality* and its manipulation with the given stimuli. Atypical mapping can only be demonstrated in the intransitive sentences, not in the causative sentences per se. Processing a causative structure does not require transforming it into its intransitive equivalent. In terms of thematic role mapping, the sentences *John caught the fish* (simple transitive) and *John boiled the fish* (lexical causative) are identical, with the *Agent* occupying the external argument position (*John*) and the *Patient* occupying the internal argument position (*the fish*). Notice that, in the task Grossman and White-Devine employed, participants are given full transitive/causative sentences with regards to which they answer the corresponding probe question. Thus, they are not presented with what would be an ''intransitive'' version of *John boiled…* which could lead participants to consider the possibility that *John* is the *Theme* of *boil*. Accordingly, there is no atypical thematic-role mapping in the stimuli employed by Grossman and White-Devine. Thus, based on this study, we cannot conclude that AD patients have difficulty with ''atypical'' thematic role mapping. If anything, what Grossman and White-Devine's study shows is that the patients might have difficulties with verbs bearing multiple argument structures.

A more recent study conducted by Price and Grossman (2005) investigated the sentence deficit associated with AD by focusing on two separate phenomena, verb transitivity and thematic role assignment. They found that participants with AD were able to detect violations related to verb transitivity (grammatical structure), but demonstrated difficulty with thematic agreements. Performance was assessed using an on-line word detection paradigm. The participants were aurally presented with a target word and, after a 500 ms tone, with a sentence that contained the target word. Participants had to press the space bar as soon as they heard the target word. The experiment included two temporal windows, one right after the violation and one four syllables later. Price and Grossman report that patients did not demonstrate a longer response latency for target stimuli following the incorrect thematic agreements in comparison with the target stimuli following correct thematic agreements in either the immediate temporal window or the four-syllable delay. In contrast, they did show a difference between the correct and incorrect transitivity agreements in both time windows. Based on these findings, Price and Grossman concluded that there is a selective impairment associated with thematic role assignment in AD. Before we adopt this conclusion, we need to examine a few potential problems with Price and Grossman's study. First, although the on-line word detection paradigm is a well-known technique developed by Marslen-Wilson and Tyler (1980) to allow us to track cognitive processes while they are being run the literature does not attest to its use with impaired patients suffering from dementia, and it remains problematic for the study conducted by Price and Grossman (2005). The specific task may have over taxed higher cognitive functions, such as attention and memory for patients that usually demonstrate short-term memory difficulties. Secondly, the experimental stimuli were not controlled for animacy and concreteness, neither for verb class nor for pragmatic plausibility.[1] For instance, the authors concluded that the patients demonstrated impaired thematic role assignment when there was no RT difference to the target word (*canyon*) when presented after sentence (a) *The eagle notices movement on the canyon* and after sentence (b) *The flame notices movement on the canyon*. However, thematic role assignment is not the main problem with sentence (b) given that it is pragmatically odd, violating animacy constraints. Thus, AD patients' non-sensitivity to sentence (b) may be an indication of an inability to determine that flames do not notice, which would be indicative of a pragmatic impairment, not an impairment of thematic role assignment. In fact, such a claim is in accordance with previous findings reporting pragmatic impairments with AD patients (Grossman, Mickanin, Onishi, Robinson, & D'Esposito, 1996).

To summarize, AD patients apparently have a verb meaning impairment that is independent of the grammatical knowledge or resource demands associated with verbs. There have been attempts to associate this deficit with the thematic component of verb representation and, more specifically, with the mapping from thematic to grammatical roles (Grossman & White-Devine, 1998; Price & Grossman, 2005) but with inconclusive results.

Before launching into a description of the present attempt to investigate this deficit, we consider some basic facts about verb thematic roles and their syntactic realization. Apart from the general semantic properties that determine their meaning, verbs impart a number of additional properties that are negligible in nouns, such as *grammatical/syntactic* and *thematic* properties. The realization of semantic participants to argument positions at the sentence level involves a close interaction between *grammatical/syntactic* and *thematic* properties of verbs.

[1] The pragmatic plausibility control is a wide-spread problem in the literature. The pragmatic plausibility effects on thematic role assignment are addressed by Saffran, Schwartz, and Linerbarger (1998).

The present study investigates the realization of thematic roles as sentence arguments by looking at *psychological* predicates.

3. Canonicity in argument realization

In the past three decades, the idea that various aspects of syntax emerge as projections of the lexical properties of words has received substantial consideration within a variety of linguistic-theoretical approaches (e.g., Chomsky, 1981). Part of this idea is that verbs are associated with argument structures, which determine the number and the specific roles of semantic participants in the event/state denoted by the verb (e.g., Grimshaw, 1990). Thus, the syntactic structure of a verb appears as a projection of the verb's semantic participants, which are realized as syntactic arguments. Similar approaches to argument realization have been proposed by researchers adopting the so-called lexical-conceptual structure framework (e.g., Jackendoff, 1990; Levin & Rappaport Hovav, 2005).

At the heart of argument realization is the notion of *thematic hierarchy*. 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 relative position (e.g., subject or object), instead of in terms of its semantic role (e.g., *Agent* or *Patient*). Thus, the mapping is controlled by strategies relative to the hierarchies. For instance, Fillmore (1968) suggests that the canonical order of arguments is *Agent* > *Instrument* > *Theme*/*Patient*, meaning that whenever there is an *Agent* in the sentence, it occupies the subject position (e.g., *The woman broke the egg*), and, in the absence of an *Agent*, it is the *Instrument* that occupies the subject position (e.g., *The fork broke the egg*); otherwise the subject is the *Theme* or *Patient* (e.g., *The egg broke*). More recently, other thematic roles, such as *Goal*, *Source*, and *Location*, have been taken into consideration, resulting in multiple types of 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). There is considerable variability in the ranking of various thematic roles. However, this inconsistency seems to concern exclusively thematic roles that follow the *Agent*, given that whenever there is an *Agent*, it occupies the subject position.[2] This observation leads us to the notion of *canonicity in argument realization* and violations 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*, two distinct cases of argument realization may emerge. The first refers to the case where the argument which follows the *Agent* in the hierarchy occupies the subject position. Although this is in accordance with the requirements of thematic hierarchy, it still deviates from the default *Agent*-first realization that every hierarchy assumes. We will refer to this kind of argument realization as *atypical*. The second case

[2] A reviewer pointed out that this is not the case in passives. It is true that in passive sentences the *Agent*, when present, figures in the *by*-phrase. There are two points that we need to keep in mind: First, the *Agent* in the *by*-phrase is no more an *argument* of the verb, but it is considered an *adjunct* and for this reason it is optional. Second, the fact that the *Agent* does not occupy the subject position in passive sentences does not mean that an *Agent*-first argument realization is not what all thematic hierarchies cited above postulate. In fact, passive sentences are often used as examples of *non-canonical* argument realization simply because due to syntactic movements, the *canonical* (*Agent*-first) realization is not respected. Thematic hierarchies describe the default order of arguments in primary types of sentences (NP-V-NP), and they do not claim to dictate grammaticality. Canonicity is independent of grammaticality. The distinction between *non-canonical* argument realization as a byproduct of syntactic operations and as a result of verb requirements was taken into account in the preparation of our experimental stimulus set.

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

comprises cases where there is a disparity between the requirements of thematic hierarchy and the actual argument realization. We will call this *non-canonical* argument realization.

Psychological (psych) verbs provide a good example of these two cases of deviations from the canonical argument realization. More specifically, subject-*Experiencer* verbs, as in (1a), demonstrate *atypical* argument realization—with *Experiencer* rather than *Agent* assigned to the first NP—, whereas object-*Experiencer* verbs, as in (1b), 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*).

(1) 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 2–5a), and from the perspective of the causer of the mental state (the *Theme* in examples 2–5b). Hereafter, we will be referring to subject-*Experiencer* verbs as ''*fear*-type verbs'' and to object-*Experiencer* verbs as ''*frighten*-type verbs''.

(2) a. Jane *fears* the thunder.
    b. The thunder *frightens* Jane.
(3) a. The public *admires* the statue.
    b. The statue *fascinates* the public.
(4) a. The children *enjoy* the music.
    b. The music *amuses* the children.
(5) a. The equation *perplexes* the class.
    b. The class *ponders* the equation.[3]

[3] 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. Our strategy here is 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.

Deviations from canonical argument realization appear to be problematic for brain-damaged populations, such as agrammatic aphasics who reportedly have problems with syntactic phenomena. This has been demonstrated both with *psych* verbs (e.g., Beretta & Campbell, 2001; Piñango, 1999, 2000) and passives (e.g., Grodzinsky, 1995; but see Berndt, Mitchum, & Haendiges, 1996). For instance, agrammatics have problems with *frighten*-type verbs (6), and also with passives of agentive (7) and *fear*-type verbs (8).

(6) The noise frightened Mary.
(7) Mary was pushed by John.
(8) Mary is admired by John.

Piñango (2006) postulates that agrammatic patients experience difficulties with passives and *psych* verbs due to the fact that these structures deviate from the 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 & Rappaport Hovav, 2005). This principle is based on semantic priority observed across languages of the world via linear order of syntactic representation: *Agent* and *Experiencer* arguments precede *Patients*/*Themes* and *Recipients*. Thus, when syntactic representation violates the canonical order of arguments, poor performance by agrammatic aphasics results.

We investigated whether or not the verb deficit observed in AD is due to a thematic role assignment impairment, motivated by the hypothesis that thematic hierarchy plays a crucial role in argument realization and by the fact that deviations from thematic hierarchy cause difficulties in brain-damaged populations. The specific question we address in this study is the following: Do AD patients have difficulty with thematic realization of predicates that require non-canonical argument realization, such as *psych* verbs? In order to ensure that we obtain a pure effect of canonicity, void of possible effects of complex structure, each verb (either *psych* or *agentive*) used in our study appeared both in active and passive voice.

In line with the previous difficulties reported with verb thematic roles in AD, we predicted difficulties with non-canonical argument realization for the patients' group. We predicted a greater difficulty with sentences violating the thematic hierarchy (e.g. *frighten* actives) than for structures which simply deviate from the standard (*Agent*-first) argument realization (e.g. *fear*-actives). Finally, while we expected no difficulties with *Agent* active items we did expect difficulties with *Agent* and *fear* passives. If we obtain an effect of canonicity in active sentences with non-canonical argument realization, then we will be in a position to talk safely about the role of canonical argument realization and, consequently, about the importance of thematic hierarchy in argument realization. We compared the performance of AD patients to that of age-matched as well as young, cognitively healthy adults. The following section provides details about the experiment.

4. Method

4.1. Participants

The participants were 10 individuals with the diagnosis of AD (mean age: 76.2; SD = 5.7), 11 elderly controls (mean age 83.7; SD = 8.3) and 49 young controls (age range: 18–25). All participants were native speakers of English with at least a grade 6 education.

4.1.1. Patients with probable Alzheimer's disease

The 10 probable AD patients diagnosed with mild-to-moderate cognitive impairment were recruited from the Memory Clinic of the Douglas Research Centre University Hospital. The diagnosis of AD was in accordance to the criteria specified by the National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA; McKhann et al., 1984). Participants' demographic and selected neuropsychological data are presented in Table 2. Results of the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) and the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) indicated that all patients showed mild to moderately severe dementia. They were capable of complying with the requirements of cognitive testing, and were provided with a full explanation of the study. Written informed consent to participate in the study was obtained.

4.1.2. Elderly controls

Eleven cognitively non-impaired participants (one male, 10 females) were recruited from a nursing home in Montreal. All normal participants scored 27 and above on MMSE. They were matched for age and education with the AD patients' group.

4.1.3. Young controls

Forty-nine Concordia undergraduate students (age range: 18–25) also participated in the study. They were administered the sentence completion task in order to compare normal performance with that of the neurologically damaged experimental participants and the elderly controls. In addition, their scores were taken as norms for the exclusion of trials in the analysis.

4.2. Verb pair selection task

The purpose of this task was to determine pairs of verbs that have similar meanings and reverse thematic roles (e.g., *admire–fascinate*). The most frequently provided verb pairs for a given pair of NPs (e.g., *The public* and *the statue*) were used to form the alternating sentence

Table 2
Mean (±standard deviation) demographic and selected neuropsychological data of AD and elderly control participants.

	AD patients ($n = 10$)	Elderly controls ($n = 11$)
Gender	F = 8, M = 2	F = 10, M = 1
Age (years)	76.6 (±5.9)	83.7 (±8.3)
Education (years)	13.8 (±2.7)	12.9 (±2.9)
MoCA (max. 30)	19 (±3)	25.8 (±2.3)[a]
MMSE (max. 30)	24.6 (±3.8)	27.8 (±3.5)
Orientation (max. 10)	6.1 (±2.7)[b]	9.7 (±0.6)
Registration (max. 3)	3 (±0)	2.8 (±0.4)
Attention (max. 5)	4 (±1.6)	4.6 (±0.6)
Recall (max. 3)	1.1 (±1.2)	1.9 (0.9)
Language (max. 8)	8 (±0)	7.9 (±0.3)
Design (max. 1)	0.4 (±0.5)	0.9 (±0.3)

[a] Based on six participants.
[b] We were not able to obtain detailed MMSE scores from two patients. The overall scores, however, are from all 10 patients.

frames for the main experiment. Thirty-four pairs of *psych* verbs which alternate between subject-*Experiencer* and object-*Experiencer* were used in the task. Participants had to use these verbs to complete pairs of sentence frames (e.g., *The public_____the statue* and *The statue_____the public*). Simple transitive verbs (e.g., *kill*) and their semantically similar unaccusative counterparts (e.g., *die*) were also included in the stimulus materials to be used in the agentive and unaccusative sentence frames (e.g., *The hunter_____the deer* and *The deer_____*). Verbs were matched for frequency according to Kucera and Francis (1982) and the MRC psycholinguistic database (Coltheart, 1981). The frequency match was based on the mean of each verb class, i.e., subject-*Experiencer*, object-*Experiencer*, *agentive verbs* and their paired *unaccusatives*.

Booklets with the 34 sentence-pair frames and a separate page containing a list of 68 verbs, were given to 20 undergraduate students of Concordia University, all native speakers of English. They were required to select a verb from the list and write it down on the sentence frame. Once they made their choice, they had to cross out the verb they used from the list, but were allowed to revise their answers when they considered appropriate to do so. Participants in this task did not take part in the experiment.

4.3. Materials and design

Seventy-two sentence frames were created (see Appendix), with 12 frames corresponding to each of the following 6 verb conditions: (1) subject-*Experiencer* verbs (e.g., *fear*); (2) the reverse equivalent of subject-*Experiencer* verbs (object-*Experiencer* verbs; e.g., *frighten*); (3) subject-*Agent* verbs (e.g., *save*); (4), (5) and (6) were the passive equivalent of (1), (2) and (3), respectively (e.g., *was feared*, *was frightened*, *was saved*). Thus, the experimental materials were comprised of three main verb types (subject-*Experiencer*, object-*Experiencer*, and subject-*Agent*) with sentences in two voices (active and passive). Examples can be found in Table 3. There were no filler sentences to avoid over-stressing the patients, and because one-third of the materials was comprised of non-*psych* verbs. Materials were divided into four blocks. For sentences corresponding to the *fear-frighten* minimal pairs, four versions were created (e.g., *The boy feared the thunder*, *The thunder frightened the boy*, *The boy was frightened by the thunder*, and *The thunder was feared by the boy*), with one version in each block. Patients and elderly controls saw all four blocks, with two blocks in each of the two sessions, one week apart. Young controls were presented with only two blocks of the experiment to avoid over-exposure to sentences belonging to the same minimal pair.

Table 3
Sample of experimental stimuli per condition.

Verb type	Voice	
	Active	Passive
Subject-Experiencer	(1) The spectators *enjoyed* the performance ($n = 12$)	(4) The performance was *enjoyed* by the spectators ($n = 12$)
Object-Experiencer	(2) The performance *amused* the spectators ($n = 12$)	(5) The spectators were *amused* by the performance ($n = 12$)
Agentive	(3) The policeman *chased* the criminal ($n = 12$)	(6) The criminal was *chased* by the policeman ($n = 12$)

4.4. Procedure

Participants were run individually in the testing room. They were seated in front of a table with a portable Apple computer running PsyScope (Cohen et al., 1993). The instructions were given to them orally by the experimenter. Participants were presented with the sentence frames with the missing verb, marked by a blank line (e.g., *The boy_____the thunder*). They were told to read each sentence and to complete it using one of four alternative verbs provided. In some cases, the patients' poor vision made reading the sentences difficult and so the experimenter read the sentence frames and verb alternatives to them.

One sentence frame was presented at a time, with the four verb alternatives presented underneath the frame in counterbalanced order. The four alternatives appeared an equal number of times in the four positions and were presented differentially to each subject. Four arrows affixed between the screen and keyboard indicated which key corresponded to each of the four possible responses. The keys used were Q, R, U, and P for the first, second, third and forth verbs, respectively. This was designed to simplify the task for the participant and to minimize key-pressing errors. Participants were required to choose the verb that would best fit the sentence frame by pressing its corresponding key on the keyboard. As soon as participants pressed the button to indicate their answer, the screen cleared and the next trial was presented. The experimental session was preceded by a practice session consisting of seven trials. When the practice session was over, participants were prompted to express any questions they might have about the experiment and were then instructed to proceed with the experimental trials. Testing was completed in two sessions each session lasting approximately 15 min.

This procedure allowed us to assess participants' comprehension of the NP constituents of the sentence frame and their ability to find a proper verb fitting both the meaning of the whole predicate and the resulting NP-V-NP structure. That is, the idea was that while there were at least two verbs that could combine with the NPs to form meaningful predicates, only one of these verbs could combine with the specific order of NPs in the frame. Therefore, we predicted that the selection of a particular verb for a given frame would be not only a function of the meaning of that verb in combination with the NPs provided, but also a function of their relative positions in the resulting structure. We were, therefore, able to investigate directly AD patients' performance in the mapping between semantic participants and syntactic projections.

4.5. Data analysis

The primary dependent measure was the percentage of correct responses. The experiment was analyzed by using a 3 (group) $\times$ 3 (verb type) $\times$ 2 (voice) repeated measures analysis of variance (ANOVA). In all cases, arcsine transformation was employed. However, since we obtained the same effects as with raw data, we chose to report the analyses on the untransformed data. All reported results are significant at the $\alpha = .05$ level by both subjects (F_1) and items (F_2) unless otherwise noted. Based on the young control data, responses to five token items across all conditions were removed from the analyses because they produced up to 30% erroneous responses.[4] For the purposes of item analyses, these items were removed from the dataset and replaced by the mean of the condition. For the participants' analyses, these items

[4] In this case, young controls' data were taken as norms. We removed token items that produced less than 70% correct responses by the young controls.

were removed from the calculations of the mean of each condition, which was produced by the remaining trials within a factor combination.

5. Results

Fig. 1 depicts the overall results for the three groups and Table 4 provides mean percentage correct and standard deviations for the three groups. A 3 (group: Alzheimer's patients, elderly controls, and young controls) by 3 (subject thematic role: subject-*Experiencer* [e.g., *fear*], object-*Experiencer* [e.g., *frighten*], subject-*Agent* [e.g., *save*]) by 2 (voice: active and passive) ANOVA with repeated-measures on subject thematic role and voice revealed a main effect of group (F_1 (2, 67) = 34.8, $p < .0001$; F_2 (2, 22) = 96.4, $p < .001$) and a main effect of subject thematic role (F_1 (2, 67) = 46.3, $p < .001$; F_2 (2, 22) = 12.8, $p = .002$), but no main effect of voice (F_1 (1, 67) = .047, $p = .83$; F_2 (1, 11) = .66, $p = .43$). An interaction between group and subject thematic role was found (F_1 (4, 67) = 13.6, $p < .001$; F_2 (4, 44) = 13.7, $p < .0001$). The source of this interaction is explored below in the comparisons between AD patients and elderly controls. As can be seen in Fig. 1, young controls yielded high accuracy ($M = 95.3\%$, SD = ±8.4) across conditions, and did not enter into further comparisons with the AD patients and elderly controls.

5.1. AD patients vs. elderly controls

A 2 (group) by 3 (verb type) by 2 (voice) ANOVA analyzing the differences between AD patients and elderly controls revealed a main effect of group (F_1 (1, 19) = 15.4, $p = .001$; F_2 (4, 44) = 13.7, $p < .0001$) and a main effect of verb type (F_1 (2, 19) = 24.4, $p < .001$; F_2

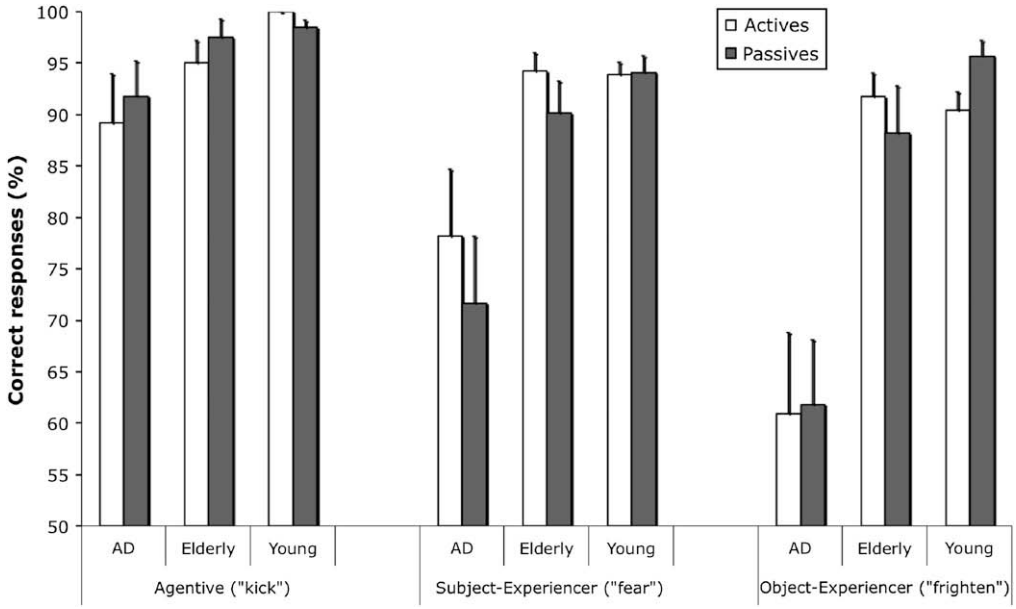

Fig. 1. Mean percentage correct responses for the three groups in all sentence-frame conditions. Error bars indicate standard errors.

Table 4
Mean percentage correct and (standard deviations) for the three groups of participants for all sentences.

Group	Sentence type (verb × voice)					
	Agentive		Fear		Frighten	
	Active	Passive	Active	Passive	Active	Passive
Alzheimer's patients	89.1 (15.2)	91.8 (10.8)	78.1 (20.6)	71.6 (20.4)	60.9 (25)	61.8 (19.9)
Elderly controls	95 (7.5)	97.5 (5.8)	94.2 (6.1)	90.1 (10.4)	91.7 (7.5)	88.1 (15.3)
Young controls	100 (0)	98.4 (5.1)	93.8 (8.2)	94.1 (11)	90.4 (12.4)	95.6 (10.7)

(2, 22) = 13.5, $p = .0002$), but no main effect of voice (F_1 (1, 19) = .29, $p = .59$; F_2 (1, 11) = .36, $p = .56$). There was, however, an interaction between group and verb type (F_1 (2, 38) = 10.9, $p < .001$; F_2 (4, 44) = 14.98, $p < .0001$). In the analyses within each group, verb type by voice repeated measures ANOVAs revealed a main effect of verb type for the AD patients (F_1 (2, 18) = 19.03, $p < .0001$; F_2 (2, 11) = 17.9, $p < .0001$). The same effect was also found for the elderly controls but only in the participants' analysis (F_1 (2, 20) = 3.90, $p = .037$; F_2 (4, 44) = 2.45, $p = .11$). There was no effect of voice (active vs. passive) for either of the two groups, suggesting that the effects of verb type are independent of syntactic frame. Two-way ANOVAs with group and voice as factors revealed no difference between AD patients and elderly controls in the agentive condition in the participants' analysis (F_1 (1, 19) = 1.17, $p = .29$), but a difference was observed in the item analysis (F_2 (1, 11) = 11.5, $p = .006$). The main differences between the two groups, however, were between the two types of *psych* conditions. In between-group contrasts, AD patients performed worse than elderly controls for both subject-*Experiencer* (*fear*) verbs (F_1 (1, 19) = 9.1, $p = 007$; F_2 (1, 11) = 22.1, $p = .0006$) and object-*Experiencer* (*frighten*) verbs (F_1 (1, 19) = 22.4, $p < 001$; F_2 (1, 11) = 166.7, $p < .0001$). Again, the voice factor was not significant in any of these comparisons.

5.2. Verb differences within the AD group

For the analysis of the difference between subject- and object-*Experiencer* within the AD group, a repeated measures ANOVA revealed a main effect of verb type (F_1 (1, 9) = 7.33, $p = .02$; F_2 (1, 11) = 5.54, $p = .04$) but no effect of voice. The pairwise analysis of the two *psych* verb types in the active voice showed that AD patients have more difficulty with object-*Experiencer* sentences than subject-*Experiencer* sentences (t_1 (9) = 2.8, $p = .02$; t_2 (11) = 2.9, $p = .01$).

The difficulties observed in the correct selection of verbs in the subject-*Experiencer* and object-*Experiencer* constructions—together with the high accuracy performance in the case of agentive frames—highlight the problems 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 committed when choosing a verb for each frame. That is, we looked at which verb they selected in lieu of the target verb. Table 5 shows the distribution of errors committed by the patients across conditions.

As can be seen, when AD patients opted for an incorrect *psych* verb, they most often selected the verb with the reverse thematic roles and very rarely the unrelated distractors in both active and passive voice constructions. For instance, when the target verb was *fear*, for a sentence frame such as *The boy_____the thunder*, 66% of the errors committed were with the reverse

Table 5
Distribution of errors committed by AD patients in psych verb selection across conditions.

Subject thematic role (target)	Verb chosen in error (% of all errors)					
	Reverse thematic role		Semantically anomalous		Syntactically anomalous	
	Active	Passive	Active	Passive	Active	Passive
Subject-Experiencer (*fear*)	66%	75%	16%	10%	19%	16%
Object-Experiencer (*frighten*)	73%	89%	11%	6%	16%	5%

distractor (e.g., *frighten* for the target *fear*). This is an indication that AD patients had no difficulty determining the semantic content of the verbs. The pattern of data supports the view that their deficit is in the assignment of verb thematic roles.

6. General discussion

The aim of the present study was to shed light on the nature of the verb deficit found in AD by looking at the ability of AD participants to assign thematic roles to the various NPs associated with verbs in different thematic grid configurations. While previous studies have touched upon the same issue as part of a broader investigation of sentence comprehension in AD (Grossman & White-Devine, 1998; Price & Grossman, 2005), we tackled this question directly by using verbs that differ only with respect to the realization of their thematic roles at the sentence level. Moreover, we introduced *canonicity* as another dimension of argument realization. Based on the fundamental role that thematic hierarchy appears to play in the mapping between semantic participants and syntactic structures, we predicted that AD patients would have difficulty with predicates whose argument realization deviated from thematic hierarchy. More importantly, in order to address the effect of *canonicity* unconfined from any possible effects of structural complexity, we restricted our investigation to NP-V-NP type of sentences, where canonicity was manipulated by the thematic requirements of the verbs used in the study. The focus of our study was the performance of patients in sentences that require subject-*Experiencer* (*fear*) verbs, which call for *atypical* argument realization (no *Agent*), and object-*Experiencer* (*frighten*) verbs, which entail non-canonical argument realization (mismatch between the thematic hierarchy and the actual realization of the arguments, with *Theme* preceding *Experiencer*).

The results are consistent with our main predictions, showing that patients had difficulties making the right choice when they had to complete a sentence with a *psych* verb of either type—subject-*Experiencer* or object-*Experiencer*. In addition, we hypothesized that if the source of patients' deficit is an inability to assign thematic roles when these result in a non-canonical argument realization—and not merely a difficulty with verb meaning—then patients would have difficulty selecting the proper *psych* verb, most often confusing it with the competing verb with reversed thematic roles. That is, in order to select a verb for a frame such as *The boy_____the thunder*, with choices such as *feared* and *frightened*, AD patients would confuse the two verbs that are semantically related. Indeed, the results confirm this hypothesis suggesting that the patients had access to the core meaning of the *psych* verbs because they very seldom chose unrelated distractors, but, instead, confused members of a minimal pair. This confusion, however, does not appear with subject-*Agent* verbs, for which AD patients perform

similarly to their age-matched controls. In the case of *psych* verb frames, the errors AD patients committed support the hypothesis that the deficit is in the mapping between semantic and syntactic representations, more specifically in the assignment of thematic roles to the arguments of the verbs.

Considering the above results, the present study suggests that thematic hierarchy plays an important role in argument realization. This is in accordance with psycholinguistic literature, such as in Ferreira's (1994) work, which emphasizes the importance of argument realization in the participants' choice between active and passive sentences.[5] It appears that patients critically rely on thematic hierarchy information in order to interpret the role of NPs at the sentence level, failing to correctly interpret sentences that deviate from canonical hierarchies. The importance of thematic hierarchy in guiding AD patients' verb selection is further emphasized by the difference in AD patients' performance in the sentences with *fear*-type verbs in comparison with *frighten*-type verbs. The sentences carrying verbs from these two classes deviate from thematic hierarchy in distinct ways: in cases where the *Agent* argument is absent (*fear*), and in cases where the lack of *Agent* is accompanied by a mismatch between the demands of thematic hierarchy and the argument realization at the sentence level (*frighten*). The fact that AD patients' performance is worse with *frighten*-type verbs suggests that they are sensitive to different degrees of deviations from canonical thematic hierarchy. This is an indication that verb-thematic information can be impaired at two seemingly different levels of argument realization: (a) when it deviates from the typical *Agent* > *Theme* roles but preserves the order within the thematic hierarchy (the case of *fear* verbs), or (b) when it deviates from the typical order of constituents to which thematic roles are assigned (case of *frighten* verbs). These two forms of deviations from canonicity in argument realization are supported by the pattern of results—with *Experiencer–Theme* structures (*fear* verbs) producing more errors than typical *Agent–Theme* structures, and with *Theme–Experiencer* structures producing the greatest amount of difficulty. This suggests that beyond thematic roles assigned to argument positions, the order of the roles assigned to these positions can be affected selectively. This dissociation in the AD patients' performance gives support to the existence of these two levels of deviation from thematic hierarchy and highlights the role of the *Agent* in sentence processing in patients with AD.

Assuming that thematic hierarchy guides the mapping from semantic representations to syntactic projections, the ability to process constructions that violate the demands of thematic hierarchy may be impaired in AD. In the present study, AD patients performed at ceiling when confronted with passive sentences with agentive verbs, such as *The boy was saved by the lifeguard*. Passive sentences by default violate thematic hierarchy because they involve suppression of the *Agent* argument. Nonetheless, in the present study, patients were not confused by the non-canonical argument realization of passives and had no difficulty selecting correct verbs to complete these sentences. It seems that when the *Agent* argument is present, AD patients are able to associate this thematic role with the right position in the sentence (this is the case of agentive actives and passives). The *Agent* argument, thus, appears to play a key role in their ability to process sentences, suggesting a difference between AD patients' and agrammatic aphasics' performance (Piñango, 2006) in processing structures with non-canonical argument realization. This disparity is consistent with the general differences observed in language processing by these two brain-damaged populations.

[5] Ferreira (1994) has shown that with agentive verbs, native speakers tend to prefer actives, while with object-*Experiencer* verbs, they have some tendency to prefer passives, so that the most prominent argument, in terms of thematic hierarchy (the *Experiencer* in this case), figures in the subject position.

The fact that the absence of the *Agent* argument creates difficulties in thematic role assignment is not surprising. Carlson and Tanenhaus (1988) claim that regularities in argument realization create a set of "mild expectations" about which thematic roles the verb, when encountered, will actually assign (p. 287). While these expectations may normally act as weak biases, they are likely to have a greater impact when linguistic abilities are diminished. A similar pattern is observed with patients demonstrating a syntactic deficit. Asyntactic patients show an advantage for sentences with canonical word order, where the preverbal NP is in fact the underlying subject, over sentences with non-canonical word order, where the bias conflicts with the correct assignment (Saffran et al., 1998).

Taken into account the general semantic deficit of patients with AD and their performance in the current study we can make certain inferences about the factors involved in thematic role assignment. While syntax is normally perceived as the decisive factor in the assignment of thematic roles, the contribution of other factors has been pointed out in some classic papers in psycholinguistics. For instance, Bever (1970) stressed the importance of word order in English and identified an inclination to interpret the preverbal NP as *Agent*. Analogous findings were reported in a number of other studies (e.g., Herriot, 1969; Kemper & Catlin, 1979; Saffran et al., 1998; Slobin, 1966). It appears that the particular deficit of AD patients with [−agentive] verbs results in a confusion when thematic role assignment has to take place in the absence of the *Agent*.

In conclusion, we have shown that verbs whose thematic structure does not conform to standard thematic hierarchies can be affected in AD, with different types of deviations from canonical argument realization resulting in distinct performance. Most significantly, the study highlights the importance of the [+agentive] feature in verb representation as a decisive factor in thematic role assignment by AD patients. Although the present results indicate that AD patients have an impairment related to thematic role assignment, further investigations are required in order to firmly establish the contribution of thematic role assignment in the context of verb semantic deficits.

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Appendix

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

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/descended/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.

***agent passive* (while the verbs were kept constant, the NPs were changed for pragmatic plausibility reasons)**

1) The children were *accompanied/arrived/grew/yawned* by their parents.
2) Beans were *cultivated/sprouted/decided/babbled* by early farmers.
3) The attorneys were *fired/resigned/concurred/drifted* by the Justice Department.
4) The train station was *illuminated/glittered/divorced/gossiped* by lasers.
5) The zebra was *killed/died/descended/sneezed* by the tiger.
6) The passengers were *saved/survived/expressed/snored* by the Coastguard.
7) The poets were *expelled/departed/moaned/wrinkled* by the king.
8) The criminal was *chased/fled/kissed/spoken* by the police.
9) The car was *stolen/vanished/helped/stuttered* by the gang
10) The boat was *pushed/fell/mopped/barked* by the wind.
11) The boy was *tickled/giggled/cured/revolved* by the feathers.
12) The students were *bored/yawned/carved/nodded* by the speech.

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