syntactic processing task has no detrimental effect. Because syntactic processing may proceed unhindered by a load, it may be performed relatively automatically, without much controlled attention. However, secondary load tasks do interfere with syntactic processing when the load-task stimuli are interleaved with the syntax task, demonstrating that, when syntactic information must be sustained across an attention shift, it suffers significantly.

Rather than assign syntactic processing to a specialized component of working memory, then, we suggest that it operates independently of the central executive. That is, working memory capacity is needed only under attention-demanding circumstances, and, insofar as syntactic processing appears to be immune to divided-attention conditions, it likely occurs relatively automatically. Caplan and Waters (1990) argued that the phonological loop may be required in some syntactic parsing circumstances, such as when subjects are "garden-pathed" or when many words must be maintained in active memory. Why not use that interpretation for the present work?

The age invariance of working memory measures and noninvariance of producing complex syntax

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Abstract: In challenging current conceptions of the role of working memory in sentence processing, Caplan & Waters consider studies comparing young and older adults on sentence processing. This commentary raises two challenges to Caplan & Waters's conclusions: first, working memory tasks appear to be age invariant. Second, the production of complex syntactic constructions appears not to be age invariant.

Caplan & Waters (C&W) raise a number of questions about the role of working memory during sentence processing. They consider evidence from studies comparing young and older adults on sentence processing tasks relevant to this issue because older adults are typically found to exhibit working memory deficits on a variety of tasks. This commentary raises two challenges to C&W's conclusions. First, working memory measures appear to be age-invariant. Second, the production of complex syntactic constructions appears not to be age-invariant.

Age invariance. C&W question whether the tasks commonly used to measure individual differences in working memory are reliable and stable. An additional concern, not considered by C&W, is whether the tasks are age invariant. As Stine (1995) notes, even when younger and older adults are matched based on working memory scores, investigators might inevitably find that older adults have processing difficulties that are seemingly unexplained by their performance on the working memory tasks.

Horn and McArdle (1992) explain that the latent variable approach to constructing measurement permits the test of two common concepts that receive little attention in intergenerational research: construct validity and construct invariance, across samples such as age groups. Horn and McArdle define measurement invariance as factorial invariance: the characteristic that measurements are composed of linear composites, that is, item scores summed to form a total score, is stable across measurement occasions of same or different samples. the authors present four criteria that are sufficient to determine factor invariance: (1) Factor patterns are equivalent across groups, a necessary condition for factor invariance to hold. (2) Factor variances are equivalent across groups. (3) Factor covariances are equivalent across groups. (4) Factor averages of composite scores are equivalent across groups. A fifth criterion they impose is whether cross-products are equivalent across groups. If the answer is "yes," then the answer to questions (1–4) is necessarily "yes"; if the answer is "no," invariance is not necessarily falsified.

To date, few studies have used a latent variable approach to assess the age invariance of working memory measures. As an example of this approach, Kemtes and Kemper (1998) assessed working memory performance for 248 adults (young and old) in four separate studies using a variety of verbal working memory tasks. With the latent variable approach, they tested whether a simple within-studies factor analytic structure with a single latent variable of working memory was reliable across age groups. For three of the studies, this single-latent-factor working memory model was validated across age groups, suggesting that a common construct was measured. Kemtes and Kemper's finding of factor invariance across these different samples strongly supports the conclusions that working memory, as measured by the digit spans, reading span, and listening span, is age invariant.

Age noninvariance. C&W also review the existing literature on the effects of aging on sentence processing and conclude that there are few age differences in on-line sentence processing although post-interpretative processes of question answering and text recall may be affected by aging. However, they overlook an additional body of research on age differences in production. Older adults show a reduction in their production of complex syntactic constructions such as those involving subordinate and embedded clauses (Kemper 1987; 1988; Kemper et al. 1989; 1992; Kynette & Kemper 1986). The age-related decline in syntactic production is somewhat greater for left-branching constructions (e.g., *The gal who runs a nursery school for our church is awfully young*) than for coordinate or right-branching constructions (e.g., *She's awfully young to be running a nursery school for our children*). This asymmetry in the production of right-branching constructions versus left-branching constructions provides strong evidence for the effects of working memory limitations. Left-branching constructions, including center-embedded object relative clauses such as *The dog that the man that the cat bit chased escaped,* are typically considered more complex than right-branching constructions such as *The cat bit the man that chased the dog that escaped* (Gibson et al. 1996; Lewis 1996b).

Cheung and Kemper (1992) investigated the relationship between age, working memory, and production using a number of different ways of measuring linguistic complexity including: mean length of utterance (MLU; Chapman & Miller 1984), developmental sentence scoring (DSS; Lee 1974), developmental level (DLEVEL; Rosenberg & Abbeduto 1987), two alternative ways of measuring Yngve depth (Yngve 1960), and two variants of Frazier's (1985) node count. In addition, propositional density (PDENSITY), based on Kintsch and Keenan's (1973) analyses of text difficulty, was computed in order to assess whether semantic content covaries with grammatical complexity. Cheung and Kemper (1993) applied structural equation modeling to these linguistic complexity metrics using language samples from younger and older adults. The best-fitting model fit the data by specifying two correlated factors, verbal ability and working memory. Age was negatively associated with working memory, leading to a decline in digit span with advancing age, and was somewhat positively associated with verbal ability, reflecting a slight improvement in vocabulary with advancing age. Working memory was related to three syntactic factors: length, measured by MLU; the amount of embedding, measured by MCU; and the type of embedding, measured by DSS and DLEVEL as well as by both Yngve depth metrics and both Frazier counts. Finally, verbal ability predicted another linguistic factor, semantic content, measured by PDENSITY, which was not correlated with the syntactic factors.

Working memory limitations associated with aging affect older adults' production of complex syntactic structures. A key determinant of syntactic complexity, affecting the DSS, DLEVEL, Yngve, and Frazier metrics, is whether embeddings occur in the main-clause subject of left-branching constructions such as "*Going to the St. Louis World Fair* was a major undertaking" or in the

main clause predicate of right-branching constructions such as "I enjoyed *going to the St. Louis World Fair.*" The ability to produce left-branching constructions appears to be especially vulnerable to aging owing to working memory limitations.

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Aphasia, prefrontal dysfunction, and the use of word-order strategies

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Abstract: Caplan & Waters's neuropsychological evidence for two types of verbal working memory rests entirely on a very restricted definition of "syntactic complexity," one in terms of word order. This opens the possibility that the dissociation they observe relates to the differential use of word-order strategies rather than to the structure of verbal working memory.

Caplan & Waters (C&W) present a substantial amount of neuropsychological data obtained in sentence comprehension tasks. These data appear to demonstrate the existence of a dissociation. On the one hand, there are aphasic patients who show a negative effect of "syntactic complexity." On the other hand, we have the patients who are assumed to suffer from prefrontal dysfunction – Parkinson and Alzheimer patients – for which there is an effect of the "number of propositions" but not of "syntactic complexity." C&W take this dissociation to indicate the existence of two types of verbal working memory. It is this interpretation that we wish to challenge.

1. *The argumentation crucially hinges on the effect of word order.* Two effects are discussed. First is the effect of number of propositions. In this respect, the two groups do not differ: both show a negative effect. Second is the effect of "syntactic complexity." "Syntactic complexity" is defined primarily in terms of word order. Word order can be canonical or noncanonical. With aphasics, sentences with canonical word order lead to better performance than sentences with noncanonical word order. For Alzheimer and Parkinson patients, there is no difference.

2. *Word-order strategies make performance on canonical sentences better than on noncanonical sentences. It has been widely assumed that aphasic patients use such strategies.* If patients, as a consequence of a verbal working memory deficit, lose track of the syntactic representation, they could compensate for this state of affairs by choosing thematic roles directly on the basis of word order. In particular, they could associate the agent role with the first noun phrase (NP) of the sentence (cf. Caplan 1983; Caplan & Futter 1986; Caplan & Hildebrandt 1988; Grodzinsky 1990). It is not necessary to assume that patients use such a strategy invariably. It is also conceivable that processing failure occurs intermittently and that the strategy is invoked only in case of processing failure (cf. Kolk & Weijts 1996). If so, every time a patient would use it, the response would be correct with canonical and incorrect with noncanonical sentences.

3. *There is no direct evidence that noncanonicity leads to a higher processing load in aphasic patients.* The idea that noncanonicity represents an independent load factor is attractive, in particular because it relates to argument movement in linguistic theory. Nevertheless, an experiment showing the idea to be valid, in which the strategic factor is controlled for, is still missing. There is ample room for doubt. In a production task, in which Dutch-speaking agrammatics had to order constituents written on cards, we have compared subject-verb-object (SVO), subject-object-verb (SOV), and verb-subject-object (VSO) orders. Generative linguists consider Dutch to be an SOV language (Koster 1975). When word order was varied within a single clause, there was little difference between the three orders. When word order was varied within an embedded clause, all three word orders became significantly more difficult, with some advantage for the SVO order (Kolk & van Grunsven 1985). This result indicates that, at least in production, it is the phrase structure complexity rather than the canonicity that determines computational load.

4. *The strategy hypothesis can account for the canonicity effect that C&W observed in aphasics just as well as the syntactic-complexity hypothesis, perhaps even better.* In view of the above, it is rather surprising that the strategic factor is not at all considered by C&W. It is obvious that the complexity hypothesis makes almost the same predictions as the strategy hypothesis. The strategy in this case would be to take the first NP of the sentence as the agent of the relevant verb (the verb for which the roles are reversed on the distractor picture). There is one sentence type for which the predictions are different: the so-called object-subject sentences (e.g., "The horse kicked the elephant that touched the dog"; the distractor picture presents a horse kicking an elephant, as well as touching a dog). For this sentence type, the complexity hypothesis predicts relatively good performance, because word order is canonical. The strategy hypothesis predicts bad performance because the horse, the first NP, is taken as the agent of "touch." The strategy hypothesis turns out to make the right prediction. The object-subject sentences are about as hard as their noncanonical controls ("subject-object") and substantially harder than another canonical sentence type ("conjoined"). Unfortunately, no statistical test of the latter comparison is reported (see Fig. 1 in Caplan & Waters 1996).

5. *The absence of word-order strategies in Alzheimer and Parkinson patients could be related to a deficit in strategy generation and/or realization.* In our view, both aphasic and Parkinson/Alzheimer patients would suffer from a deficit in the general type of verbal working memory described by Just and Carpenter (1992), although the aphasics' deficit would be more severe. This assumption accounts for the presence of a proposition effect in all three groups. The absence of word-order strategies in Parkinson/Alzheimer patients would be related to another aspect of their prefrontal dysfunction and would lie in the domain of supervisory processes. In a recent paper on the supervisory attentional system, Shallice and Burgess (1996) identify "strategy generation" as an important component of this system. It could be this component itself or the realization of strategies – requiring the intactness of various other components – that is defective in Alzheimer and Parkinson patients.

Is it timing after all?

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Abstract: Even though there is ample evidence from the sentence-comprehension literature for specialized working memory systems in normal and patient populations, some open questions remain. One of them is an explanation for a missing "post-interpretive" processing deficit in a variety of accuracy-judgment tasks in an aphasic patient with a severe verbal working memory problem.

The target article by Caplan & Waters (C&W) provides an excellent overview of the specific effects of working memory capacities on different levels of sentence comprehension in normal and patient population studies. However, their conclusions about non-aphasic patients (dementia of the Alzheimer type [DAT] and Parkinson disease [PD] patients) with severe verbal working