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A modular account of language change in Alzheimer's disease

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Abstract

The following analysis derives from a larger study of language functioning, in which the nature of language change in six subjects with mild cognitive impairment (MCI)/probable Alzheimer's disease (AD) is compared to that of nine healthy adult subjects and eighteen healthy elderly subjects (Cohen Sherman et al 2011). In this analysis—which uses the same data set—AD-type language change is considered more narrowly, in light of linguistic modularity arguments and specifically, the declarative/procedural memory model. Attempts are made first to identify any significant difference between groups (AD/MCI, healthy adult, healthy elderly) in terms of overall language abilities, as measured by performance on a Relative Clause Elicited Imitation (RCEI) task. Data are then analyzed according to a subset of lexical-, structural- and semantic-type measures. In keeping with prior research, significant differences in general linguistic abilities are found to distinguish AD/MCI subjects from both healthy adults and the healthy elderly. Of the sub-type measures, only the lexical variable is significant in distinguishing AD/MCI subjects from their age-matched healthy elderly counterparts. Results are taken to support the declarative/procedural memory model and modularity arguments more generally.

Introduction

Alzheimer's disease (AD) is a progressive, generalized dementia affecting a broad range of cognitive functions and leading to near-complete neurodegeneration (Alzheimer's Foundation of America 2010). Common symptoms of the disease are well-documented but definitive diagnosis proves difficult since brain tissue samples obtained via autopsy are, at present, the only means of confirming beyond any doubt that a patient suffered from AD[1]. Thus, it remains valuable to investigate further means of probable diagnostics and/or early indicators of AD. A hallmark of Alzheimer's-type dementia is language degeneration, especially impairments of semantic fluency (Hodges and Patterson 1995). Increasingly though, researchers are finding that other types of language irregularities (e.g. lexical, morphological) may precede declines in semantic fluency. In general, any findings which point to an asymmetric language decline are valuable tests of linguistic modularity arguments and the idea that different aspects of language may be controlled by interrelated but semi-autonomous brain regions which can develop and/or deteriorate at differential rates.

For decades, linguistics has looked to 'modularity of mind' arguments as a way of grounding certain field fundamentals; modularity arguments have been variously cited to explain anything from innateness to acquisition processes and ever-so-increasingly (but not unrelatedly), pathological performance (Fodor 1983; de Haan *et al* 2010). The latter is an especially useful extension and one with great potential for practical application. At its theoretical base, it is quite similar to the many modularity arguments to have preceded it, most of which have claimed syntactic processing to be fundamentally separate from linguistic processes which are not rule-governed in the same manner (Linebarger 1989). For most theoretical practitioners, this allows for a relatively neat delineation of syntactic abilities on the one hand and lexical functioning on the other (Kinsella 2009). To be sure, there are arguments to be made in dissent of this view (Pustejovsky 1995); it remains a fact however, that foundational theories in nearly every linguistic sub-field assume, explicitly or otherwise, the syntactic/lexical distinction.

What is less clear, even to the more dogmatic of modularists, is the relative location of semantic, phonological, and morphological faculties; to the extent that their reliance on rules is undetermined or indeterminable, so too is their modular location. Semantic functioning is of especial concern for the purposes of this analysis and as such, it is helpful to assign a preliminary modular identity despite the aforementioned uncertainties. In light of current and past research, semantics will be assumed to group more reliably with lexical functioning as opposed to syntactic functioning (Duong *et al* 2006; Rebok *et al* 1990).

The more controversial points of linguistic modularity aside, it remains a useful framework even in its most basic formulation, namely that which articulates only syntactic and lexical capacities as definitively distinct in any modular sense. Indeed, this is the version most familiar to linguists looking to make such a theory practically applicable. The base simplification allows for contributions and input from disciplines other than linguistics, most notably cognitive neuroscience. Especially in the case of language pathology, there is an ever-increasing reliance on neuroimaging as a means of grounding linguistic theory. Of these

[1] Given this difficulty, some physicians and researchers have introduced the Mild Cognitive Impairment (MCI) diagnosis as a way of identifying patients presenting with Alzheimer's-like symptoms but who, for obvious reasons, have not been confirmed to have AD. MCI, though a diagnosis all its own and one which is by no means synonymous with Alzheimer's, is nonetheless a helpful diagnostic proxy since MCI patients go on to suffer from (autopsy-confirmed) AD at rates ten times that of non-MCI groups (Cohen Sherman *et al*, forthcoming).

approaches, the declarative-procedural model is among the most well-established and widely accepted. It posits the lexical and syntactic faculties to be governed by distinct regions of the brain associated with declarative and procedural memory, respectively. In this model, syntax and other grammar-based linguistic processes are carried out in the frontal cortex and basal ganglia regions while the lexicon is associated primarily with temporal and tempoparietal neural structures (Ullman 2001). With this as a base assumption, the declarative-procedural model acquires real predictive power. Many current researchers make reference to this model as a means of accounting for various particularities relating to a host of pathological and/or degenerative language disorders, AD among them (Ullman 2001; Walenski *et al* 2009).

With specific reference to AD, much current research aims to evaluate the declarative-procedural model in light of its ability to accurately predict and/or correlate clinical manifestations of the disease. Early results suggest, for example, that AD-type neurodegeneration is associated with significant declines in lexical and semantic abilities but that syntactic abilities remain relatively unaffected, at least in the early clinical stages (Kempler *et al*, 1987). These findings, coupled with the general medical understanding that AD affects the temporal regions most severely (Scheltens et al. 1992; Killiany et al. 1993), are often summarized as being generally concordant with the declarative-procedural model.

The analysis to follow is a continuation of previous research, with the goal being to weigh in—empirically rather than speculatively—on the question of linguistic modularity as it relates to AD in particular. The hypothesis, then, is as follows:

It is expected that (i) Clinical AD/MCI patients will show an appreciable deterioration in language abilities, as compared to either healthy adults or the healthy elderly and that (ii) this deficit will be more marked in the case of primarily lexical and semantic performance; syntactic functioning is hypothesized to be relatively less affected.

Methodology

All data in this analysis is derived from a larger, unprecedentedly comprehensive study into AD-type language degeneration (Cohen Sherman *et al,* 2011), the questions and goals of which are beyond the scope of this small and comparatively limited investigation. Certain methodological approaches of that larger study do, however, require mention. These include the three-way grouping of subjects as part of the healthy adult (MIT), healthy elderly (Cornell) or AD/MCI cohort (MGH), a grouping schema upon which all subsequent statistical analyses are based[2]. Because grouping is done according to combined age and AD characteristics, three-way comparisons are almost always followed by post-hoc analyses designed to isolate the "AD/MCI effect" (i.e. the Cornell-MGH comparison), as this is the variable of primary concern in this particular analysis.

Though the larger study developed and administered an all-encompassing battery of linguistic tests (including elicited imitation, 3-word, and picture description tasks, among others), this sub-investigation deals exclusively with Relative Clause Elicited Imitation (RCEI) data. In large part, this choice was purely practical: RCEI was, at the time of initial investigation, the only task completely transcribed and scored. In a sense though, the choice proved provident in that elicited imitation involves both lexical and syntactic faculties (Lust *et al,* 1996), represented in this data set in terms of lexical and structural sub-scores.

The larger data set codes also for a semantic variable in the sense that each elicited imitation task is administered via two distinct sets of batteries, one of which is semantically meaningful (+SEM) and the other of which is semantically vacuous (-SEM). A prediction of semantic abilities and the (potentially) differential deterioration thereof was included as part of the hypothesis in light of the persuasive findings of earlier studies on the matter (Hodges and Patterson 1995) and a conscious effort to identify the most promising avenues for future research.

Four variables, then, were subjected to statistical analysis using SPSS. These included overall RCEI performance ("RCEI.total," measured as a composite battery score), lexical RCEI performance ("RCEI.lex," measured in terms of total number of lexical-type errors), structural RCEI performance ("RCEI.str," measured in terms of total number of syntactic-type errors) and semantic RCEI performance ("DIFFplus/minusRCEI.total," a distilled variable measured as the magnitude of difference in +SEM battery scores as against –SEM battery scores).

For each of the above variables, a one-way analysis of variance (ANOVA) was conducted to determine significance. Where a significant difference of means was identified[3], post-hoc

[2] The relevant grouping of subjects is according to age and clinical status. For convenience, these cohorts are identified sometimes by institution, where healthy adult = MIT (subjects in this cohort are MIT undergraduate or graduate students and all interviews were conducted on campus), healthy elderly = Cornell (subjects were healthy elderly drawn from the Ithaca, NY area and all interviews were conducted at Cornell), and AD/MCI = MGH (subjects were patients referred to study by physicians at Massachusetts General Hospital or affiliated organizations and all interviews were done at MGH).

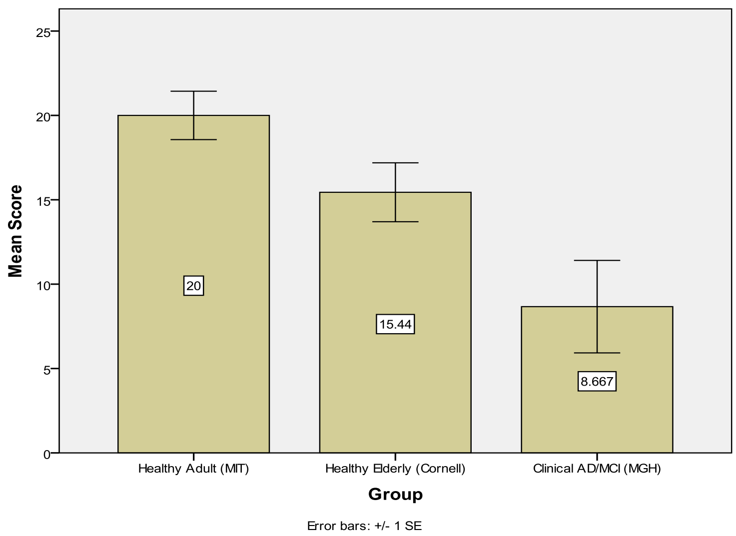
[3] Fisher LSD tests were administered in all and only cases where the omnibus F was significant. This stipulation provides some degree of statistical "protection" against alpha-error (Sirkin 2006), which is especially important in light of the general shortcomings of the Fisher LSD (see footnote below).

analyses using the Fisher LSD test[4] were done in an attempt to determine which of the comparisons accounted for the overall significance. Especial attention was paid to the Cornell-MGH comparison, since these age-matched groups differ only in AD characteristics, thus making it possible to isolate the desired "Alzheimer's effect."

Results

A one-way analysis of variance (ANOVA) was conducted to compare the effect of group membership—a combined proxy for age and AD characteristics—on RCEI performance in healthy adult (MIT), healthy elderly (Cornell) and clinical AD/MCI (MGH) conditions. RCEI performance was measured in terms of overall composite scores and also in terms of disaggregated measures relating to lexical and structural sub-scores and semantic difference scores. Overall composite scores were figured as an integer score out of twenty-four, where twenty-four is the total number of RCEI token sentences—one point was recorded for each response marked as correct, zero points were given in the case of an incorrect response. Lexical and structural sub-scores were figured as an error count score across all batteries, where errors classified as either lexical or structural were summed to yield respective error scores. The semantic difference score is calculated as the magnitude difference between the +SEM battery score (a twelve token subset of sentences with semantic meaning, score ceiling of twelve) and the –SEM battery score (a twelve token subset of sentences without semantic meaning, score ceiling of twelve).

Figure 1. RCEI: Overall scores by group



The ANOVA showed that the effect of age/AD characteristics on overall RCEI performance is significant, F(2,30)= 5.312,

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[4] The legitimacy of the Fisher LSD is sometimes debated on the grounds that it allows for unacceptable levels of alpha error (i.e. >.05), or the chance of identifying a significant result where none exists. It is just this leniency, however, which makes it an appropriate test for the study at hand; the study—owing to its incredibly small N and possibly small effect sizes, among other factors—is at incredible risk for beta error, the case where a significant effect is not detected where one does, in fact, exist (Sirkin 2006). So because the study lacks statistical power and moreover because comparisons are rather limited in number (maximally three-way, making the risk of alpha-error only slightly elevated), the choice of a lenient post-hoc seems justifiable. Thus, the standard .05 is taken as the threshold significance level, even in the case of the Fisher LSD. Should the study be extended in sample size or otherwise made less prone to beta-error, the applicability and legitimacy of such a test ought to be re-evaluated.

p=.001. The mean total score is significantly lower in the clinical AD/MCI group condition (M=8.67, SD=6.713) than in either the healthy adults group condition (M=20, SD=4.301), p=.003, or the healthy elderly group condition (M=15.44, SD=7.406), p=.037. There is no significant difference in mean total scores of the healthy elderly as compared to healthy adults. A graphical representation of this data is given in Figure 1. Overall significance is shown in Table 1 (first row) and post-hoc *p* values are given in Table 2 (first row).

Table 1. Linguistic Performance by Study Group

	Subscore mean[a]			
	Healthy Adult (MIT) (n=9)	**Healthy Elderly (Cornell) (n=18)**	**Clinical AD/MCI (MGH) (n=6)**	***p* value**[b]
RCEI Total[c]	20.00	14.44	8.67	.011
RCEI Lexical	4.89	10.93	18.33	.003
RCEI Structural	0.22	0.94	2.33	.034
RCEI Semantic	2.00	2.056	2.33	.918

[a]As explained in METHODOLOGY, the semantic score reported here is actually a magnitude difference score.
[b]*P* values are based on the one-way analysis of variance (ANOVA).
[c] Note that RCEI Total is a composite score which includes more subscores than those disaggregated here.

Table 2. Multiple Comparisons of Selected Variables

(A) Group	**(B) Group**		***p* value**[a]
RCEI Total		Healthy Elderly (Cornell)	.101
		Clinical AD/MCI (MGH)	.003
	Healthy Elderly (Cornell)	Clinical AD/MCI (MGH)	.037
		Health y Adult (MIT)	--
RCEI Lexical	Healthy Adult (MIT)	Healthy Elderly (Cornell)	.037
		Clinical AD/MCI (MGH)	.001
	Healthy Elderly (Cornell)	Clinical AD/MCI (MGH)	.028
		Health y Adult (MIT)	--
RCEI Structural	Healthy Adult (MIT)	Healthy Elderly (Cornell)	.235
		Clinical AD/MCI (MGH)	.010
	Healthy Elderly (Cornell)	Clinical AD/MCI (MGH)	.052
		Healthy Adult (MIT)	--

[a] *p* values are based on a (protected) Fisher LSD test.

Significant differences were likewise found in mean lexical sub-scores among the three groups, F(2,30) = 7.077, p=.003. Post-hoc analyses using the Fisher LSD test showed that the average lexical sub-score was significantly higher in the clinical AD/MCI group condition (M=18.33, SD=8.189) than in either the healthy adults group condition (M=4.89, SD=3.219), p=.001, or the healthy elderly group condition (M=10.94, SD=7.55), p=.028. The average lexical sub-score was also significantly higher for the healthy elderly as compared with the healthy adults, p=.037. In Figure 2, mean lexical sub-scores are graphed by group. Overall significance is shown in Table 1 (second row) and post-hoc p values are given in Table 2 (second row).

Figure 2. RCEI: Lexical subscore by group

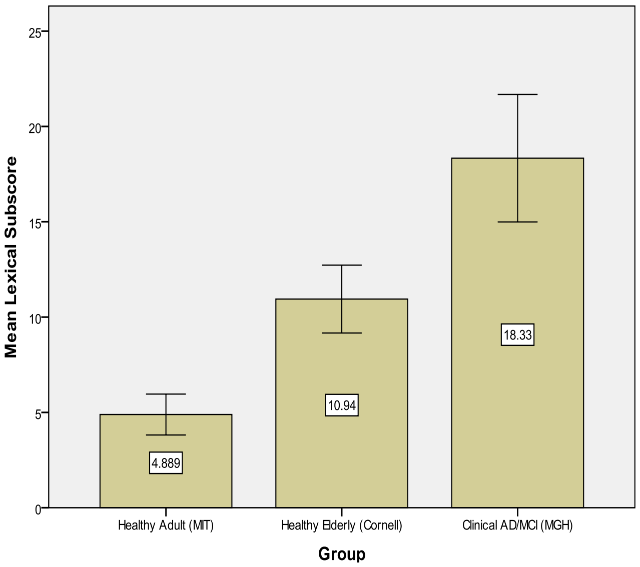


Figure 3. RCEI: Structural subscore by group

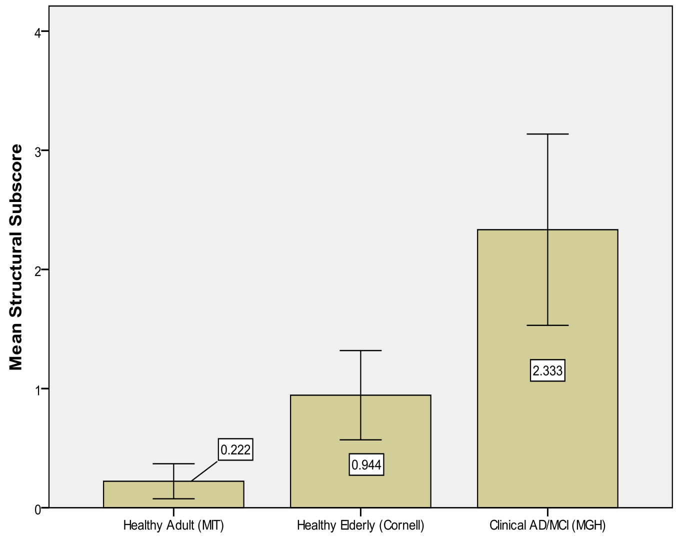


Figure 4. RCEI: Semantic subscore by group

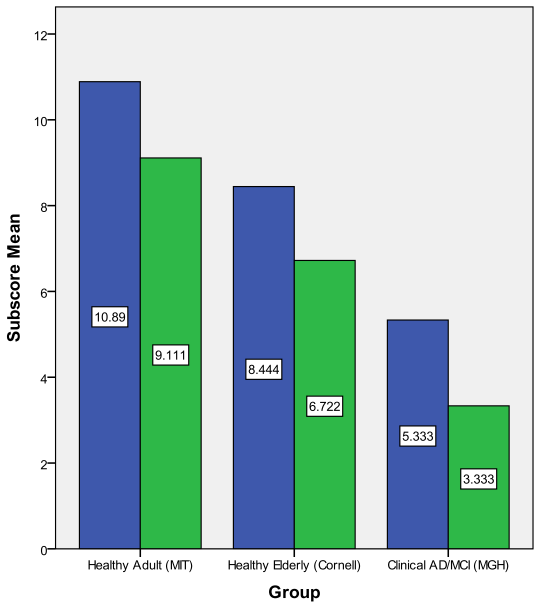
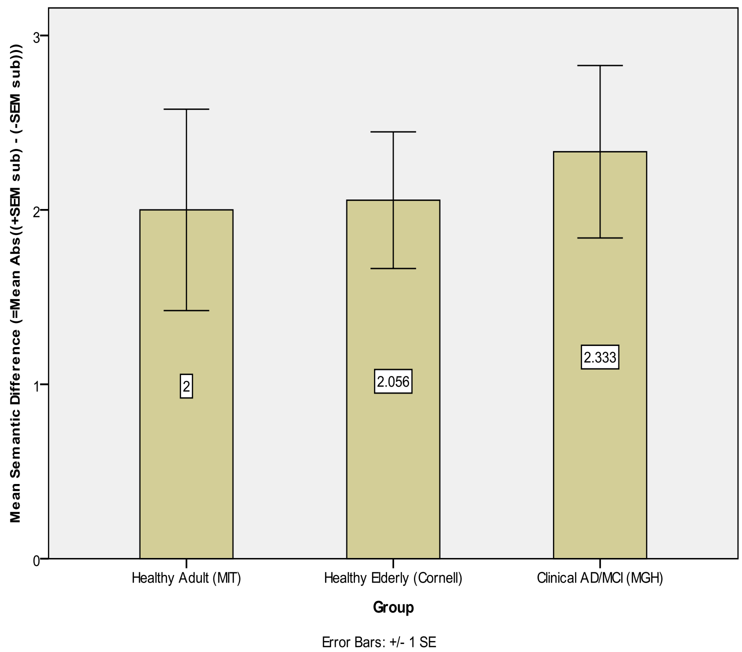


Figure 5. RCEI: Semantic difference by group



The effect of age/AD characteristics on structural sub-scores was significant, $F(2,30) = 3.779$, $p=.034$. Post-hoc analyses showed that the mean structural sub-score was significantly higher in the clinical AD/MCI group condition (M=2.33, SD=1.966) than in the healthy adults group condition (M=.22, SD=.441). No other group comparisons were significant. Mean structural sub-scores are graphed by group in Figure 3. Overall significance is given in Table 1, p.4 (third row) and post-hoc p values are listed in Table (third row).

The omnibus F for semantic difference scores was not significant $F(2,30) = 0.86$, $p=.918$, meaning that scores of semantic difference do not differ significantly as a function of age/AD characteristics. As such, no post-hoc comparisons were obtained. Figure 4, p.6, graphs semantic sub-score by group. In that figure, a side-by-side comparison is made between +SEM battery scores and –SEM battery scores. Distilled from that data are the mean semantic difference scores, which are then graphed by group in Figure 5. Overall significance for the difference scores is given in Table 1 (fourth row).

Discussion

Interpretation of Results

From the preliminary results given above, it would appear as if the data *generally support* the initial hypothesis, which predicted (i) that linguistic performance would be significantly lower overall for clinical AD/MCI subjects relative to both the healthy adult and healthy elderly cohorts and (ii) that this difference in linguistic performance would be significantly more pronounced in lexical- and semantic-type tasks and less so in structural-type tasks. To evaluate this hypothesis, it is necessary to consider the post-hoc *p* values for relevant dependent variables, "RCEI.total," "RCEI.lex," and "RCEI.str." In a somewhat separate manner, it is also necessary to consider the non-significance of the semantic variable as possibly contradictory evidence as regards the hypothesis.

In the case of "RCEI.total," mean scores for the clinical AD/MCI cohort were in fact significantly lower than those of either the healthy adult or healthy elderly populations. That mean scores differ significantly between the two age-matched groups (Cornell-MGH) is an especially encouraging result, as it suggests an "Alzheimer's effect" independent of age effect(s). Indeed, of the between-group comparisons implied by the hypothesis—MGH-Cornell *and* MGH-MIT—only the former is truly useful in any scientifically valid sense. In the case of the latter comparison, a significant result says nothing of the source of difference (i.e. whether it is age or AD/MCI characteristics) since healthy adults differ from clinical AD/MCI patients on at least two levels: age and AD/MCI status.

At this point, then, it is helpful to refine the orientation of the analysis so that the MGH-Cornell comparison is understood as the primary one of interest. Thus, in evaluating the second extension of the hypothesis, one need only compare the MGH-Cornell post-hoc *p* value for "RCEI.lex" with the corresponding post-hoc *p* of "RCEI.str." Crucially, the first of these post-hoc p's was significant, meaning that the clinical AD/MCI group had significantly higher lexical error scores (i.e. they made more lexical-type errors, on average) than did the healthy elderly group. In the case of structural error scores, no significant difference was found in means of the clinical AD/MCI group as against the healthy elderly. A significant "RCEI.lex" post-hoc *p* value, as compared to a non-significant "RCEI.str" post-hoc *p*, makes it more certain that there exists a meaningful difference[5] (Cornell v. MGH) in mean lexical sub-scores and less certain that there exists such a difference (Cornell v. MGH) in structural sub-scores. Frustratingly, the real premise of the hypothesis (i.e. that lexical differences would be *greater or more marked* than structural differences) is largely unanswerable in light of the fact that "RCEI.str" returned a non-significant MGH-Cornell post-hoc *p*, thereby making it impossible to compare magnitude effects. To get around this, non-significant differences are sometimes assigned a *t* value of zero and then compared to other non-zero *t*'s (as in, those associated with significant *p*'s); this approach, though, is not entirely sound and for this reason, is not attempted here. The difference in certainty, discussed above, ought to be enough to affirm the basic extension of the hypothesis.

Before deciding finally on the overall strength of the hypothesis, one ought to consider the semantic variable, "DIFFplus/minusRCEI.total," and its overwhelming non-significance. Of the four dependent variables studied, "DIFFplus/minusRCEI.total" was the only one to return a non-significant omnibus F in the preliminary ANOVA . This means that there is no apparent age/AD effect on semantic difference scores. This finding is in contrast to earlier research on the subject of semantic fluency in subjects with probable AD; most of this research notes significant AD-related declines in semantic abilities, especially semantic memory (Hodges & Patterson 1995; Nebes 1989). If valid, the anomalous finding of this analysis with regard to the semantic variable also poses an implicit challenge to the declarative/procedural model, given that semantics is thought to be processed in regions of the brain associated with declarative memory (e.g. anterior temporal lobes) (Martin & Chao 2001) . Of course, the question remains whether the semantic variable extracted for the purposes of this analysis is analogous in type to more traditional semantic measures. Manipulating semantic meaning in the context of elicited imitation (i.e. by devising +SEM/-SEM battery types) is likely not the most direct way of assessing semantic abilities and any variations therein. Fortunately, the larger study from which this analysis derives includes a number of tasks which lend themselves more naturally to semantic analyses (e.g. picture description, 3-word task) in the sense that a semantic variable can be extracted more or less directly, with minimal abstraction.

[5] Meaningful difference refers here to the research hypothesis, as statistically defined. In other words, the difference is meaningful if between-group variation is too great to be attributed to chance and must therefore be attributed to an independent "Alzheimer's effect."

Taken together, the significance results for the variables "RCEI.lex," "RCEI.str," and "DIFFplus/minusRCEI.total," support the notion of linguistic modularity, as introduced in the beginning of this analysis. If the language faculty were domain-general in nature, one would expect language deficits and declines to be uniform across all linguistic categories. Analysis of just three linguistic categories—syntax ("RCEI.str"), semantics ("DIFFplus/minusRCEI.total") and the lexicon ("RCEI.lex")—reveals just the opposite pattern: AD/MCI subjects make significantly more lexical-type errors than do the healthy elderly, but the difference in structural-type errors between the two groups is non-significant, as is the difference in semantic (difference) scores between those two groups. Moreover, even the non-significant structural- and semantic-type results differ from one another in their degree of non-significance, with the latter being highly non-significant and the former only marginally so. Clearly then, this analysis' findings are consistent with the notion of linguistic modularity.

More arguably, the analysis is also consistent with the declarative/procedural model of memory, which in its essence, is linguistic modularity as applied to neurobiology. Again, the one caveat to this consistency is the unexpected non-significance of the semantic variable, which patterned in ways not predicted by the declarative/procedural model. In that model, lexical and semantic functioning are usually grouped together as part of declarative memory and expected therefore to pattern together where applicable (Ullman 2001; Tulving and Markowitsch 1998) . In the case of AD-type language change, lexical *as well as* semantic functioning was hypothesized to be relatively more impeded than syntactic functioning, given that the neurodegeneration characteristic of AD affects the temporal regions most severely (and the temporal areas are precisely where the lexicon and semantics, like all other aspects of declarative memory, are processed) (Scheltens et al. 1992; Ullman 2001; Tulving and Markowitsch 1998). The fact that the semantic variable returned a highly-non significant result, combined with the comfortable significance of the lexical variable, casts some degree of doubt on the declarative/procedural model; it does not, however, undermine its validity *per se*. Rather than dismantling an otherwise legitimate framework, it is perhaps better to view the anomalous patterning of the semantic variable as just that, especially in light of the conceptual problems and uncertainties discussed above in relation to "DIFFplus/minusRCEI.total." More important is the consistent patterning of "RCEI.lex" as compared to "RCEI.str," since both of these variables are more naturally derived and/or assessed in the context of elicited imitation.

Anticipated Criticisms

Largely ignored in this analysis was the independent effect of age on language abilities in each of the three groups. This omission is potentially problematic in that the age effect may bear importantly on conclusions and connections made in this analysis. It could be the case, for instance, that age effect patterns prove similar to those identified for the "Alzheimer's effect." In other words, it could be that the healthy elderly also lose lexical abilities in a comparatively more marked fashion than they do structural abilities. To the extent that AD-type language change mirrors that of normal ageing, this analysis fails to fully account for the data in all its richness.

The second category of criticisms relates to statistical approach. In this analysis, great care was taken to maintain the integrity of the experimental design (of the original study), in which all groupings are made according to a combined proxy which takes into account both age and AD/MCI characteristics. This yields three independent groups (healthy adults, healthy elderly and clinical AD/MCI patients) and *one* independent variable (IV), hence the choice of the one-way ANOVA. Post-hoc comparisons are then used as a means by which to separate out the component IVs (age and AD characteristics) and measure their respective effects on the DV(s). In theory, this seems a logical approach to data analysis, given the design of the study in question. In reality though, the multi-step analyses implied by the ANOVA complicate the statistical picture. Might there exist a simpler, more direct way to assess significance in this study? In answer to this, one can imagine a scenario in which data are recoded in binary fashion to a yield a new age variable (i.e. “0” for subjects previously classified as healthy adults and “1” for subjects previously classified as either healthy elderly or clinical AD/MCI) and also a new AD/MCI variable (i.e. “0” for all subjects classified previously as either healthy adults or healthy elderly and “1” for all subjects classified previously as clinical AD/MCI patients). In this case, a two-way ANOVA with fixed factors “age” and “AD/MCI” and dependent variables “RCEI.total,” “RCEI.lex,” “RCEI.str,” and “DIFFplus/minusRCEI.total” could be run. Besides eliminating the need for post-hoc procedures, the two-way ANOVA is appealing in its ability to derive fairly transparent interaction effects between age and AD/MCI status, which, though not of particular import in this analysis, are likely to prove important in future analyses.

Conclusion

This analysis looked at language abilities across three groups: clinical AD/MCI subjects, healthy adult subjects and healthy elderly subjects. With regards to overall linguistic competence, as measured by score totals on the RCEI task, significant differences were found between mean RCEI scores of AD/MCI subjects as compared with those of both the healthy adult and healthy elderly populations. When AD/MCI subjects were compared to their age matched, healthy elderly counterparts across lexical-, structural-, and semantic-type measures, a significant difference was found only in the case of the lexical-type measure. This finding in particular supports linguistic modularity arguments and somewhat more arguably, the declarative/procedural memory model.

An implicit goal of this analysis was to identify promising avenues for future research in the context of the larger study. In the immediate future, it is hoped that more lexical- and structural-type variables might be identified and evaluated as a means by which to retest the finding that lexical-type measures appear more sensitive to AD-related language declines than do structural-type measures. Likely these variables will be extracted from relevant portions of the 3-word task and may include measures such as noun and verb type:token ratios (a lexical measure) and percent complex clauses (a structural measure), and possibly others. Further into the future, it could be worthwhile to investigate semantic variables with greater precision than was allowed in this analysis. Semantic variables ought to be extracted from tasks which include an inherent semantic component—the 3-word and picture description tasks are but two examples.

In sum, this analysis should be treated as a jumping-off point for related investigations into AD-type language change and its differential effects on various linguistic sub-categories, categories which, in future analyses, need not include only lexical-, structural- or semantic-type measures. They might, for example, incorporate phonological- and/or morphological-type measures in addition. As it stands now, the findings of this small scale analysis lend support to modularity arguments in that asymmetric language declines are seen in AD/MCI subjects. Ultimately, a comprehensive range of data could better inform theories of linguistic modularity. And though ideas of this type will necessarily reference AD-type language change, their applicability extends far beyond.

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