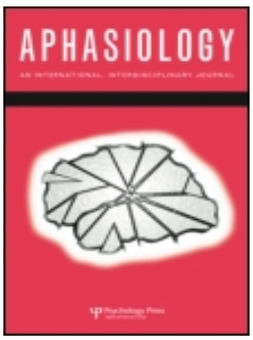

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Productive vocabulary across discourse types

Gerasimos Fergadiotis[1], Heather Harris Wright[1], and Gilson J. Capilouto[2]

[1]Department of Speech and Hearing Science, Arizona State University, Tempe, AZ, USA
[2]Rehabilitation Sciences, University of Kentucky, Lexington, KY, USA

Aims: The goals of the study were (a) to examine the effect of discourse type on lexical diversity by testing whether there are significant differences among language samples elicited using four discourse tasks (procedures, eventcasts, story telling, and recounts); and (b) to assess the extent to which age influences lexical diversity when different types of discourse are elicited.
Methods & Procedures: A total of 86 cognitively healthy adults participated in the study and comprised two groups – young adults (20–29 years old) and older adults (70–89 years old). Participants completed the discourse tasks and their language samples were analysed using dedicated software (voc-*D*) to obtain estimates of their lexical diversity.
Outcomes & Results: A mixed 2 × 4 ANOVA was conducted and followed by an investigation of simple main effects. A lexical diversity hierarchy was established that was similar for both age groups. The study also uncovered age-related differences that were evident when the stimuli were verbally presented but were eliminated when the language samples were elicited using pictorial stimuli.
Conclusions: Results indicated that lexical diversity is one of the microlinguistic indices that are influenced by discourse type and age, a finding that carries important methodological implications. Future investigations are warranted to explore the patterns of lexical diversity in individuals with neurogenic language disorders and assess the clinical utility of measures of lexical diversity.

Keywords: Lexical diversity; Ageing; Linguistics; Diversity.

Discourse is a naturally occurring form of communication that involves the activation and interaction of multiple interconnected cognitive and linguistic subsystems. According to Phillips and Jorgensen (2002) ". . . what underlies the word 'discourse' is the general idea that language is structured according to different patterns that people's utterances follow when they take part in different domains of social life" (p. 1). This definition highlights the predictable nature of structural similarities among

Address correspondence to: Gerasimos Fergadiotis, MA, CCC-SLP, Arizona State University, Department of Speech and Hearing Science, P.O. Box 870102 Tempe, AZ 85287-0102, USA. E-mail: gfergadiotis@gmail.com

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instantiations of the same discourse type and also emphasises that discourse is *language in use* that serves a social purpose (Goffman, 1981). Eliciting and analysing language samples has been gaining prominence among clinicians and researchers precisely because discourse analysis provides the opportunity to observe complex cognitive/linguistic behaviours and conduct a wide variety of analyses to understand the nature of cognitive-communicative deficits.

A variety of elicitation techniques have been used to obtain language samples depending on the focus of the study. For example, participants have been asked to describe a common procedure like planting a flower in a garden (Brady, Armstrong, & Mackenzie, 2005; Caspari & Parkinson, 2000). In other studies researchers have asked participants to describe pictorial stimuli (Christiansen, 1995; Nicholas & Brookshire 1993; Olness, 2006; Wright & Capilouto, 2009). Further, narratives have been elicited through re-telling of familiar stories (i.e., story retellings) and/or sharing past experiences (i.e., personal narratives or recounts) (Ash et al., 2006; Coelho, Grela, Corso, Gamble, & Feinn, 2005; Hough & Barrow, 2003; Ulatowska, North, & Macaluso-Haynes, 1981).

It is generally accepted that the type[1] of discourse a speaker chooses to respond when a specific elicitation technique is used may impose different cognitive and linguistic demands (Bliss & McCabe, 2006; Brady et al., 2005; Nicholas & Brookshire, 1993; Ulatowska, Allard, & Chapman, 1990). As a result, the performance on some indices that are used to assess microlinguistic (e.g., syntactic complexity) and macrolinguistic (e.g., story elements) aspects of verbal output can vary depending on the discourse type (Li, Volpe, Ritterman, & Williams, 1996; MacLachlan & Chapman, 1988).

Further, there is a general consensus that performance on some indices of discourse production can also vary as a function of age (Harris, Kiran, Marquardt, & Fleming, 2008). For example, age has been found to be positively correlated with the number of words, number of utterances, and amount of irrelevant content produced but negatively related to content quality produced by cognitively healthy adults (Juncos-Rabadán, Pereiro, & Rodriguez, 2005). Additionally, Capilouto, Wright, and Wagovich (2005) found that healthy younger participants' (mean age = 22.4, $SD = 2.2$) narrative samples were associated with significantly higher percentage of information units compared to older participants' (mean age = 71.4, $SD = 8.2$) narratives; and Marini, Boewe, Caltagirone, and Carlomagno (2005) found that their older participants (> 75 years old) produced significantly less-complex sentence structures and had significantly lower occurrences of local coherence and global coherence compared to younger adults (i.e., < 59 years old). Conversely, other aspects of discourse production, such as the range of vocabulary exhibited by a speaker, have been shown to increase with age (Hultsch, Hertzog, Dixon, & Small, 1998; Schaie, 1996).

Although many aspects of discourse production have attracted considerable interest in clinical populations and have also been used to explore differences across discourse elicitation techniques and age groups, one of the most illuminative predictors of oral performance, *lexical diversity* (LD), is often neglected (e.g., Armstrong, 2000). Alternatively, when it has been used, it is often estimated incorrectly (e.g., Avent & Austermann, 2003). LD, which can be loosely defined as one aspect of a

[1] For the purposes of this study, discourse *type* is defined as the discourse that is predominantly produced as a response to a specific elicitation task.

speaker's range of vocabulary[2] (Durán, Malvern, Richards, & Chipere, 2004), has been studied in fields such as language acquisition and neuropathology and has been linked to vocabulary knowledge as well as communicative ability (Durán et al., 2004; Jarvis, 2002; McCarthy & Jarvis, 2007; Zareva, Schwanenflugel, & Nikolova, 2005;). Paradoxically, LD has remained underutilised in studying the discourse production patterns of individuals with aphasia (with some exceptions; e.g., Wright, Silverman, & Newhoff, 2003) despite the fact that the cardinal deficit of aphasia is anomia. It would be expected that LD would be one of the speech-language pathologists' most valuable tools in exploring the efficacy of aphasia therapy, assessing the severity of discourse production deficits, and quantifying results for research purposes.

How LD varies with respect to discourse type is not well understood. For example, Bliss and McCabe (2006) have suggested that story telling from wordless picture books ". . . consists of a richer vocabulary than personal narratives [recounts] because of the contents of the illustrations" (p. 131). However, O'Loughlin (1995) reached different conclusions in an investigation of how *lexical density* (a ratio of frequency weighted lexical items divided by the sum of lexical and grammatical items which reportedly also measures LD) in adult English language learners varied as a function of task format and type. O'Loughlin found that personal narratives were associated with higher lexical density compared to picture descriptions and he suggested that ". . . 'open' tasks seem to elicit language with a higher degree of lexical density than 'closed' tasks [. . .] because candidates are not constrained by any stimulus material" (1995, p. 234). With respect to single versus sequential pictures, Wright and Capilouto (2009) demonstrated that narratives elicited from single picture stimuli were associated with lower LD compared to narratives elicited with sequential picture stimuli.

The main reason the study of LD has been limited is that identifying a robust index to measure LD has been challenging. Often the tools that had been used by researchers had been restricted to type/token ratio (TTR), various algebraic transformations of TTR,[3] and probabilistic models such as Yule's K (Yule, 1944). However, these tools are known to covary with sample length, thus yielding mathematically and conceptually spurious results; or are prohibitively complex to implement (Jarvis, 2002; Malvern & Richards, 1997; Tweedie & Baayen, 1998; Vermeer, 2000). Therefore, reaching conclusions based on comparisons of discourse samples within and between participants, as well as across studies, has been problematic.

Recently a new measure, *D*, has been developed that combines an algebraic transformation model and curve fitting to estimate LD. *D* appears to be relatively robust to length variation (McKee, Malvern, & Richards, 2000) and its validity has been explored in several studies and has been found to be satisfactory (Malvern & Richards, 1997; McCarthy & Jarvis, 2010; McKee et al., 2000). *D* can be estimated using the vocD program in Computerised Language Analysis (CLAN; MacWhinney, 2000) and the process is reasonably automated and straightforward once the samples have been transcribed.

There is an increasing interest in using language sample analysis both as a clinical tool for differential diagnosis (e.g., Fleming & Harris, 2008; Murray, 2009); as well as a key indicator for determining the efficacy of treatment approaches for individuals

[2]For a brief collection of the terms and definitions that have been used for lexical diversity, the interested reader is referred to Yu (2010).

[3]For, example, Split TTR (Engber, 1995), Root TTR (Guiraud, 1960), Corrected TTR (Carroll, 1964), Log TTR (Herdan, 1960).

with aphasia (e.g., Cameron, Wambaugh, Wright, & Nessler, 2006; Rider, Wright, Marshall, & Page, 2008; del Toro et al., 2008). However, establishing the factors that influence the observations of the construct of interest is crucial for inference testing. The sources of variation that affect the measurement in each experimental design need to be adequately understood and modelled. Otherwise, pinpointing the impaired processes responsible for the observed behaviours during discourse production in any clinical population may be problematic.

In anticipation of investigating the clinical and research utility of LD using tools from computational linguistics such as *D*, two primary goals were set for this study. First, we were interested in exploring the effect of discourse elicitation technique on LD by testing whether there are statistically significant differences in LD among four commonly used tasks for eliciting discourse for clinical and research purposes (procedures, eventcasts, story telling, and recounts). It was expected that, by using *D*, we would be able to reveal significant differences among all types of discourse for both older and younger adults. Specifically, we hypothesised that procedural discourse would be associated with the least LD because of the repetition of a small number of key terms that are required to describe a procedure. Further, based on previous findings reported by Wright and Capilouto (2009) we expected that story telling would elicit higher LD than single pictures. Last, we anticipated that if O'Loughlin's "open versus closed tasks" hypothesis were correct, recounts would be associated with higher LD than story telling. The second goal was to assess the extent to which age influences LD when using each of the aforementioned types of discourse. Given that a positive relationship has been found between age and range of vocabulary, we hypothesised that older individuals would demonstrate higher lexical diversity across all types of discourse.

METHOD

Participants

Participants included 86 adults with no known neurological impairments, 43 young adults (20–29 years old; YG) and 43 older (70–79 years old; OD) adults. The proportion of females in the YG and OD groups was 44% and 56%, respectively; there was no statistically significant difference between the proportion of females between the two groups, as assessed by a two-sample z-test, $z = 1.08$, $p = .28$. Participants, who lived independently, were recruited from the Lexington, KY and Phoenix, AZ communities as part of a larger study. The mean ages for the groups were 23.00 years and 75.28 years, respectively. Groups differed significantly for age, $F(1, 84) = 4770.67$, $p < .001$, but not years of education, $F(1, 84) = .42$, $p = .75$. All participants met the following inclusion criteria for participation in the study: (a) no history of stroke, head injury, or neurogenic disorder, per self-report, (b) aided or unaided hearing acuity within normal limits; (c) normal or corrected visual acuity; (d) monolingual speakers of English; (e) normal cognitive functioning as indicated by performance on the Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975); and (f) no signs of depression as indicated by a passing score (0–4) on the Geriatric Depression Scale (Brink et al., 1982). See Table 1 for demographic information for participant groups.

TABLE 1
Demographic data and test scores for younger and older groups

	Groups	
	Young group (N = 43)	*Older group (N = 43)*
Age	22.98	75.28
Years of education	16.00	15.56
Gender	19 F, 24 M	24 F, 19 M
Race	40 White[a], 3 African American	42 White, 1 African American
MMSE *t*-score[b]	56.6 (5.31)	60.67 (8.64)
GDS[c]	1.74 (2.19)	1.31 (1.92)

[a]Three participants identified themselves as Hispanic; [b]Mini Mental Status Examination *t*-score, study inclusion criteria was an MMSE *t*-score of 30 or greater; [c]Geriatric Depression Scale-short form.

Discourse elicitation

Stimuli and instructions. Participants' discourse samples were collected in a single session and four different elicitation tasks were used. They were elicited in random order and included: procedures, eventcasts, story telling, and recounts. The first task was designed to elicit procedural discourse, which is an activity-focused, step-by-step description of how to achieve a goal (Longacre, 1996). The other three tasks were designed to elicit three different types of narrative discourse: eventcasts, story telling, and recounts.

Narrative discourse is primarily characterised by two etic parameters: contingent temporal sequencing and agent orientation (Longacre, 1996). Eventcasts are narratives that explain a scene of activities, stories are fictionalised, highly structured forms, and recounts are verbal reiterations of an event (Heath, 1986).

Each experimental discourse task was introduced with a warm-up task. For the procedural discourse task, first, the examiner modelled the task by providing the steps to make a pot of coffee. Subsequently, participants were asked to provide the steps to: (a) make a peanut butter and jelly sandwich and, (b) plant a flower in a garden. For the eventcasts, participants were presented with the Nicholas and Brookshire (1993) single pictures and were asked to produce a story that was based on temporal sequencing ("*Take a minute to look at this picture; when you are ready, tell me a story that has a beginning, middle and end*"). A practice task preceded participants' narrative descriptions of the experimental stimuli. The practice task included a brief narrative provided by the examiner describing the Picnic Scene from the *Western Aphasia Battery-Revised* (WAB-R; Kertesz, 2007); then the participants were asked to practise and provide a story for the Cookie Theft picture from the *Boston Diagnostic Aphasia Examination-3* (BDAE-3; Goodglass, Kaplan, & Barresi, 2001). During practice, feedback was provided to avoid eliciting a simple description of objects, characters, and/or their physical characteristics.

Participants also viewed and told the story depicted in the wordless picture book *Picnic* (McCully, 1984). This is a story about a family of mice who drive to the forest for a picnic. The baby mouse falls out of the truck on the way to the picnic site; however, the family does not notice and continues on without her. The family eventually realises the baby mouse has been lost, and the story concludes when the family finds

the baby mouse back on the road and decide to have their picnic then and there. Participants were presented with the stimulus book and were allowed as much time as they desired to view it and get familiar with the story. Then they were asked to "Tell a story that goes with the pictures". Prior to the task, the examiner provided an example of how to tell a story using a different wordless picture book (*The Great Ape*; Krahn, 1978). Finally, to elicit the recounts, each participant was asked to recall and share three past experiences: (a) what they did last weekend, (b) what they did during their last holiday and (c) what they did during their last vacation. Similar to the previous tasks, the examiner initially modelled the task by providing a brief personal narrative about a trip to San Diego, California. For the picture descriptions and the recounts, if the participant stopped after 15 seconds or less, he/she was prompted with, ''Can you tell me more?''

To determine the extent to which our tasks elicited the narratives as intended, we examined the language samples provided by the study participants. According to Longacre (1996) narratives are characterised by temporal succession and agent orientation as opposed to expository discourse, which is theme oriented and lacks these two elements. So all language samples that were elicited using the eventcasts, story telling, and recounts were checked for the presence of these two etic parameters by the first author. Subsequently a research assistant who was blind to the purposes of the specific analysis also checked the language samples; when there was lack of agreement, conclusions were reached by consensus.

First, each of the aforementioned samples was examined for a clearly identifiable mainline that described contingent events that could readily be placed along a temporal continuum. Such chronological sequencing was signalled implicitly or explicitly through function words such as then, before, after, etc. Further, all language samples were examined for the presence of particular agents participating in the sequence of events. The percent of language samples that demonstrated those characteristics can be found in Table 2. Of the three, story telling consistently elicited narratives that unfolded over time and involved particular events and characters. Eventcasts were also associated with a high likelihood of eliciting narratives, though often less complex. Recounts, specifically the recount asking participants to narrate what they did last Christmas, were more susceptible to commentaries regarding family dynamics and activities that lacked temporal contingency. Nevertheless, overall the sampling

TABLE 2
Percentage of language samples that exhibited temporal succession and agent orientation for each stimulus type

		Etic parameters	
Task	*Stimulus*	*Temporal succession*	*Agent orientation*
Eventcasts	Birthday cake[a]	91%	93%
	Cat in the tree[a]	91%	91%
Story	Picnic[b]	100%	100%
Recounts	Last weekend	88%	90%
	Last vacation	91%	91%
	Last Christmas	84%	89%

[a]Nicholas and Brookshire (1993); [b]McCully (1984).

procedures appeared to elicit the narrative genre successfully. Typical samples for each type of discourse are presented in Appendix A.

Transcription. Samples were digitally recorded and then orthographically transcribed in the CLAN format (MacWhinney, 2000) by trained research assistants. Samples were then segmented into c-units. A c-unit is a communication unit and includes an independent clause with its modifiers (Loban, 1976); it is commonly used to segment oral discourse samples (Hughes, McGillivray, & Schmidek, 1997). Approximately 10% of the samples were randomly selected and transcribed again for reliability purposes. Intra- and inter-rater word-by-word transcription reliability was 96.1% and 95.2%, respectively. Nonwords, hesitations, revisions, repetitions, and onomatopoeia were excluded via transcription codes in CLAN. Samples were further coded using the GEM command, which allowed for marking and analysing specific parts in samples that contained the different types of discourse.

Lexical diversity

To investigate lexical diversity, *D* was calculated (Malvern & Richards, 1997) using the voc-*D* program in CLAN. *D* has been described in detail elsewhere, and therefore only a brief review of the approach is offered here (cf. MacWhinney, 2000; McCarthy & Jarvis, 2007; McKee et al., 2000). Estimating *D* involves a series of random text samplings to plot an empirical TTR versus number-of-tokens curve for a sample. First, 35 tokens are randomly drawn from the text without replacement and the TTR is estimated. This process is repeated 100 times and the average TTR for 35 tokens is estimated and plotted. The same routine is then repeated for subsamples from 36 to 50 tokens. The average TTR for each subsample of increasing token size is subsequently plotted to form the empirical curve. Then the estimation of *D* involves solving a mathematical formula to produce a theoretical curve that maximises the fit to the empirical TTR curve using the least squares approach (see Figure 1). Lower *D* values result in steeper theoretical curves that fit better the empirical curves of people with poorer LD. Because *D* is the product of a sampling, stochastic process, its value varies each time the program is run. For that reason the whole process is repeated three times and the final *D* value is the average of the three runs.

RESULTS

Preliminary analysis

Prior to performing the statistical analyses for addressing the study aims, data were examined through various PASW Statistics 18.0.1 (SPSS Inc.) programs for accuracy of data entry, missing values, univariate outliers with extreme *z* scores, (larger than 3.3), and fit between variables' distributions (in terms of skewness and kurtosis) and the assumptions of univariate analysis (i.e., gross violations of normality and homoscedasticity). The data were examined separately for the two groups. For both groups, no outliers or cases with missing data were identified. The shape of distributions was assessed using histograms and was found satisfactory. The assumption regarding homogeneity of variances, as assessed using Levene's test, was also met.

To ensure that gender was not a significant factor a $4 \times 2 \times 2$ mixed analysis of variance (ANOVA) was conducted to evaluate the effect of discourse type, gender,

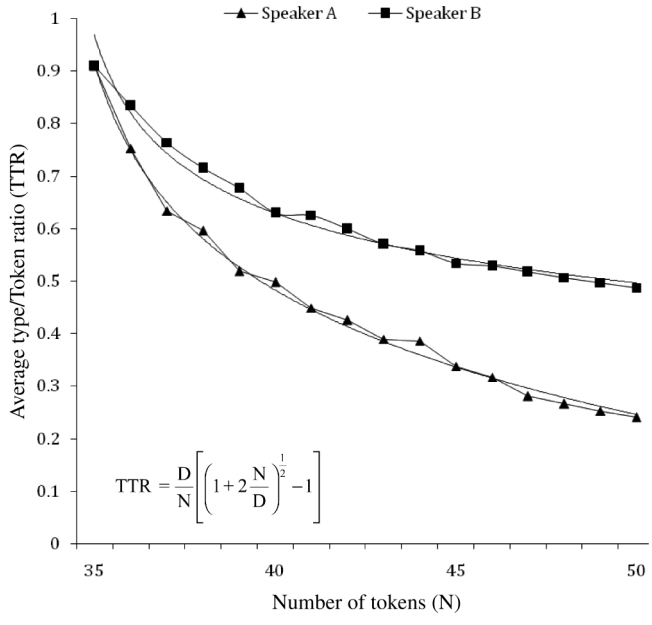

Figure 1. Average TTR values for increasing number of tokens for two speakers. The slope of the fitted nonlinear curves correspond to different *D* values. The steeper the slope of the fitted line, the lower the *D* value. Selection of the best-fitting curve is determined using a least squares approach.

and age on lexical diversity (LD). The dependent variable was D. The between-participants factors were age group (young and old; YG and OD) and gender. The within-participants factor was type of discourse (procedural discourse, eventcasts, story telling, and recounts). Results indicated that the main effect for gender was not statistically significant, $F(1, 82) = 1.095$, $p = .299$. The interactions that included gender (i.e. gender*type, gender*age, gender*type*age) were not statistically significant. Further, for each group separately, LD and education were not correlated significantly. A summary of the results from the correlational analyses can be found in Appendix B.

Lexical diversity across age and discourse type

Because gender was not a significant factor, it was removed from the analysis and a 4×2 mixed ANOVA was conducted that included age and type of discourse (between and within factor, respectively). Significant results were found for the discourse type main effect, $\Lambda = .19$, $F(3, 82) = 118.90$, $p < .01$, *partial* $\eta^2 = .81$, and the interaction, $\Lambda = .90$, $F(3, 82) = 3.03$, $p = .03$, *partial* $\eta^2 = .10$. The age main effect was not significant, $F(1, 84) = 3.60$, $p = .06$, *partial* $\eta^2 = .04$.

To better understand the significant interaction, age and discourse type simple effects were examined by conducting a series of independent sample *t*-tests and paired-sample *t*-tests, respectively. To control for Type I error, familywise alpha was set to .0125 and .025 for each age and discourse type simple main effect, respectively (Maxwell & Delaney, 2004). Subsequently, familywise error rate across the *t*-tests was controlled using the Holm's sequential Bonferroni approach.

Results indicated that the YG and OD groups demonstrated similar LD for the eventcasts and story; however, the OD group yielded significantly greater LD for the

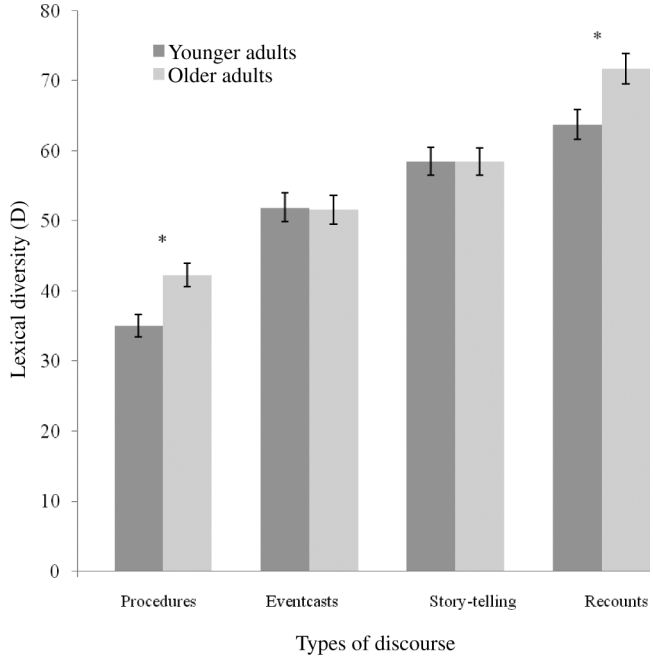

Figure 2. Mean lexical diversity for each type of discourse within each group.

procedures and recounts (see Figure 2). For both groups, procedures were associated with the least LD and recounts with the highest. Story telling was associated with the second highest LD, whereas the LD of the samples that were elicited using eventcasts fell between procedures and story telling. All comparisons were significant with the exception of the comparison of LD between eventcasts and story telling for the YG group, $t(42) = 2.08$, $p = .04$ (see Tables 3 and 4).

DISCUSSION

The purpose of this study was twofold. First, the study was designed to explore how discourse type influences lexical diversity (LD); and second, whether age-related differences exist. Four discourse types that are often used in clinical and research practice

TABLE 3
Mean lexical diversity scores and standard deviations (SD) for younger and older adults and group differences for each discourse type

	Younger group		*Older group*			
Discourse type	*M*	*SD*	*M*	*SD*	*t(84)*	*p*
Procedural	35.91	11.60	42.33	11.05	−2.64	.01*
Eventcasts	53.56	19.62	51.61	11.61	.56	.58
Story	58.81	11.24	58.50	14.81	.11	.92
Recounts	64.81	15.09	71.73	12.22	−2.55	.01*

To control for Type I Error, *alpha* was set to .0125 for each simple effect. *$p < .0125$.

TABLE 4
Mean lexical diversity differences and standard deviations (SD) and comparisons among discourse types for each group

Comparison	*Mean Δ*	*SD*	*t(42)*	*p*
		Younger group		
Procedural vs Eventcasts	−17.65	18.38	−6.30	<.001*
Eventcasts vs Story	−5.25	16.54	−2.08	.04
Story vs Recounts	−6.00	15.57	−2.78	.008*
		Older group		
Procedural vs Eventcasts	−9.28	12.92	−4.71	<.001*
Eventcasts vs Story	−6.89	12.69	−3.56	<.001*
Story vs Recounts	−13.22	14.29	−6.07	<.001*

To control for Type I Error, *alpha* was set to .008 for each simple effect. *$p < .008$.

were compared (procedural discourse, eventcasts, story telling, and recounts) across younger and older participants. Using dedicated software, which allows for comparisons of LD regardless of sample length variation, significant differences in LD were found for the discourse tasks used for both older and younger participants. To the best of our knowledge, after quantifying LD with accuracy, it was demonstrated for the first time that LD appears to be one of the microlinguistic indices that is influenced by discourse type and age. In what follows is a discussion of the results, their methodological implications, and future directions. Yet prior to discussion of the results, it is important to note the probabilistic nature of the assumption of homogeneity of discourse genre. According to this assumption, a single genre of discourse is elicited when a specific elicitation technique is used. However, eliciting a specific type of discourse is a non-deterministic process that entails both a predictable component and a random element. Ideally, each technique has increased probabilities of eliciting discourse that is consistent with a specific genre. The randomness of the process stems primarily from the fact that different speakers might produce different genres under the same elicitation conditions. For example, when presented with a picture and asked to tell a story, some participants might provide a narrative with a structured story format whereas others might provide a description that includes listing picture details. Further, even the same speaker might not choose to respond using a specific genre consistently when presented with the same task. In both cases the likelihood of responding using the targeted genre is directly related to a number of factors such as how specific the instructions were and how well participants understood them, whether the task was modelled or not; and, the quality of the stimuli and the type of feedback participants received during practice. To the extent that participants are not producing the same discourse genre in response to a specific elicitation technique, the assumption of genre homogeneity will not hold. In the current study participants received specific instructions for the tasks, were provided task examples, and then practised the tasks prior to completing the experimental tasks. Even though we do not dismiss the probabilistic nature of discourse homogeneity, considering the procedures followed, the analysis of narrative characteristics, and the inclusion of only cognitively healthy study participants, it is reasonable to assume that the participants provided the targeted discourse type in response to the specific elicitation technique.

Discourse type hierarchy

By using the voc-*D* command within CLAN to get relatively robust estimates of LD, a LD hierarchy for the four discourse types was found. The hierarchy was similar for both the older and younger groups. Procedural discourse yielded the lowest LD. This finding most likely reflects the relatively small range of vocabulary that is necessary to adequately describe a common procedure plus the repeated production of lexical items that are involved in the majority of the steps. Conversely, recounts were associated with the highest LD; a finding that at least partially, appears to contradict some researchers' hypothesis (e.g., Bliss & McCabe, 2006) that story telling from wordless picture books is associated with higher LD than recounts because of the contents of the presented pictorial stimuli. Based on the results it appears that, once sample length is no longer a factor, speakers have a significantly higher probability of demonstrating richer vocabulary when asked to produce personal recounts. These findings support O'Loughlin's hypothesis that "open" tasks may elicit language samples with a higher degree of LD than "closed" tasks.

The results expand on Wright and Capilouto's (2009) finding that, for older individuals, single pictures elicit language samples with reduced LD. In their study Wright and Capilouto demonstrated that narratives elicited from single picture stimuli were associated with lower LD compared to narratives elicited from sequential picture stimuli. In the current study single pictures (i.e., eventcasts) were compared to language samples elicited using a wordless picture book and were also found to be associated with lower LD; but for the older group only.

The younger group's LD results for the eventcasts and story telling warranted additional exploration. A post-hoc power analysis was conducted using G-Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) to compute the achieved power for rejecting the null hypothesis (i.e., no difference in LD between eventcasts and story telling for the younger group). After setting the effect size d_z to *.32,* the familywise error rate to .008, and the sample size to $n = 43$, the power was estimated to be equal to .26. Based on this finding, it appears quite plausible that the null hypothesis was not rejected because a difference was absent but rather due to the study's lack of power to detect it. Rather, analyses of the current data suggest that it is not "safe" to conclude that younger adults exhibit similar LD for eventcasts and story telling. Nevertheless, this hypothesis should be tested empirically in the future.

Taken as a whole, these results are consistent with the general consensus that different discourse types are associated with varying levels of cognitive and linguistic demands. The demands are imposed on the speaker when different elicitation techniques are utilised and can be expressed in the person's performance (Armstrong, 2000; Bliss & McCabe, 2006), as in this case with LD. Based on the results we were able to uncover variation that originates not from the individual's latent trait, but rather from the discourse type that the participant chooses to produce, thus untangling and highlighting one of the factors that influence LD performance.

Findings from the study have important methodological implications. First, based on the significant differences among the types of discourse, it is clear that if LD is to be explored in discourse samples produced by adults with or without neurogenic communication impairments, a "type of discourse" factor needs to be included. This would allow for more accurate modelling of the data, as LD can vary across individuals but it can also vary as a function of discourse type. Further, as far as LD is concerned, direct comparisons across studies that have used different elicitation

techniques should be interpreted cautiously considering the hierarchy established in this study. It is noteworthy though that, if LD is not quantified using a robust measure such as *D*, comparisons should probably be avoided altogether, as the stability of the results would be compromised due to sample length variation. In addition, collapsing data across types of discourse might also be problematic as such an approach could result in eliminating some otherwise meaningful distinctions.

Age and lexical diversity

Apart from identifying mean differences among language samples elicited using different discourse tasks, we also found differences between the two age groups. Initially it was hypothesised that older individuals would demonstrate higher LD across the four discourse types. Interestingly however, the differences in LD were only evident in procedural discourse and recounts. When the narratives were elicited using pictorial stimuli (i.e., eventcasts and fictional narratives using the wordless picture book) the older and younger study participants performed similarly. Possibly, the increased degree of structure and constraint that was imposed by pictorial stimuli moderated the difference in LD between older and younger adults. This finding could explain why in some studies, which have investigated lexical richness (Kemper & Sumner, 2001) without the support of pictures, researchers have found that age is a significant factor as opposed to studies that have used pictorial stimuli to answer the same question (e.g., Cooper, 1990).[4]

Although the results of the study indicate age-related differences in LD, it is not known whether the higher LD associated with the language samples of older individuals is actually indicative of more informative procedural discourse and/or more elegant, detailed recounts. Based on the current analysis (i.e., *D*) it is not obvious what drives the interaction that was observed. It is possible that, as some researchers have suggested, some discourse skills increase with age. For example, there is evidence that healthy older adults often produce more elaborate narrative structures with complex plots that are evaluated more positively by listeners (Kemper & Kemtes, 2000; Kemper, Rash, Kynette, & Norman, 1990; Wingfield & Stine-Morrow, 2000); and, in turn, could influence LD. An alternative explanation that warrants consideration is that the older individuals' greater LD could be related to a failure in inhibitory mechanisms. Some researchers have argued (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; Hasher, Lustig, & Zacks, 2007) that, as people get older, their ability to suppress irrelevant information becomes less effective. Therefore it is possible that, in the absence of supporting stimuli, older individuals are more susceptible to producing off-topic comments that in turn inflate their LD. However, this is beyond the scope of the current study and warrants further investigation.

CONCLUSIONS AND FUTURE DIRECTIONS

In this investigation of the potential utility of LD using a tool from computational linguistics (i.e., *D*), we examined the relationship between LD and type of discourse, and to what extent age-related differences exist. By using *D* we expected to find significant differences among all types of discourse for the two age groups; and that the

[4]It is important to note, however, that both studies referenced here used TTR to estimate LD; therefore their findings could have been confounded with sample length as well.

older individuals would demonstrate higher LD compared to the younger adults. We found that LD, as measured by *D*, varies as a function of discourse type. An LD hierarchy was established that was similar for both age groups. We also found age-related differences that were evident when the stimuli were verbally presented but were eliminated when the language samples were elicited using pictorial stimuli. In future studies researchers should investigate how LD relates to other discourse microlinguistic indices (e.g., information units) to allow for a richer interpretation within a more general discourse production framework.

In future studies with clinical populations researchers should consider the role of the presence of pictorial stimuli. It is quite possible that what holds for our sample that consisted of neurologically intact adults might not hold for a sample of individuals with aphasia. The reason is that what is regarded as "constraint" for cognitively healthy adults might serve as "support" for individuals with limited lexical resources. Therefore it is possible that language samples elicited using pictorial stimuli might be more lexically diverse because of the depicted features that could boost the activation of lexical items. In addition, another area that warrants exploration is the potential of LD as an index of naming difficulties in individuals with aphasia as well as LD's utility as a clinical tool for the classification of individuals of aphasia. Such work could enrich our understanding of the lexical abilities of individuals with aphasia during discourse production and could lead to the development of a comprehensive discourse-processing framework for assessment and rehabilitation purposes.

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APPENDIX A

Eventcast narrative example: *The Birthday Cake* (Nicholas & Brookshire, 1993)

There was a boy and he had his sixth birthday. And his mother had invited uh other children with their mothers to celebrate the birthday with them. She had baked a beautiful um birthday cake. She had left the room for a short time to let the let the guests in. During that time, the dog approached the birthday cake and took big mouthfuls

out of it. So, mom was so mad. She got her brush and was trying to flush the dog out from underneath the sofa. In the meantime little Frankie was crying because he was so upset that his beautiful birthday cake had been damaged.

Eventcast narrative example: *The Cat in the Tree* (Nicholas & Brookshire, 1993)

Once upon a time there was a little girl. And she had uh she was riding her tricycle. And she had a cat. And the cat ran up the tree and got out on a low lying branch. And &sh she was screaming screaming screaming for her cat to come down. Well, her daddy's such a sweet daddy uh decided to climb the tree. He had a ladder. And just as he got onto the branch big branch to try to reach the cat the ladder fell down. The dog of course went bananas and was trying to help daddy get down. And the sound of the dog barking alerted the neighbors. Well, they called the fire department to come and rescue daddy and the cat.

Story telling narrative example: *Picnic*

Well, this mouse family decide to ah take a family vacation out to a picnic one day. One sunny Sunday afternoon. um so the mom and the dad and the um big brother got in the front seat. And all the little other baby mice got in the back. Um some brought baseball gloves. And Amelia she uh she doe she doesn't like sports that much so she brought her just her um little bear to play with. Um on the way they didn't have a back on their truck. And on the way there um the ride was really bumpy. And everybody was bumping up and down. Um and Amelia was in the back. And she didn't have anything to hold on to because she . . . all she worried about was her um little pink bear. So, um it was bumpy and she couldn't hold on. And the truck hit a big rock. And Amelia flew out. Nobody noticed that Amelia flew out. So, the truck just drove away and they got to the picnic site. And all the little mice ran out and started playin(g). And um the mom and dad brought out uh the picnic stuff. And they didn't even notice that Amelia was gone. They fished; they played um loop-de-loo. They picked flowers. They drank. They played banjo. And the um older mice were settin(g) up for the picnic. It was all so fun. They ate pie and meat and um were just hanging out; didn't know that anything was ba . . . was wrong. Um some of them were climbing trees. But meanwhile Amelia was up still on the road scared and crying. She was really hungry. She decided to stand up and pick some berries. She had missed her lunch because everybody else was having the picnic. Meanwhile &Am Amelia was reaching for berries because she was so hungry and scared. She ate some berries and that filled her up for the day. Suddenly the mother noticed that somebody was missing. There were only eight children instead of nine. So she called she told everybody to start looking. Some started looking. Some started crying. It was a big terrible mess and they couldn't find Amelia anywhere. One of the adults made the executive decision to go home and see if they had left her at home for some reason. They all hopped back in the car. Meanwhile Amelia was thinking that she would never get found again. But they were searching on the road. And suddenly one of the little boys in the back spotted her. They were calling her name. Amelia, she finally heard (th)em. And then the little boy spotted her. She ran out to the road. "Here I am", she said. And everybody cheered. They gave her a hug, a big bear hug and let her go. And she had realized that she didn't bring her pink little bear. She said "oh no, I lost him just like they lost me!" She ran out to the woods

where she had eaten the berries. And she found him and hugged him. And then they took another picnic with Amelia this time.

Recount narrative example: *Last Christmas*

Okay um typically the Christmas' at my family. About six o'clock we all came over and with our presents for everybody else including stocking stuffers. We filled the stockings with everybody else's stocking stuffers. Getting things ready to go. We put our presents under the tree. And by the point that we were done we had more presents than we did tree. And um then after that we had a steak dinner. And even though it was freezing cold outside, my dad grilled steaks. So, he took out his coat, he went out there, made the steak as mom was cooking the rest the rest of the meal. Getting the salad ready, baking the potato. And then at that point we had dinner. When we're finished with dinner, my brother rushed through and did the quickest kitchen clean up job of his life, like he always does every year. And after, he distributed the presents to particular sections of the living room. To where everybody gets to sit down in their own place. And we opened up stockings and presents and then after it was done we cleaned up. And then uh we went home with our gifts.

Recount narrative example: *Last Weekend*

Okay uh Saturday as usual I went to Costco to do the weeks shopping. um &a We bought some Bush Beans, some butter, and some meat in a package. Then eh we came home and we both took a nap. And we watched television in the evening. On Sunday we had arranged to go out to lunch with two friends. So, we got up in quite a leisurely way at about ten o'clock. We met our friends at eleven thirty. We went out and we had a very pleasant lunch. The food was delicious and the price was right. After that, we came home and uh took our usual afternoon nap for about a half an hour. After that I read the Sunday newspapers. And in the evening I watched channel eight um including a very interesting series uh which comes on at nine o'clock called Masterpiece Theater. After that I went to bed. I was in bed about ten o'clock and uh read my usual thirty minutes and then went to sleep.

Recount narrative example: *Last Vacation*

My last vacation I went to Northern California specifically Kofax, California because my family was having a giant barbecue. In order to get to the barbecue on time, we had to leave around four thirty in the afternoon uh the day before and then drive for twelve hours throughout the night. Uh however we were able to surprise my stepfather, as he did not think we were able to make it. And so it was quite a pleasant surprise for everyone. There was then the family barbecue and it was good fun.

APPENDIX B

Correlational analyses relating education to lexical diversity for each type of discourse across groups

	Types of discourse			
	Procedures	*Eventcasts*	*Story*	*Recounts*
Younger adults	.13 (.40)	.14 (.38)	.10 (.54)	−.02 (.89)
Older adults	.117 (.46)	−.032 (.36)	.002 (.99)	−.11 (.48)

p values are shown in parentheses.