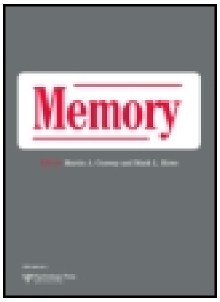

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Modelling longitudinal changes in older adults' memory for spoken discourse: Findings from the ACTIVE cohort

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Episodic memory shows substantial declines with advancing age, but research on longitudinal trajectories of spoken discourse memory (SDM) in older adulthood is limited. Using parallel process latent growth curve models, we examined 10 years of longitudinal data from the no-contact control group (N = 698) of the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) randomised controlled trial in order to test (1) the degree to which SDM declines with advancing age, (2) the predictors of these age-related declines and (3) the within-person relationship between longitudinal changes in SDM and longitudinal changes in fluid reasoning and verbal ability over 10 years, independent of age. Individuals who were younger, were White, had more years of formal education, were male and had better global cognitive function and episodic memory performance at baseline demonstrated greater levels of SDM on average. However, only age at baseline uniquely predicted longitudinal changes in SDM, such that declines accelerated with greater age. Independent of age, within-person decline in reasoning ability over the 10-year study period was substantially correlated with decline in SDM (r = .87). An analogous association with SDM did not hold for verbal ability. The findings suggest that longitudinal declines in fluid cognition are associated with reduced spoken language comprehension. Unlike findings from memory for written prose, preserved verbal ability may not protect against developmental declines in memory for speech.

Keywords: Discourse memory; Aging; Language comprehension; Individual differences; Latent growth curve modelling.

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Most of the inferences about developmental trajectories of change in memory for spoken discourse come from cross-sectional studies comparing groups of individuals of different ages and ability levels (Schneider, Daneman, & Pichora-Fuller, 2002; Tun, McCoy, & Wingfield, 2009; Wingfield & Stine-Morrow, 2000). Although these studies are informative in describing age differences, we are aware of no research examining within-person change in memory for spoken discourse over time, or individual differences in change in spoken discourse memory (SDM) among older adults. Critically, cross-sectional and longitudinal estimates of age-related change differ for a number of cognitive abilities (Lindenberger, von Oertzen, Ghisletta, & Hertzog, 2011; Sliwinski & Buschke, 1999), including language production (Kemper & Sumner, 2001). Inferences about developmental change based on cross-sectional analysis alone are problematic (Baltes, Reese, & Nesselroade, 1977; Hofer & Sliwinski, 2001; Lindenberger et al., 2011). Because longitudinal data analysis involves a direct investigation of within-person developmental change and individual differences in rates of change, such analyses may yield more accurate estimates of age-related declines in memory for spoken discourse. The current study aims to fill this major gap in the research by investigating long-term changes in SDM over 10 years among a group of healthy older adults.

Although memory for language is often treated as a component of episodic memory (Hultsch, Hertzog, Dixon, & Small, 1998), comprehension of discourse involves processes that are distinct from episodic memory, including decoding and integrating phonological and lexical representations, parsing incoming strings into syntactic constituents, abstracting and retaining message-level semantics separate from the verbatim form and integrating message-level propositional information across sentences (Frazier & Rayner, 1982; Kintsch, 1998; Kintsch & van Dijk, 1978). Not surprisingly, then, memory for text may be supported by cognitive underpinnings that are distinct from those that underlie episodic memory, such as memory for word lists (Lewis & Zelinski, 2010). Maintaining a propositional representation from text is cognitively demanding and shows substantial declines in older adulthood (Johnson, 2003; Payne & Stine-Morrow, 2012; Radvansky, 1999; Radvansky, Zwaan, Curiel, & Copeland, 2001). Estimates from a recent meta-analysis have shown that, on average, older adults perform at about the 22nd percentile of the distribution of younger adults in memory for discourse (Johnson, 2003). In reading, Stine-Morrow, Miller, Gagne, & Hertzog (2008) have shown that older adults may compensate for age-related declines in propositional memory in part by regulating how they allocate attention to text during encoding. However, given that auditory presentation diminishes the ability to self-regulate input (Stine, Wingfield, & Poon, 1989), age differences in memory may well be amplified in auditory modalities. In fact, a meta-analysis (Johnson, 2003) found that, across a wide range of testing conditions, older adults performed significantly better when discourse memory tasks involved written presentation (d for young-old comparison = .76) compared to aural presentation via a tape recorder (d = .92).

Two divergent patterns of age-related change characterise findings in cognitive ageing (Baltes, 1997; Schaie, 1994). For fluid cognitive abilities (Cattell, 1971), also called cognitive mechanics (Baltes, 1997) or cognitive processes (Salthouse, 2010), ageing is associated with monotonic declines that are dependent on the processing efficiency of the cognitive system. In contrast, crystallised abilities (Cattell, 1971), also called cognitive pragmatics (Baltes, 1997) or cognitive products (Salthouse, 2010), are based on the accumulation of knowledge and experience and are often stable or show selective growth into adulthood. Research in the cognitive neuroscience of ageing has found support for this dichotomy in the neural substrates that subserve these functions (Hedden & Gabriele, 2004; Raz & Rodrigue, 2006). For example, tasks that tax processing speed and executive control are correlated with cortical grey matter and white matter structure and function (e.g., lower pre-frontal cortical volume; greater white matter hyperintensities), which are more vulnerable to biological senescence in normal ageing (Gunning-Dixon & Raz, 2003).

These divergent developmental patterns of change in cognitive ability have substantial effects on language comprehension (Burke & Shafto, 2008; Stine-Morrow Miller, & Hertzog, 2006). Older adults score upwards of one standard deviation higher on vocabulary measures compared to younger adults (Verhaeghen, 2003) and, even into old age, verbal and literacy skills appear to benefit multiple language comprehension mechanisms (Payne, Gao, Noh, Anderson, & Stine-Morrow, 2012; Payne, Grison, Gao, Christianson, Morrow, & Stine-Morrow, in press; Stine-Morrow, et al., 2008). For example, high-verbal older adults show evidence for facilitation in visual word recognition (Lien et al., 2006; Ruthruff, Allen, Lien, & Grabbe, 2008), and greater verbal skills appear to compensate for the negative effects of ageing on text memory, in part, through the implementation of online encoding strategies (Payne, Gao, et al., 2012; Stine-Morrow et al., 2008). At the same time, older adults with lower fluid cognitive abilities (e.g., working memory, reasoning, inhibitory control) show substantially worse memory for language (DeDe, Caplan, Kemtes, & Waters, 2004; Lustig, May, & Hasher, 2001; Payne Jackson, et al., 2012; Stine-Morrow et al., 2008; van der Linden et al., 1999; Zelinski & Stewart, 1998).

Most studies assessing individual differences in cognition and memory for language are cross-sectional, however, with few studies examining how these processes relate over time. One exception to this is a longitudinal study by Zelinski and Stewart (1998). This study examined whether individual differences in baseline age and longitudinal changes in inductive reasoning and verbal ability predicted longitudinal changes in memory for written discourse over 16 years, in a sample of adults aged 55–81 years. In addition to finding substantial declines in text recall over the study period that were predicted by baseline age, this study also found that longitudinal changes in both reasoning and verbal ability were correlated with changes in text recall. In the current study, we aimed to extend the findings from Zelinski and Stewart (1998) to examine longitudinal changes in memory for spoken discourse over time. We examined individual differences in longitudinal change in SDM over 10 years, using a sample of older adults from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) trial (Ball et al., 2002; Jobe et al., 2001; Willis et al., 2006).

Although individual differences in text memory can be partially explained by differences in fluid and verbal ability, it is unclear whether these same effects hold for auditory memory. We hypothesised that educational level, health status and baseline cognitive function may partially account for the relationship between discourse memory, verbal ability and reasoning ability. Therefore, we simultaneously examined the associations of these variables with SDM. Further, we hypothesised that trajectories of change in reasoning, a common proxy measure of fluid ability, and SDM would be coupled over 10 years, even after accounting for other possible variables that may explain these intercorrelations. Moreover, because verbal ability is protective of episodic memory generally (Manly, Schupf, Tank, & Stern, 2005; Stern, 2009) and text memory in particular (Payne Jackson, et al., 2012; Stine-Morrow et al., 2008), we hypothesised that older adults with greater verbal ability would show relative preservation of SDM. However, given that speech occurs at a pace uncontrolled by the listener so that it does not afford the use of many of the self-regulatory strategies available to skilled readers, we also considered the possibility that verbal ability may be relatively less protective in the auditory domain, so that individual differences in verbal ability would show an attenuated relationship with changes in SDM.

METHOD

Study Sample

In ACTIVE (Ball et al., 2002; Jobe et al., 2001, Willis et al., 2006), 2802 older participants were randomised to a no-contact control group or to one of three training interventions focusing on processing speed, inductive reasoning or episodic memory. For the current study, our sample only included individuals from the no-contact control group (N = 698), because we were interested in examining normative change in memory for spoken discourse, absent the effects of the cognitive training interventions (see Sisco, Marsiske, Gross, & Rebok (in press) for effects of memory training on SDM).

Measures

Spoken discourse memory. Memory for spoken discourse was measured with the Paragraph Recall task from the Rivermead Behavioral Memory Test, version 2 (Wilson, Cockburn, & Baddeley, 1985, 2003). Alternative passages were administered at different assessments. The Rivermead paragraph recall task was administered in small groups of 2–4 participants at each measurement occasion. Participants listened to an audiotape recording of a passage, recorded by a professional narrator. The passage was spoken with a normal prosody at a comfortable and constant rate. Immediately after hearing the passages, participants were asked to write down everything they could remember. Passages were scored for the total number of propositions correctly recalled

(Brown, Snodgrass, Kemper, Herman, & Covington, 2008; Turner & Greene, 1978; Wilson et al., 1985). Scores were equated to remove test form artefacts, using an equipercentile equating procedure (Gross et al., 2012; Kolen & Brennan, 1995) and were then standardised to a *T*-score (*M* = 50, *SD* = 10) based on the baseline mean and standard deviation of the sample. SDM was assessed across all testing sites at seven waves: baseline, post-test (.2 years) and longitudinal follow-ups at 1, 2, 3, 5 and 10 years.

Inductive reasoning. Reasoning was measured with the Letter Sets, Letter Series and Word Series tasks from the Schaie-Thurstone Adult Mental Ability Test (Schaie, 1985). These tests require participants to identify patterns in a series of items and either generate the next item in the series or decide which item does not adhere to the pattern. These measures have been used in previous studies to assess the components of fluid ability in cross-sectional (Kyllonen & Christal, 1990; Salthouse, 2005; Suß, Oberauer, Wittmann, Wilhelm, & Schulze, 2002), longitudinal (Baltes, 1997; Schaie, 1994) and intervention (Ball et al., 2002; Payne, Jackson, et al., 2012; Willis & Nesselroade, 1990) research. Scores were standardised to a *T*-score (*M* = 50, *SD* = 10) based on the pre-test mean and standard deviation and a composite average of the three variables was formed. Reasoning was assessed across all testing sites at the seven waves of the data collection. Alternative forms were administered at different assessments. Test materials were visually presented.

Verbal ability. Verbal ability was measured with a recognition vocabulary test from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, & Harmon, 1976). Participants were presented with a series of target words and were asked to choose a correct synonym from among four alternative options. Vocabulary was assessed across all testing sites at four waves: baseline, 3, 5 and 10 years. This measure was standardised to a *T*-score (*M* = 50, *SD* = 10), based on the baseline mean and standard deviation of the sample. Alternative forms were administered at different assessments. Test materials were visually presented.

Demographics and covariates. The final model adjusted for: (1) *demographics* including age, sex, race and years of education; (2) self-reported *health status* on a 5-point scale (1 = excellent; 5 = poor); (3) global *cognitive function* as measured by the Mini-Mental State Examination (MMSE; cut-off score for participation in ACTIVE= 23) (Folstein, Folstein, & McHugh, 1975); (4) baseline *psychomotor speed*, as measured by a composite of the Digit Symbol Substitution Test, Digit Symbols Copy and Useful Field of View (UFOV) (Ball & Owsley, 1993; Wechsler, 1981) tasks; and (5) baseline auditory *episodic memory*, as measured by the Auditory Verbal Learning Test (Schmidt, 2004).

Analysis plan

The major goal of this study was to examine whether within-person trajectories of change in reasoning and verbal ability over 10 years are related to within-person changes in SDM, independent of age and other demographic characteristics. To address this aim, we used parallel process latent growth curve models (Cheong, MacKinnon, & Khoo, 2003; Muthén, 2008; Preacher, Wichman, MacCallum, & Briggs, 2008). In parallel process models, multiple latent growth processes are estimated simultaneously (in this case, for SDM, reasoning, and verbal ability). This approach allows us to explicitly test whether random intercepts (initial level) and slopes (longitudinal changes) for one process are correlated with intercepts and slopes for other processes. Absolute model goodness of fit was assessed using the Comparative Fit Index (CFI), the Non-Normed Fit Index (NNFI) and the Root Mean Square Error of Approximation (RMSEA). The latent slope factors were specified by fixing factor loadings to the number of years from baseline, so that the mean slope of these models could be interpreted as annual changes in SDM, reasoning and verbal ability.

Figure 1 presents the structural equation model diagram for the parallel process latent growth model of SDM, verbal ability and reasoning. Preliminary analyses showed that the best growth trajectories for SDM and reasoning included a fixed and random intercept, fixed and random linear term, a fixed second intercept to adjust for practice or retest and a fixed quadratic effect, indicating a non-linear trajectory. The best fitting model for verbal ability was similar, but did not include a quadratic term. Models were adjusted for individual differences in age at baseline, sex, race, education, health status, global cognitive functioning, episodic memory and psychomotor

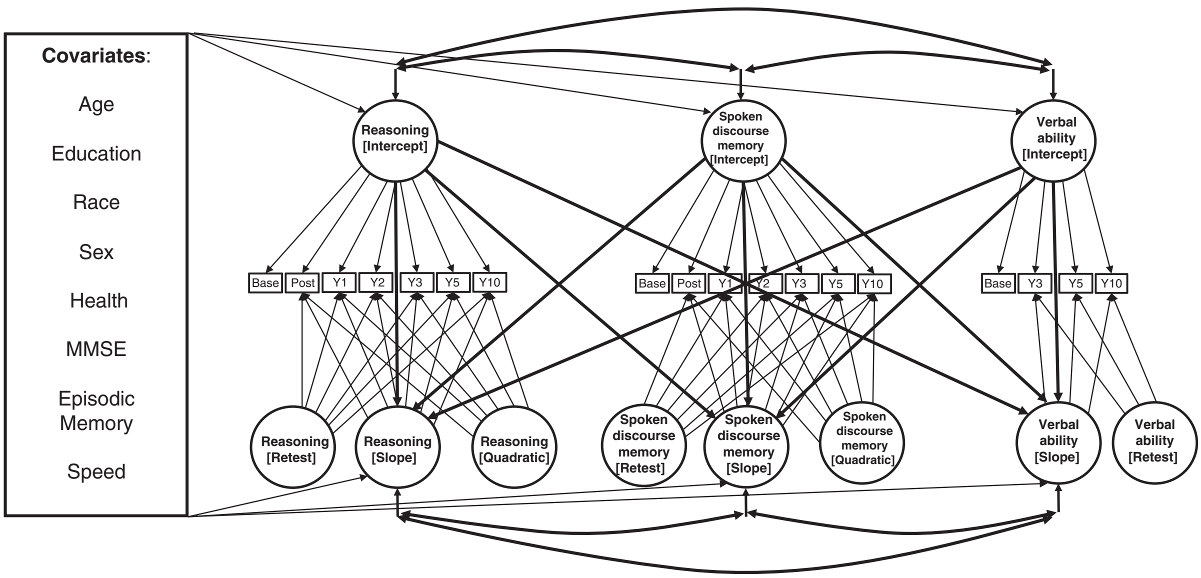

Figure 1. Structural equation model diagram for parallel process latent growth model of spoken discourse memory, reasoning and vocabulary score.

speed. These models were conducted using the structural equation modelling programme AMOS, version 16 (Arbuckle, 2006), with Full Information Maximum Likelihood estimation.

RESULTS

Table 1 includes the sample characteristics for each variable of interest at the baseline measurement. Participants were mostly White (72%), female (74%), on average 74 years old, and had, on average, 13 years of education.

Estimated means, variances and regressions from the parallel process growth curve model are presented in Table 2. This model showed good fit to the data (RMSEA = .03; CFI = .98). The retest effect for SDM was not statistically significant, but for verbal ability and reasoning, retest effects were equivalent to approximately 6.3 years and 15.3 years of age, respectively (Table 2).[1] Although there was a significant heterogeneity in the random slopes for SDM, verbal ability and reasoning, annual decline in these variables was not statistically significant after adjustment for covariates (Table 2). In the following subsection, we present the longitudinal relationships between changes in SDM, verbal ability and reasoning. We then turn to the findings for the effects of the covariates on individual differences in the level and rates of change in SDM, verbal ability and reasoning.

[1]These estimates were calculated as the ratio of the model-estimated retest effect and the model-estimated cross-sectional age-related effect. The ratio describes the magnitude of the retest effect relative to the effect of age on cognition.

Longitudinal changes in SDM, reasoning and verbal ability

Towards our primary goal of examining the longitudinal relationships between SDM, reasoning ability and verbal ability, the main results of interest from the parallel process growth curve

TABLE 1
Sample characteristics at baseline (N = 698)

Variable	Mean or N	Standard deviation or percent	Observed range
Age	74.05	6.05	65, 94
Years of education	13.37	2.71	6, 20
Female	514	74%	–
Health status	2.64	.87	1, 5
Mini-Mental State Examination (MMSE)	27.27	1.99	23, 30
White	503	72%	–
Spoken discourse memory (SDM)	49.83	9.68	20.73, 80.18
Reasoning	49.38	9.13	20.78, 80.07
Verbal ability	49.55	10.03	17.54, 64.65

Note: We derived T-scores for SDM, reasoning and verbal ability standardised to baseline in the whole sample (N = 2802).

TABLE 2
Estimated means, variances and regressions from parallel process latent growth curve model of spoken discourse memory, reasoning, and verbal ability over 10 years (*N* = 698)

	Spoken discourse memory (SDM)		Verbal ability		Reasoning	
Parameter estimate	Estimate	SE	Estimate	SE	Estimate	SE
Latent Variable Means						
Baseline Intercept	50.21***	.29	49.85***	.30	49.84***	.24
Trajectory	–.54	.64	.36	.47	.38	.42
Retest	.47	.32	1.69***	.35	2.30***	.16
Quadratic	.08***	.01	@0	–	–.05***	.01
Latent residual variances						
Baseline intercept	23.24***	1.98	46.60***	3.22	32.39***	1.91
Trajectory	.14**	.06	.08*	.04	.20***	.03
Regressions on baseline intercept						
Age	–.13***	.04	.27**	.06	–.15**	.05
Female sex	–1.55**	.57	.67	.73	.13	.57
Education	.67***	.09	1.26***	.12	.72***	.09
MMSE	.86***	.13	1.09***	.17	.72***	.09
White	3.80***	.54	4.92***	.68	3.53***	.53
Health	–.27	.28	–.57	.36	–1.22***	.28
Episodic memory	2.94***	.28	.74*	.35	1.26***	.27
Processing speed	–.54	.27	–.67	.35	–2.58***	.30
Regressions on Trajectory						
Age	–.03**	.01	.01	<.01	–.03***	<.01
Sex	–.13	.12	–.03	.09	.06	.08
Education	<.01	.02	–.01	.02	–.03	.02
MMSE	.03	.03	–.05*	.02	–.03	.02
White	.05	.12	.06	.09	.05	.08
Health	<.01	.06	.03	.04	–.01	.04
Episodic memory	.09	.07	.02	.05	.12**	.05
Processing speed	–.08	.06	<.01	.05	–.02	.04
Baseline SDM	–.01	.01	<.01	<.01	<.01	<.01
Baseline vocabulary	<.01	<.01	–.02*	<.01	<.01	<.01
Baseline reasoning	<.01	<.01	<.01	<.01	<.01	<.01
Model fit statistics						
χ^2/df	1.69					
RMSEA	.03					
CFI	.98					
NNFI	.96					

Note: Sex is parameterised as Female = 1; White is parameterised as White = 1.
MMSE: Mini-Mental State Examination. @0: parameter constrained to 0 in model. SE: standard error. RMSEA: Root Mean Square Error of Approximation. CFI: Comparative Fit Index. NNFI: Non-Normed Fit Index.
**p* <.05; ***p* <.01; ****p* <.001.

model are the residual correlations between the latent intercept parameters and latent slope parameters (Table 3).

At baseline, SDM, verbal ability and reasoning were all significantly intercorrelated, suggesting a substantial shared variance between initial performance on SDM, verbal ability and reasoning even after adjusting for baseline covariates. Importantly, the pattern of correlations among longitudinal trajectories was different. The residual correlation between changes in reasoning and SDM (r = .87) was considerably higher than the

TABLE 3
Estimated latent residual correlations from parallel process latent growth curve model of spoken discourse memory, reasoning and vocabulary score over 10 years (*N* = 698)

Latent residual correlations		
	Initial levels	*Trajectories*
r(SDM, verbal ability)	.34***	.43
r(SDM, reasoning)	.38***	.87***
r(Verbal ability, reasoning)	.35***	.22

SDM: spoken discourse memory.
****p* <.001.

correlation at baseline, indicating that approximately 76% of the variance in change in SDM is shared with change in reasoning over a 10-year period. Although verbal ability and SDM were strongly related at baseline, the correlation between change in SDM and change in verbal ability failed to reach statistical significance (r = .43), with the growth processes only sharing approximately 18% of variance in within-person trajectories over 10 years. The same pattern was found between changes in verbal ability and reasoning, as the correlation between changes in these two processes also failed to reach statistical significance (r = .22).

Predictors of change in SDM, reasoning and verbal ability

At baseline, participants who were younger, were White, had more years of formal education and had better episodic memory and global cognitive function demonstrated better baseline performance in SDM. In contrast to these relationships with initial status, predictors of rates of change were less robust. The only covariate that reliably predicted individual differences in longitudinal trajectories of change in SDM was age at baseline, such that older adults had a steeper annual rate of decline. Figure 2 illustrates the age-related differences in rates of change in SDM over 10 years. This plot shows the model-estimated 10-year slopes at three different levels of age at baseline: 66 years (the 10th percentile of age at baseline), 73 years (the 50th percentile of age at baseline) and 83 years (the 90th percentile of age at baseline). As can be seen, the 10-year change in SDM is accelerated among adults who were older at baseline.

At baseline, individuals who were younger, were White, had more years of formal education and had better episodic memory and overall cognitive function had better baseline verbal ability. However, only global cognitive function and initial verbal ability emerged as significant predictors of change in verbal ability over 10 years.

For reasoning, the overall pattern of findings was similar to the SDM findings. At baseline, participants who were younger, were White, had more years of formal education, had better episodic memory, psychomotor speed and global cognitive function, and were higher in health status had better baseline reasoning. However,

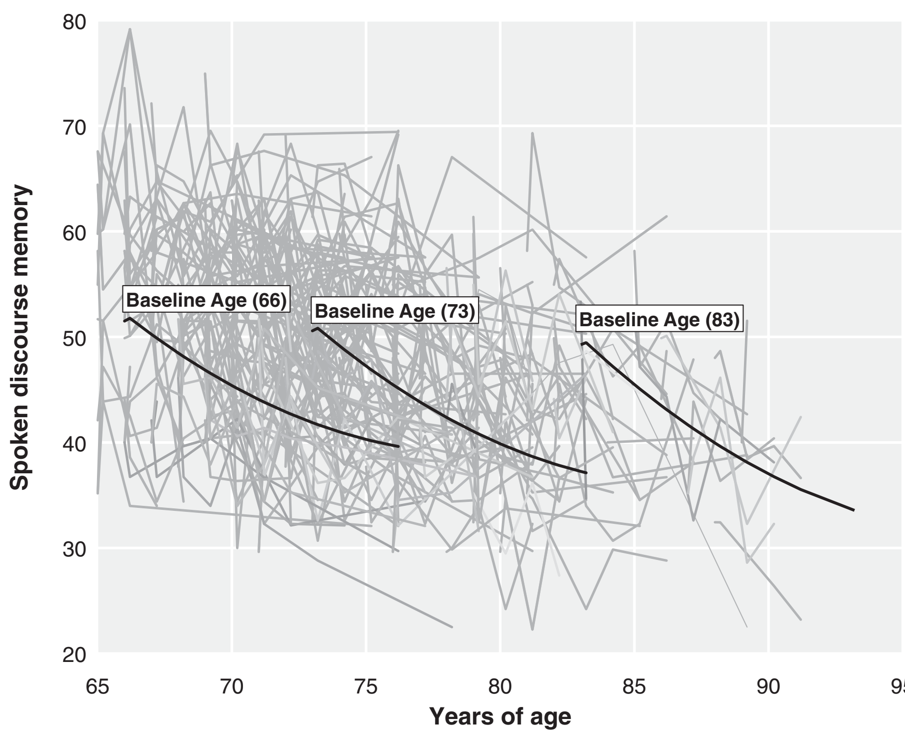

Figure 2. Model-estimated 10-year trajectories of change in spoken discourse memory as a function of age at baseline, adjusted for covariates in Table 2 (N = 698). Note: Random 20% sample of raw individual scores highlighted in gray. Model-implied trajectories have been shown for ages 66 (10th percentile), 73 (50th percentile) and 83 (90th percentile).

only baseline age and baseline episodic memory performance were reliable predictors of change in reasoning over time. Older adults showed a steeper annual rate of decline in the reasoning composite over a 10-year study period, and those with better initial episodic memory at baseline showed attenuated declines in reasoning.

DISCUSSION

The findings from the present study contribute to the literature on ageing and memory for language (Johnson, 2003; Light, 1991) by demonstrating the long-term longitudinal relationships between memory for spoken discourse and markers of fluid reasoning and verbal cognition. As far as we know, this paper provides the first longitudinal investigation of individual differences in developmental changes in memory for spoken discourse among older adults. Our findings indicated that there was a substantial longitudinal coupling between SDM and reasoning ability over 10 years, but that this relationship did not hold for SDM and verbal ability. Moreover, of all the measures at baseline, age was the only reliable predictor of change in SDM. This finding is particularly interesting, given that age remained a unique predictor after adjusting for several covariates known to influence discourse memory.

Our findings are largely consistent with those from Zelinski and Stewart (1998) in showing longitudinal declines in discourse memory that could be predicted by age at baseline. At the same time, our findings provide important extensions to their study. First, our longitudinal assessment is based on a larger sample, which is especially important given power-related issues for assessing longitudinal intercorrelations (Hertzog, von Oertzen, Ghisletta, & Lindenberger, 2008). The use of structural equation modelling techniques for examining correlated change is a strength of this study. By modelling correlated change in all three processes simultaneously, our analyses could be adjusted for initial levels of each process, as well as health status, global and specific cognitive function (MMSE, psychomotor speed, episodic memory), and demographic characteristics, including age. Lastly and most importantly, examining memory for discourse in the auditory modality complements the existing longitudinal investigations into discourse memory that have predominantly used written text material (Dixon & de Frias, 2004; Hultsch et al., 1998; Small, Dixon, Hultsch, & Hertzog, 1999; Zelinski & Stewart, 1998).

Our findings that both baseline age and change in reasoning were related to changes in SDM are entirely consistent with the results from Zelinski and Stewart (1998). However, in contrast to their findings in the text domain, neither level nor change in verbal ability significantly influenced individual differences in rates of change in SDM. It may be that preserved verbal ability does not provide the same degree of protective benefits for discourse memory in the auditory domain. One reason for this was suggested earlier: perhaps individual differences in attentional allocation during encoding serve as a mediating mechanism underlying the relationship between verbal ability and memory for written text. That is, there may be differences in attentional allocation strategies during encoding between high- and low-verbal individuals that differentially impact text memory. Findings by Stine-Morrow, et al. (2008) are consistent with this interpretation. In this study, participants read a series of sentences and larger discourses for recall in a self-paced reading paradigm. Stine-Morrow et al. examined changes in reading time as a function of a number of indices of linguistic difficulty and found that highly verbal individuals showed facilitated word-level processing, but also allocated more time to encoding propositional information online, leading to improved memory (see also Payne, Gao et al., 2012).

Because the rate of auditory input is fixed by an external source (the speaker), there is no clear way to regulate the pacing and timing of input at encoding. Thus, preserved verbal abilities may have little effect on memory for spoken discourse. Such ecological constraints on strategy use in the auditory domain may be another reason why reasoning was such a strong predictor of rate of change in SDM, given that there is a low likelihood that individual differences in encoding strategies may affect memory performance in this domain (cf. Friedman & Miyake, 2004). These findings are also consistent with a larger number of studies suggesting that control over input during encoding across a variety of tasks is essential to learning and memory (Chin, Payne, Fu, Morrow, & Stine-Morrow, in press; Voss, Gonsalves, Federmeier, Tranel, & Cohen, 2011).

Note that it is not necessarily true that listeners cannot modulate speech input in all cases. For example, speakers and listeners rely on a number of mechanisms to regulate comprehension during conversations (Garrod & Pickering, 2004; Tanenhaus & Brown-Schmidt, 2008). When speech is received at a pre-determined rate (e.g., radio and television; Stine, Wingfield, & Myers, 1990), however, age differences in memory may be more robust (Johnson, 2003). A recent study by Piquado, Benichov, Brownell, and Wingfied (2012) showed that self-regulatory control over speech input serves as a compensatory mechanism among older adults, especially those with central hearing acuity deficits. These findings warrant further research, including direct comparisons between auditory and visual text memory over time.

To the extent that non-verbal reasoning is a proxy for general fluid cognitive ability and executive control abilities (Kyllonen & Christal, 1990; Salthouse, 2005; Süß et al., 2002), these findings are consistent with the claim that preserved fluid reasoning ability may be an important domain-general cognitive component underlying effective language comprehension in older adulthood (Zelinski & Stewart, 1998). Goh, An, and Resnick (2012) recently examined cross-sectional and longitudinal relationships between a number of measures of executive control and episodic memory among middle-aged and older adults. They found substantial baseline correlations between most executive control and memory variables, but at the same time, heterogeneous trajectories of change over time among most cognitive abilities. While our findings are globally consistent with these results, given that we found very few predictors of within-person change in reasoning, discourse memory or verbal ability, our results stand in contrast to those of Goh et al. (2012) in one major way: the substantial longitudinal correlation found in the current study between change in reasoning and change in SDM, which was actually larger longitudinally than cross-sectionally.

Important caveats and limitations in the current study need to be addressed. First, ACTIVE included no measures of sensory ability, including auditory function. This is problematic for the current study, given the substantial literature indicating that age-related declines in audition are a critical aspect of speech comprehension and memory (Schneider, Pichora-Fuller, & Daneman, 2010; Tun, Benichchov, & Wingfield, 2010; Tun et al., 2009; Wingfield, Tun, & McCoy, 2005). Age-related declines in auditory processing have broad influences on cognitive performance and may result in permanent alternations of how auditory information is processed in the ageing brain (Lindenberger & Baltes, 1994). Although presentation of the passages in the Rivermead task were presented at a volume that was comfortable for the participants, it is possible that misperceptions of the auditory signal were at least partially responsible for age-related memory errors. As a result, this likely leads to an overestimated effect of age-related decline and the possibility of an overestimated correlation between reasoning and SDM at baseline, along with a change in reasoning and SDM over time. Note, however, that modality-specific sensory deficits have been shown to share high correlations with a number of other biomarkers of physical and cognitive health (Anstey, 2012), suggesting that acuity measures may serve as a proxy for more general function. Given that it is likely that audition is comorbid with at least some of the individual difference indicators included as covariates in the current study, we believe it is unlikely that the substantial relationship found between change in reasoning (a non-verbal visual task) and change in SDM could be completely mediated by auditory sensory processing. Nevertheless, future research should aim to examine how longitudinal declines in SDM are influenced by both cognitive and sensory factors simultaneously.

Lastly, the recognition vocabulary measure used in the current study may have been less demanding on participants than other commonly used verbal ability tasks (e.g., Weschler Adult Intelligence Scale, Wide Range Achievement Test cf. Strauss, Sherman, & Spreen, 2006). Indeed, there was some evidence for non-normality in the distribution of this measure at each test occasion, with a greater degree of clustering of scores at the higher range. At the same time, such recognition vocabulary tasks have shown to be reliable and valid predictors of language comprehension in prior research (Stine-Morrow et al., 2008; Lewis & Zelinski, 2010). Indeed, in the current study, vocabulary scores did show an adequate range at baseline compared to our other measures (see Table 1), and showed good external validity, relating to a number of covariates at baseline (see regression estimates for covariates in Table 2).

In conclusion, a growing number of studies examining individual differences in cognition have suggested that there are substantial individual differences in language comprehension among older adults (see Burke & Shafto, 2008 for a review). The findings from the current study contribute to this literature by showing that analyses of longitudinal change can provide powerful insights into developmental changes in memory for language. Furthermore, our study extends this literature to the auditory domain. Despite a growing number of studies recently suggesting rather heterogeneous longitudinal relationships between changes in cognition over time (Goh et al., 2012; McArdle, Grimm, Hamagami, Bowles, & Meredith, 2009; Tucker-Drob, 2011), our findings suggest strong relationships between declines in memory for spoken discourse and non-verbal executive reasoning abilities. Collectively, our findings suggest that longitudinal declines in cognitive ability are strongly associated with declines in memory for speech, but in contrast to the text memory domain, preserved verbal ability may not be as protective against developmental declines.

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