Executive function (EF), a component of cognition, mediates most purposeful behavior. Age-related declines in EF may account for age-related deficits in information processing (Raz, 2000). A task requiring high-level information processing ability, such as that required to comprehend written discourse, seems a reasonable means to determine if reduced EF ability in aging is related to reduced ability to comprehend written discourse.

The purpose of this study was to investigate the effects of age and concept formation/abstract reasoning components of EF on written discourse comprehension. The study hypothesizes that the relationship between age and written discourse comprehension ability is mediated by EF (i.e., concept formation/abstract reasoning). That is, the declines in written discourse comprehension observed in older adults are not due to age, but due to declines in EF. The research questions are: 1) Are there differences in younger and older adults' written discourse comprehension ability? 2) Are there differences in younger and older adults' EF ability in terms of concept formation/abstract reasoning? 3) What are the relationships between reader-related variables, written discourse comprehension ability, and concept formation/abstract reasoning? 4) Does concept formation/abstract reasoning mediate the effects of age on written discourse comprehension ability in adults?

Method

Participants

Data collection is ongoing, but sixteen adults have participated: eight older adults (*M* age = 69.75; *SD* = 11.74) and eight younger adults (*M* age = 27.88; *SD* = 7.28). Participant selection criteria included: (a) English speaking; (b) negative for neurological injury, dementia, or psychiatric illness; (c) at least 12 years of formal education; (d) at least a 25 out of 30 points on the *Mini-Mental State Exam* (MMSE: Folstein, Folstein, & McHugh, 1975); (e) at least a 6th grade oral reading level on the *Wide-Range Achievement Test-3* (WRAT-3: Wilkinson, 1993); (f) vision and hearing sufficient for the tasks.

Screening and Ability Tests

Each participant completed the MMSE, a test that screens for changes in cognitive functioning. Near visual acuity was assessed through self-report and clinical examination. Functional reading level was screened using the WRAT-3. Vocabulary recognition was assessed using the vocabulary portion of the *Nelson-Denney Reading Test* (Form H) (Brown, Fishco, & Hanna, 1993). The Story B portion of the Logical Memory subtest of the *Wechsler Memory Scale*-III (Wechsler, 1997) was used to assess memory for connected speech. Speed of information processing was assessed using *The Digit Symbol Substitution Test* (Wechsler, 1981).

Experimental Tasks

EF ability was assessed using the computerized version of the *Wisconsin Card Sorting Test* (WCST: Heaton, Chelune, Talley, Kay, & Curtis, 1993), a measure thought to capture concept formation/abstract reasoning ability (Keil & Kaszniak, 2002). The WCST required participants to sort cards according to rules using feedback from the examiner. Written discourse comprehension was assessed using the reading comprehension portion of the *Nelson-Denney Reading Test* (Brown et al., 1993), a timed, forced-choice (five answer choices) task.

Results

Nonparametric statistics were used for all statistical analyses. An alpha level of $p = .05$ was used for all statistical tests. A Mann-Whitney *U* test was conducted to evaluate group differences on demographics and ability tests. To control for type I errors, a more stringent alpha level of .008 was used based on a Bonferroni correction (.05/6). The groups did not differ in terms of sex, $z = -1.00$, $p = .442$; years of education, $z = -1.98$, $p = .05$; MMSE, $z = -2.57$, $p = .01$; LMS total score, $z = -2.16$, $p = .028$; or vocabulary, $z = -2.05$, $p = .038$. The groups did differ in terms of age, $z = -3.36$, $p < .001$.

The first question posed was, "Are there differences in younger and older adults' discourse comprehension ability?" Group differences were found with older adults scoring lower than younger adults, $z = -3.12$, $p < .001$. The next question was, "Are there differences in younger and older adults' EF ability in terms of concept formation/abstract reasoning?" The perseverative response score on the WCST was used as a measure of concept formation/abstract reasoning. Again, group differences were found. Older adults scored lower than younger adults, $z = -3.10$, $p < .001$.

The third question posed was, "What are the relationships among age, written discourse comprehension ability, and concept formation/abstract reasoning? Spearman-Rho correlations were used. To control for type I errors across the three multiple comparisons, a more stringent alpha level of .02 was used (.05/3). This step established that there was an effect that may be mediated. Age, written discourse comprehension, and concept formation/abstract reasoning were all highly correlated. Table 1 details the results.

The final question asked was, "Does concept formation/abstract reasoning mediate the effects of age on written discourse comprehension ability in adults?" A mediation model was used to answer this question. First, multiple regression was used to estimate the paths of the model. Figure 1 details the coefficients and standard errors of the multiple regressions. The dependent variable of written discourse comprehension was regressed on the independent variable of age. Next, the mediator variable EF (i.e., concept formation/abstract reasoning) was regressed on the independent variable of age. Finally, the dependent variable written discourse comprehension was regressed on the mediator variable EF (i.e., concept formation/abstract reasoning). Second, using the coefficients and standard errors, it had to be determined if the effect of the independent variable (age) on the dependent variable (written discourse comprehension) was significantly reduced by controlling for the mediator (EF). Here, the effect of age is reduced to nearly zero. The beta for age changed from -.790 to almost zero. The Sobel test was used to determine if the change was significant and if full mediation was reached. The Sobel value was significant, $z = -2.84$, $p = 0.005$. See Figure 2.

Discussion

The current study provided evidence that the effects of age on written discourse comprehension are fully mediated by the concept formation/abstract reasoning portion of EF as measured by the perserverative response score on the WCST. Older adults scored lower than younger adults on a written discourse comprehension task supporting previous studies that indicate a decrease in written discourse comprehension ability with age (Harris, Rogers, & Qualls, 1998; Kemper, 1992). In addition, older adults performed poorer on a task of concept formation/abstract reasoning. This provides support for the executive decline hypothesis (Dempster, 1992).

The finding that concept formation/abstract reasoning mediates written discourse comprehension in this study indicates that age is not the variable responsible for decreases in

written discourse comprehension. Declines in EF are responsible. Aging brain literature documents changes in brain structure with age, especially in areas purported to be important for EF (Oosterman et al., 2008; Raz, 2000). However, some older adults benefit from functional reorganization of the brain (Cabeza, 2002), thereby experiencing fewer declines in function. If older adults are able to maintain EF ability, perhaps they can experience fewer declines in the ability to comprehend written discourse comprehension.

Conclusion

Findings provide evidence that the effects of age on written discourse comprehension are fully mediated by concept formation/abstract reasoning portions of EF. Thus, older adults may need to consider cognitive stimulation programs aimed at maintaining EF skills (i.e., concept formation/abstract reasoning). Further, concept formation/abstract reasoning portions of EF may be a reasonable starting place for the rehabilitation of disordered groups; however, more evidence is needed.

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Table 1. Correlation matrix: Age, written discourse comprehension, and concept formation/abstract reasoning (EF)

	Age	*Nelson Denney Reading Comprehension*
Nelson Denney Reading Comprehension	[L] -.75 (.001)*	
WCST:CV4 (Perseverative Responses)	[L] .78 (.001)*	[L] -.91 (<.001)*

Note. [M] = Medium Effect Size r = +/- .3-.49, [L] = Large Effect Size r > +/- .5, (p-value), * = Significant correlation at p<.02.

Figure 1. Coefficient and standard errors of multiple regressions

EF (WCST Pers Resp) regressed on Age

B (unstandardised regression coefficient)	0.416
se (standard error)	0.077

Nelson Denney Reading regressed on Age AND EF (WCST Pers Resp)

EF (WCST Pers Resp)	
B (unstandardised regression coefficient)	-0.644
se (standard error)	0.193
beta (standardised regression coefficient)	-0.765
Age	
beta (standardised regression coefficient)	-0.155

Figure 2. Sobel test