Applied Neuropsychology: Adult
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hapn21

The Predictive Impact of Biological and Sociocultural Factors on Executive Processing: The Role of Age, Education, and Frequency of Reading and Writing Habits

Charles Cotrena[a], Laura D. Branco[a], Caroline O. Cardoso[ab], Cristina Elizabeth I. Wong[c] & Rochele P. Fonseca[a]

[a] Department of Psychology, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil

[b] Department of Psychology, Feevale University, Novo Hamburgo, Brazil

[c] Department of Psychology, Autonomous University of Sinaloa (UAS), Sinaloa, Mexico

Published online: 25 Jun 2015.

To cite this article: Charles Cotrena, Laura D. Branco, Caroline O. Cardoso, Cristina Elizabeth I. Wong & Rochele P. Fonseca (2015): The Predictive Impact of Biological and Sociocultural Factors on Executive Processing: The Role of Age, Education, and Frequency of Reading and Writing Habits, Applied Neuropsychology: Adult, DOI: 10.1080/23279095.2015.1012760

To link to this article: http://dx.doi.org/10.1080/23279095.2015.1012760

APPLIED NEUROPSYCHOLOGY: ADULT, *0*: 1–10, 2015

ISSN: 2327-9095 print/2327-9109 online
DOI: 10.1080/23279095.2015.1012760

The Predictive Impact of Biological and Sociocultural Factors on Executive Processing: The Role of Age, Education, and Frequency of Reading and Writing Habits

Charles Cotrena and Laura D. Branco
Department of Psychology, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil

Caroline O. Cardoso
Department of Psychology, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil; Department of Psychology, Feevale University, Novo Hamburgo, Brazil

Cristina Elizabeth I. Wong
Department of Psychology, Autonomous University of Sinaloa (UAS), Sinaloa, Mexico

Rochele P. Fonseca
Department of Psychology, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil

Although the impact of education and age on executive functions (EF) has been widely studied, the influence of daily cognitive stimulation on EF has not been sufficiently investigated. Therefore, the aim of the present study was to evaluate whether the age, education, and frequency of reading and writing habits (FRWH) of healthy adults could predict their performance on measures of inhibition and cognitive flexibility. Inhibition speed, inhibitory control, and set shifting were assessed using speed, accuracy, and discrepancy scores on the Trail-Making Test (TMT) and Hayling Test. Demographic characteristics and the FRWH were assessed using specialized questionnaires. Regression analyses showed that age and the FRWH predicted speed and accuracy on the TMT. The FRWH predicted both speed and accuracy on the Hayling Test, for which speed and accuracy scores were also partly explained by age and education, respectively. Surprisingly, only the FRWH was associated with Hayling Test discrepancy scores, considered one of the purest EF measures. This highlights the importance of regular cognitive stimulation over the number of years of formal education on EF tasks. Further studies are required to investigate the role of the FRWH so as to better comprehend its relationship with EF and general cognition.

Key words: *cognition, education, neuropsychology*

In the past few decades, neuropsychological research has aimed to obtain a deeper understanding of the role of sociocultural and biological variables on cognitive functioning (Ardila, 2007; Sánchez, Torrellas, Martín, & Barrera, 2011; Wong, Cotrena, Cardoso, & Fonseca, 2010). Some

Address correspondence to Charles Cotrena, Department of Psychology, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Av. Ipiranga, 6681, Prédio 11, 9° andar, sala 932, Porto Alegre/RS, 90619-900, Brazil. E-mail: c.cotrena@gmail.com

of the most extensively studied variables in this regard have been age (Ballesteros, Mayas, & Reales, 2013; D'cruz & Rajaratnam, 2013), education (Peña-Casanova et al., 2009), socioeconomic status (Jang, Choi, & Kim, 2009), gender (Varnava & Halligan, 2007), and, only more recently and in a small number of studies, reading and writing habits (Jefferson et al., 2011; Pawlowski et al., 2012). Knowledge regarding these variables is key for our comprehension of several clinical conditions, for ensuring the accuracy of diagnoses, and for generating normative data for neuropsychological tests (Peña-Casanova, Monllau, & Gramunt, 2007). Insufficient knowledge regarding these factors may have a negative impact on the interpretation of neuropsychological data and may lead to false positives, because cognitive alterations associated with sociocultural and biological characteristics, such as low education or advanced age, may be mistakenly attributed to neurological conditions (Lecours et al., 1987; Parente, Fonseca, & Scherer, 2008; Peña-Casanova et al., 2007).

Age is one of the most extensively studied biological factors in relation to neuropsychological performance (Wasylyshyn, Verhaeghen, & Sliwinski, 2011; Wong et al., 2010). Although researchers and clinical practitioners agree that aging leads to cognitive alterations (Ska & Joanette, 2006), there is no consensus as to which aspects of neuropsychological performance are the most influenced or impaired during the course of aging. Furthermore, there appears to be no agreement as to the age at which cognitive alterations begin (Grieve, Williams, Paul, Clark, & Gordon, 2007; Head, Kennedy, Rodrigue, & Raz, 2009; K. J. Johnson, Lui, & Yaffe, 2007; Rodríguez-Aranda & Sundet, 2006; Salthouse, 2009). The role of gender on the executive functions (EF) of healthy adults has also been sparsely studied, and results regarding its influence on these processes remain inconsistent (Campbell, 2006; Huster, Westerhausen, & Herrmann, 2011).

Studies on the effect of sociocultural variables on cognition have focused mostly on education, suggesting that the number of years of formal education and associated variables such as the quality of education are important determinants of neuropsychological performance (Ardila, Ostrosky-Solis, Rosselli, & Gómez, 2000; Ardila & Rosselli, 2007; Byrd, Jacobs, Hilton, Stern, & Manly, 2005; Parente, Scherer, Zimmermann, & Fonseca, 2009; Seo et al., 2007). The literature also suggests that higher levels of education are associated with increases in cortical thickness (Jiang et al., 2014), gray and white matter volume (Foubert-Samier et al., 2012), and cerebral metabolism (Cosentino & Stern, 2013). The effects of education on brain structure and functioning have also been discussed in terms of cognitive reserve, a term used to refer to individual differences in anatomical and functional neuronal characteristics that may result from exposure to occupational and educational experiences, and lead to an increased capacity to cope with degenerative diseases or brain damage (Barulli & Stern, 2013; Stern, 2009). Cognitive reserve has also been associated with an increased use of compensatory strategies following brain lesions (Baldivia, Andrade, & Bueno, 2008; Valenzuela & Sachdev, 2006). Conversely, low education may lead to poor neuropsychological performance so that individuals with low education levels may behave similarly to patients with neurological lesions in certain neuropsychological tasks (Beausoleil, Fortin, Le Blanc, & Joanette, 2003; Lezak, Howieson, & Loring, 2004). The complex interaction between age and education and the protective effects of education on cognition have been extensively studied in the literature (Ardila et al., 2000; Ashaie & Obler, 2014; Foubert-Samier et al., 2012; R. Johnson, Simon, Henkell, & Zhu, 2011; Wilson et al., 2009).

Because of recent criticisms of the ability of the number of years of education to accurately represent academic achievement—especially in terms of the quality and long-term effects of educational input—recent studies have proposed several alternative variables that may be more representative of the impact of formal schooling and sociocultural variables on neuropsychological performance. Variables identified in this regard include the quality of what is written and read, reading proficiency (Catts, Fey, & Proctor-Williams, 2000; Gee, Walsemann, & Takeuchi, 2010), and the frequency of each individual's reading and writing habits (Jefferson et al., 2011; Pawlowski et al., 2012). In fact, some studies have suggested that the frequency of reading and writing habits (FRWH) may make a more relevant contribution to cognitive performance than the number years of formal schooling (Dotson, Kitner-Triolo, Evans, & Zonderman, 2009).

The FRWH, when quantified as the weekly frequency with which individuals read and/or write different types of text, has some significant advantages when compared to other similar variables. Frequent cognitive stimulation has been found to have beneficial effects on both cognition (Jefferson et al., 2011) and quality of life (Clare et al., 2012). Additionally, engagement in cognitively stimulating activities has been increasingly used as a proxy measure of cognitive reserve (Jefferson et al., 2011). Although variables such as reading proficiency are able to capture some of these features and have been found to predict performance on some measures of executive functioning (Dotson et al., 2009), they do not reflect the frequency of daily cognitive stimulation associated with reading and writing. The FRWH taps into both reading ability and the frequency of cognitive stimulation and may therefore represent an exciting new area of research for neuropsychology. However, its effects on cognition as a whole, and specifically on EF, have not yet been investigated.

The term "EF" refers to a group of skills involved in the performance of voluntary, independent, autonomous, and organized actions oriented toward a specific goal (T. M. Anderson & Knight, 2010; Lezak et al., 2004). EF have been defined as a constellation of top-down mental processes involved in effortful behavioral control, which include, but are not limited to, inhibition, working memory, cognitive flexibility, planning, problem solving, and reasoning (Diamond, 2013). Impairments in these abilities can have significant repercussions on daily functioning (Fuster, 2000). Of all of the executive components listed in the literature, inhibitory control appears to be the most appropriate for assessment through neuropsychological tasks. This ability refers to the inhibition of dominant responses and is considered one of the key EF, not least due to its role in several other neuropsychological components (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Inhibitory control is greatly influenced by age (Borella, Carretti, & de Beni, 008), and its decline has been associated with significant impairment in general cognition as well as specific impairments in attention and learning (M. C. Anderson, Reinholz, Kuhl, & Mayr, 2011; Hasher & Zacks, 1988; Persad, Abeles, Zacks, & Denberg, 2002). Some studies on inhibitory control and its relationship to biological and sociocultural variables have also revealed that this cognitive function may vary according to education, but not according to gender (Bielak, Mansueti, Strauss, & Dixon, 2006).

In addition to inhibitory control, recent studies have also shown that "shifting," or the ability to alternate between tasks or mental operations, may also have a significant impact on several other cognitive processes (Miyake et al., 2000). Shifting is strongly related to cognitive flexibility, which involves adjusting one's perspective or behavioral strategy in response to changing environmental demands (Diamond, 2013). Cognitive flexibility appears to be inversely correlated with age (Wecker, Kramer, Hallam, & Delis, 2005) and positively correlated with education (Tombaugh, 2004). Given the large number of investigations into EF, the paucity of knowledge regarding the influence of sociocultural variables on these cognitive functions is particularly alarming. It is also important to note that the FRWH has not been studied in relation to these two executive components.

The involvement of both inhibitory control and cognitive flexibility in reading and writing has been confirmed by several empirical studies. Some of the most noteworthy contributions to this area have been from studies of children, which have shown that certain EF play a crucial role in the acquisition and early development of reading and writing abilities. Altemeier, Abbott, and Berninger (2008), for instance, found that these executive components have a significant influence on performance in both timed and untimed reading and writing tasks and that the developmental course of these two functions can predict children's literacy outcomes by Grade 4. More recently, in a longitudinal study of 5- to 8-year-old children, Röthlisberger, Neuenschwander, Cimeli, and Roebers (2013) found that a composite measure of EF including inhibition, working-memory, and cognitive flexibility scores could predict both reading and spelling abilities and that worse EF were generally associated with poor academic performance in subsequent grades. Interesting theoretical and empirical considerations regarding the relationship between inhibition and literacy were also made by Jabłoński (2013), who found associations between inhibitory control and literacy in 3- to 5-year-olds and revealed a complex relationship between this cognitive function and writing ability. In spite of these interesting findings linking inhibitory control, cognitive flexibility, and reading and writing skills, most studies on the topic tend to assess reading and writing proficiency, rather than the FRWH, which could provide relevant information regarding the longitudinal interaction between cognitive stimulation and EF. As previously mentioned, the assessment of reading and writing habits could also help to elucidate the relationship between EF and the quality of the formal education that individuals receive.

To address this gap in the literature, the aim of the current study was to investigate whether biological variables such as age and sociocultural factors such as education and the FRWH are able to predict executive performance in general and inhibitory control and cognitive flexibility in particular.

METHOD

Participants

The present sample was composed of 200 healthy individuals ($n = 67$; 33.5% male) aged 19 to 74 years old ($M = 40.56$ years, $SD = 17.64$ years) with 5 to 35 years of formal education ($M = 13.44$ years, $SD = 4.88$ years), which was calculated by the sum of the total years spent in primary and secondary school, university, and other learning environments. Participants were recruited from the community and by convenience from work and university settings. Several of these individuals then referred other potential participants through snowball sampling methods. All participants were Brazilian and native Portuguese speakers who presented no uncorrected sensory deficits and no symptoms of depression (indicated by a score <19 on the Beck Depression Inventory-II [BDI-II]; Gorenstein, Pang, Argimon, & Werlang, 2011) or signs of dementia (scores less than 24 on the Mini Mental State Examination [MMSE], adapted to the local population by Chaves & Izquierdo, 1992; Kochhann, Varela, Lisboa, & Chaves, 2010). The exclusion criteria for the current study's sample consisted of a history of alcohol abuse or dependence, self-reported current or previous use of illicit drugs or benzodiazepines, symptoms of psychiatric disorders (measured through the Self-Report Questionnaire [SRQ]; Mari & Williams, 1986), and scaled scores less than 7 in the Block Design and Vocabulary subtests of the Wechsler Adult Intelligence Scales-Third Edition. Sample characteristics are displayed in Table 1.

Most participants ($n = 114$) were aged 19 to 39 years old, and the means and standard deviations show that participants had a high number of years of formal schooling. The clinical data obtained are in accordance with what would be expected for healthy individuals, as scores on the MMSE ($M = 28.26$, $SD = 1.85$), BDI-II ($M = 6.23$, $SD = 4.47$), and SRQ ($M = 2.91$, $SD = 2.55$) were within the range most commonly observed in such participants.

TABLE 1
Summary of Participants' Sociocultural, Demographic, and Clinical Data

Variables	*M*	*SD*
Age	40.63	17.66
Sch.	13.41	4.89
FRWH	16.74	5.31
MMSE	28.25	1.86
WAIS Vocabulary	10.18	2.99
WAIS Block design	12.63	2.69
BDI-II	6.23	4.48
SRQ	2.91	2.56

SD = standard deviation; FRWH = frequency of reading and writing habits; Sch. = years of formal schooling; MMSE = Mini Mental State Examination; WAIS = Wechsler Adult Intelligence Scale; BDI-II = Beck Depression Inventory; SRQ = Self-Report Questionnaire.

Instruments and Procedure

Participants provided written consent and were individually assessed under appropriate conditions in accordance with ethical guidelines for research with human participants. Participants took part in a 45-min session during which instruments used for the collection of data regarding sample characterization and inclusion criteria were administered, followed by the assessment instruments themselves. The instruments used to investigate inclusion and exclusion criteria as well as to collect demographic data consisted of the following.

Sociocultural and health information questionnaire (Fonseca et al., 2012). This self-report questionnaire was composed of questions regarding biological and sociocultural variables such as gender, age, education, socioeconomic status, and FRWH. The instrument allows for the identification of exclusion and inclusion criteria and measures participant education through the number of years of formal schooling, excluding failed grades but including primary, secondary, and higher education as well as any other activity characterized as formal learning (e.g., professional or academic training courses, college preparatory courses). The questionnaire also includes a measure of FRWH, described in the study of Pawlowski et al. (2012). Briefly, the instrument quantifies reading and writing habits according to the weekly frequency of reading magazines, newspapers, books, and other materials and the weekly frequency of writing text messages, letters, and other materials. The frequency with which individuals engage in each of these activities is assigned one of the following scores: every day (4 points), a few days a week (3 points), once a week (2 points), rarely (1 point), and never (0 points). The scores assigned to each reading and writing activity are summed to obtain a total FRWH score, which can range from 0 to 28 points.

Mini mental state examination (Chaves & Izquierdo, 1992; Kochhann et al., 2010). The MMSE is a brief screening instrument with subtests that assess cognitive functions such as attention, memory, and language. The instrument is frequently used to identify symptoms of dementia.

Beck depression inventory-II (Beck, Steer, & Brown, 1996; adapted to Brazilian Portuguese by Gorenstein et al., 2011). The BDI-II consists of a self-report inventory that screens for the presence of symptoms of depression in the 2 weeks prior to its administration.

Self-report questionnaire (Mari & Williams, 1986). The SRQ-20 is a self-report questionnaire that screens for psychiatric symptoms and suicide risk through a total of 20 "yes" or "no" questions.

Wechsler adult intelligence scale-III (Nascimento, 2004). The Vocabulary (verbal) and Block Design (nonverbal) subtests of this scale were used in the current study. The Vocabulary subtest requires that the participant provide a definition for each of a series of words that are orally and visually presented by the examiner.

The two instruments used to assess EF are described in the following paragraphs.

Trail-Making Test (TMT; Reitan, 1992). This task is composed of two parts, the first of which (Part A) predominantly assesses attentional and visuoperceptual processes, while the second (Part B) provides a measure of inhibitory control. In Part A of the task, the participant is asked to use a pencil to connect a series of numbers distributed on an A4 sheet of paper in ascending order, while Part B of the TMT requires that participants connect both letters and numbers in alternating and ascending order. The maximum obtainable error score on each part of the test is 24, while the maximum amount of time provided to participants for the completion of the full TMT is 5 min. The total time to completion on Part B of the TMT is widely used as a measure of the speed of inhibition (Strauss, Sherman, & Spreen, 2006), while the discrepancy between the time taken to complete each of the two sections of the task (TMT-Part B speed – TMT-Part A speed) was used as an indicator of set shifting (Corrigan & Hinkeldey, 1987). This particular discrepancy score has been able to detect inhibition deficits in conditions such as eating disorders (Roberts, Tchanturia, & Treasure, 2010), obsessive-compulsive disorder (Tükel et al., 2012), schizophrenia (Owens et al., 2011), and Parkinson disease (Ridgel, Kim, Fickes, Muller, & Alberts, 2010). Accuracy on Part B of the TMT has also been found to be associated with inhibition scores on tasks such as the Stroop test (Chaytor, Schmitter-Edgecombe, & Burr, 2006; Spikman, Kiers, Deelman, & van Zomeren, 2001), and it has been used in the literature as a measure of response selection (Riccio, Homack, Jarratt, & Wolfe, 2006) and cognitive control (McDonald, Hunt, Henry, Dimoska, & Bornhofen, 2010). In light of these findings, TMT-B errors were used as a measure of inhibitory control in the present study.

Hayling test (Burgess & Shallice, 1997; adapted to Brazilian Portuguese by Fonseca, Oliveira, Gindri, Zimmermann, & Reppold, 2010). Cognitive functions assessed by this instrument include processing speed, initiation, inhibitory control, and cognitive flexibility. As part of this task, participants are provided with sentences in which the last word is missing and they are asked to complete the sentence with a word that logically fits the sentence (Part A) or with a word that is semantically unrelated to the sentence (Part B). Time and accuracy in Part B of the task are indicators of response inhibition speed and inhibitory control, respectively, while the difference between the time taken to complete both parts of the task (Hayling Test Part B speed – Hayling Test Part A speed) and the ratio between these two values (Hayling Test Part B speed/Hayling Test Part A speed) provide measures of cognitive flexibility and switching. As such, these four variables were used in the present study as indicators of inhibition and cognitive flexibility for the participants assessed. The accuracy in Part B of the Hayling Test is scored out of a maximum of 15 points.

Data Analysis

The Statistical Package for the Social Sciences Version 20.0 was used to analyze the data from the current study. Gender differences on the variables of interest were evaluated through student's *t* tests for independent samples, and exploratory Pearson correlations were used to identify potential predictors of performance on the Hayling Test and TMT. Factors related to each variable of interest according to *t* tests (in the case of gender) or correlation results (age, education, FRWH) were then entered as predictors in the multiple linear regression model of that particular variable. Predictors were entered into each model successively according to the magnitude of their correlation with the dependent variable. When gender differences were present, gender was entered first in the model to adjust for these effects. Results were considered significant at $p \leq .05$.

RESULTS

The results of the descriptive analysis of participant performance are displayed in Table 2.

The results of correlation analyses between age, education, and performance on the TMT and Hayling Test are displayed in Table 3.

As can be observed in Table 3, age, education, and reading and writing habits were weakly to moderately correlated with performance on the Hayling Test and TMT. Overall, age appeared to be most strongly correlated with variables related to performance on the TMT. The number of years of formal schooling was negatively correlated with accuracy in the second part of the Hayling Test, while the FRWH was weakly but significantly correlated with speed and accuracy on both the Hayling Test and the TMT.

Given the discrepancy between the number of men and women in the sample, the impact of gender on performance in both tasks was also analyzed. The analyses revealed no differences in the performance of the Hayling Test. However, men had significantly lower accuracy than women on Part B of the TMT ($p = .042$). To avoid confounding effects of gender, this variable was included as a predictor in the regression model for the number of errors on the TMT-B.

The results of these analyses were used to perform a series of multiple linear regressions to identify which of these factors, or combinations of them, could have greater predictive power regarding performance on these two neuropsychological measures. Independent variables that correlated significantly with dependent variables were entered in the regression models according to the magnitude of their correlation. Additionally, given the presence of gender differences in accuracy on the TMT-B, gender was also entered into the regression model for this variable. The results of these analyses are shown in Table 4.

As can be observed in Table 4, age was present in the regression models of all three TMT variables, as was the FRWH. Gender was also able to predict part of the variability in TMT-B accuracy scores. Both speed and accuracy on the Hayling Test were partially predicted by the FRWH,

TABLE 2
Descriptive Data for Performance on Measures of Executive Function in the Present Study

	Gender		
	Female	*Male*	
Variable	*M (SD)*	*M (SD)*	*p*
TMT-Part B speed	95.2 (41.5)	102.1 (88.2)	.457
TMT-Part B errors	0.41 (0.93)	0.71 (0.96)	**.041**
TMT-Part B speed – TMT-Part A speed	52.9 (35.2)	65.6 (83.4)	.240
Hayling Test Part B speed	50.7 (33.0)	49.5 (39.0)	.822
Hayling Test Part B errors	4.88 (3.14)	5.09 (3.77)	.676
Hayling Test Part B speed – Hayling Test Part A speed	28.2 (30.0)	30.0 (37.4)	.721

TMT = Trail-Making Test.

TABLE 3
Pearson Correlation Coefficients Between Age, Sociocultural Variables, and Performance on the Hayling Test and TMT

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1. Age	—								
2. Education	**.430****	—							
3. FRWH	−.013	**.331****	—						
4. TMT-B – Sp	**.296****	−.075	**−.226****	—					
5. TMT-B – Er	**.246****	−.030	**−.219****	**.392****	—				
6. TMT-B sp – TMT-A sp	**.267****	−.065	**−.210****	**.960****	**.367****	—			
7. Hayling B – Sp	**.154***	−.079	**−.255****	.114	**.155***	.061	—		
8. Hayling B – Er	.030	**−.304****	**−.262****	.063	.077	.027	**.251****	—	
9. Hayling B sp – Hayling A sp	.115	−.027	**−.165***	.032	.126	.000	**.879****	**.220****	—

FRWH = frequency of reading and writing habits; TMT-B = Trail-Making Test-Part B; Sp = Speed; Er = Errors.
**p* < .05. ***p* < .001.

TABLE 4
Multiple Linear Regression Analysis of Performance in the Hayling Test and TMT on Age, Gender, Education, and Frequency of Reading and Writing Habits

Variables	*B*	*SE (B)*	*β*	*p*
TMT-B Speed				
Step 1				
Age	1.020	.238	.296	**.000**
Step 2				**.000**
Age	1.000	.232	.290	**.001**
FRWH	−2.512	.776	−.218	
TMT-B Errors				
Step 1				**.041**
Gender	0.294	.143	.147	
Step 2				
Gender	0.345	.139	.173	**.014**
Age	0.014	.004	.263	**.000**
Step 3				
Gender	0.307	.137	.154	**.026**
Age	0.014	.004	.254	**.000**
FRWH	−0.035	.012	−.195	**.005**
TMT-B Speed – TMT-A Speed				
Step 1				
Age	0.846	.220	.266	**.000**
Step 2				
Age	0.830	.216	.216	**.000**
FRWH	−2.159	.719	−.204	**.003**
Hayling B Speed				
Step 1				
FRWH	−1.685	.455	−.255	**.000**
Step 2		.450		
FRWH	−1.672	.135	−.253	**.000**
Age	0.298		.151	**.029**
Hayling B Errors				
Step 1				
Education	−0.219	.049	−.304	**.000**
Step 2				
Education	−0.175	.051	−.243	**.001**
FRWH	−0.114	.045	−.180	**.012**
Hayling B Speed – Hayling A Speed	−1.013	.432	−.165	**.020**
FRWH				

TMT-B = Trail-Making Test-Part B; FRWH = frequency of reading and writing habits.

with education contributing as a predictor of Hayling Test Part B errors and age as a predictor of Hayling Test Part B speed. Interestingly, the FRWH was the most closely associated with the Hayling Test discrepancy score, which is considered to be the purest measure of inhibitory control yielded by this instrument.

DISCUSSION

The current study aimed to explore the effects of sociocultural and biological variables on neuropsychological performance. More specifically, it sought to investigate the predictive power of age, education, and reading and writing habits over set shifting and inhibitory control as measured by the Hayling Test and the TMT.

The results of a multiple linear regression analysis revealed that age and the FRWH had the greatest predictive power over speed in Part B of the TMT and the TMT discrepancy score, which measure inhibition speed and set shifting, respectively. Gender, age, and the FRWH were also found to have an effect on the efficacy of inhibitory control as measured by accuracy in Part B of the TMT. The FRWH also predicted performance on all three Hayling Test scores, with age and education also explaining part of the variability in the speed and accuracy of the test.

The correlation analyses indicated that age was most closely related to time to completion on both the TMT and Hayling Test. These results are in agreement with the literature, which suggests that processing speed may decrease with advancing age (Lu et al., 2013; Salthouse, 1996). Associations between advancing age and poorer performance on instruments such as the Hayling Test have also been shown by other studies (Bielak et al., 2006). The decrease in performance speed observed in older individuals during the Hayling Test could also be due to a reduction in the efficacy of inhibitory control, which may lead to impaired set shifting due to difficulties in inhibiting responses or mental processes to alternate between them. This hypothesis is supported by longstanding theories regarding the impact of reduced inhibitory control on other mental processes throughout cognitive aging (Hasher & Zacks, 1988; Healey, Hasher, & Campbell, 2013).

Education, as measured by the number of years of formal schooling, proved to be negatively correlated with the number of errors in Part B of the Hayling Test. This may be associated with the beneficial effects of education on cognition in general (Pawlowski et al., 2012) and in verbal measures of EF specifically (Machado et al., 2009).

Although significant, the correlations between age, education, and EF were found to be weaker than those reported in some of the existing literature (e.g., Perry et al., 2009). However, low correlations between TMT performance and age or education have also been identified in other studies (Biswas, 2014; Pluncevic-Gilgoroska, Manchevska, & Bozhinovska, 2010). One possible explanation for these findings is the wide range of variables involved in TMT performance. Studies have shown that scores on the test may be influenced by factors as varied as genetic polymorphisms (Wishart et al., 2011), vocabulary level (Fine, Delis, & Holdnack, 2011), and socioeconomic status (Sarsour et al., 2011). These factors were not controlled for in the present study and may have influenced our results regarding the correlation between demographic variables and EF.

Although the FRWH is a novel variable and has not yet been sufficiently explored in the literature, our results regarding its influence on executive functioning were promising. Not only was it negatively correlated with the time taken to complete both the TMT and Hayling Test, but it also displayed negative correlations with variables pertaining to accuracy in these tasks. The predictive power of reading and writing habits over performance in these instruments could be due to the role of this variable as an indirect measure of the quality of formal education received by each participant; that is, individuals with a higher FRWH may have received better-quality education and therefore benefited the most from the influence of this factor on cognition. This hypothesis is supported by studies that have shown that differences in neuropsychological performance are associated with both the quantity and the quality of education received (Manly, Jacobs, Touradji, Small, & Stern, 2002). These findings underscore the importance of controlling for the quality of participant education when researching neuropsychological performance (Casarin, Wong, Parente, Salles, & Fonseca, 2012). It is also possible that a combined effect of education and a high FRWH led to greater accuracy and efficiency, resulting in a shorter time required to complete the tasks administered. The combined effects of these two variables on EF have been previously reported in the literature (Pawlowski et al., 2012) and may suggest that continuous cognitive stimulation, such as that offered by a high FRWH, may reinforce the effects of formal education on cognition.

Although the influence of reading and writing habits on neuropsychological performance has only recently begun to be explored, some similar variables such as literacy have been more extensively studied. Such variables have been suggested as having an important role in establishing cognitive reserve, for which development is known to be strongly influenced by formal education and occupational attainment (Stern et al., 1994). Although the importance of these variables has already been established, there are divergences as to how they should be quantified. Education, for instance, is generally operationalized as the number of years of formal education obtained by an individual; however, recent data suggest that literacy and reading ability may make for more robust measures of educational attainment as relevant to cognitive reserve (Jefferson et al., 2011; Manly, Schupf, Tang, & Stern, 2005). It is possible that these variables provide a more accurate measure of the results and quality of an individual's education (Stern, 2009) and represent the frequency of cognitive stimulation following the end of formal education. Therefore, the FRWH may also be able to contribute to the study of the relationship between education and cognitive reserve. This variable is strongly related to both literacy and reading proficiency and provides an approximate measure of the level of cognitive stimulation to which individuals are routinely exposed. As such, the study of reading and writing habits could also shed light on the role of such activities in the ongoing maintenance of cognitive reserve.

Although the study of variables such as reading and writing habits has great potential in terms of its contribution to knowledge regarding cognitive function, there is a marked scarcity of research in this area. This may create a problem in the measurement of these variables, as no standard way to quantify this type of data has been developed. Although the current study aimed to assess the FRWH with the greatest possible precision and specificity, there is no certainty as to whether this is the ideal way of operationalizing this variable. Furthermore, due to the lack of studies on the impact of reading and writing activities on cognitive function, especially EF, it is somewhat difficult to compare the present results to those of other studies in the literature. However, the paucity of similar studies in the literature also indicates that the current study has tapped into a research area that has thus far remained unexplored. To the authors' knowledge, no studies have investigated the influence of the FRWH on EF.

In light of these observations, we suggest that this topic be further investigated in future studies, using additional or alternative measures of EF. In addition to providing further evidence of the effect of cultural and demographic variables on EF, such investigations may also yield more detailed information regarding the nature of the influence of these factors on set shifting and inhibitory control. Although the instruments used in the present study are known measures of set shifting and inhibitory control, the high correlation between our variables may have limited the interpretability of our findings. Although these two constructs are known to be closely related (Friedman & Miyake, 2004), the use of different instruments may reduce the overlap between measures of each of these variables and allow for a more detailed analysis of the influence of age, education, and the FRWH on each of these cognitive processes. In future studies, researchers may also wish to examine the combined effects of demographic variables and general intellectual functioning on specific EF, so as to contribute to theoretical models of EF and to our understanding of the interaction between these different cognitive processes.

Overall, other findings in the literature corroborate the present results regarding the interaction between neuropsychological performance and the impact of variables such as age (Ska & Joanette, 2006), education (Byrd et al., 2005; Peña-Casanova et al., 2009; Seo et al., 2007), and, more recently, reading and writing habits (Jefferson et al., 2011; Pawlowski et al., 2012). The results obtained in the current investigation also point to the role of the FRWH in maintaining cognitive function by providing daily cognitive stimulation as well as preserving the benefits accrued by educational attainment. As such, it is important to control for this variable in neuropsychological investigations and to explore its relationship with different clinical conditions, as it may provide relevant information regarding protective or favorable prognostic factors. In summary, the current study's findings underscore the importance of the investigation of the individual and combined influence of variables such as age, education, and the FRWH on EF.

ORCID

Charles Cotrena http://orcid.org/0000-0002-3573-7809
Laura D. Branco http://orcid.org/0000-0001-7967-7142

REFERENCES

Altemeier, L. E., Abbott, R. D., & Berninger, V. W. (2008). Executive functions for reading and writing in typical literacy development and dyslexia. *Journal of Clinical and Experimental Neuropsychology*, *30*, 588–606. doi:10.1080/13803390701562818

Anderson, M. C., Reinholz, J., Kuhl, B., & Mayr, U. (2011). Intentional suppression of unwanted memories grows more difficult as we age. *Psychology and Aging*, *26*, 397–405.

Anderson, T. M., & Knight, R. G. (2010). The long-term effects of traumatic brain injury on the coordinative function of the central executive. *Journal of Clinical and Experimental Neuropsychology*, *32* (10), 1074–1082.

Ardila, A. (2007). Normal aging increases cognitive heterogeneity: Analysis of dispersion in WAIS-III scores across age. *Archives of Clinical Neuropsychology*, *22*, 1003–1011.

Ardila, A., Ostrosky-Solis, F., Rosselli, M., & Gómez, C. (2000). Age-related cognitive decline: The complex effect of education. *Archives of Clinical Neuropsychology*, *15*, 495–513.

Ardila, A., & Rosselli, M. (2007). Illiterates and cognition: The impact of education. In B. P. Uzzell, M. O. Ponton, & A. Ardila (Eds.), *International handbook of cross-cultural neuropsychology* (pp. 23–44). Hillsdale, NJ: Lawrence Erlbaum.

Ashaie, S., & Obler, L. (2014). Effect of age, education, and bilingualism on confrontation naming in older illiterate and low-educated populations. *Behavioural Neurology*, *2014*, Article ID 970520. doi:10.1155/2014/970520

Baldivia, B., Andrade, V. M., & Bueno, O. F. A. (2008). Contribution of education, occupation and cognitively stimulating activities to the formation of cognitive reserve. *Dementia & Neuropsychologia*, *2*, 173–182.

Ballesteros, S., Mayas, J., & Reales, J. M. (2013). Cognitive function in normal aging and in older adults with mild cognitive impairment. *Psicothema*, *25*, 18–24. doi:10.7334/psicothema2012.181

Barulli, D., & Stern, Y. (2013). Efficiency, capacity, compensation, maintenance, plasticity: Emerging concepts in cognitive reserve. *Trends in Cognitive Sciences*, *17*, 502–509. doi:10.1016/j.tics.2013.08.012

Beausoleil, N., Fortin, R., Le Blanc, B., & Joanette, Y. (2003). Unconstrained oral naming performance in right- and left-hemisphere-damaged individuals: When education overrides the lesion. *Aphasiology*, *17*, 143–158.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.

Bielak, A. A. M., Mansueti, L., Strauss, E., & Dixon, R. A. (2006). Performance on the Hayling and Brixton Test in older adults: Norms and correlates. *Archives of Clinical Neuropsychology*, *21*, 141–149.

Biswas, P. (2014). *Inclusive human machine interaction for India*. Cham, Switzerland: Springer International.

Borella, E., Carretti, B., & de Beni, R. (2008). Working memory and inhibition across the adult lifespan. *Acta Neuropsychologica*, *128*, 33–44.

Burgess, P. W., & Shallice, T. (1997). *The Hayling and Brixton Tests*. Thurston, Suffolk, UK: Thames Valley Test Company.

Byrd, D. A., Jacobs, D. M., Hilton, H. J., Stern, Y., & Manly, J. J. (2005). Sources of errors on visuospatial tasks: Role of education, literacy and search strategy. *Brain and Cognition*, *58*, 251–257.

Campbell, A. (2006). Sex differences in direct aggression: What are the psychological mediators? *Aggression and Violent Behavior*, *11*, 237–264.

Casarin, F. S., Wong, C. E. I., Parente, M. A., Salles, J. F., & Fonseca, R. P. (2012). Comparison of neuropsychological performance between students from public and private Brazilian schools. *Spanish Journal of Psychology*, *15*, 942–951.

Catts, H., Fey, M., & Proctor-Williams, K. (2000). The relationship between language and reading: Preliminary results from a longitudinal investigation. *Logopedics Phoniatrics Vocology*, *25*, 3–11.

Chaves, M. L., & Izquierdo, Y. (1992). Differential diagnosis between dementia and depression: A study of efficiency increment. *Acta Neurologica Scandinavia*, *85*, 378–382.

Chaytor, N., Schmitter-Edgecombe, M., & Burr, R. (2006). Improving the ecological validity of executive functioning assessment. *Archives of Clinical Neuropsychology*, *21*, 217–227.

Clare, L., Hindle, J. V., Jones, I. R., Thom, J. M., Nelis, S. M., Hounsome, B., & Whitaker, C. J. (2012). The AgeWell study of behavior change to promote health and wellbeing in later life: Study protocol for a randomized controlled trial. *Trials*. doi:10.1186/1745-6215-13-115

Corrigan, J. D., & Hinkeldey, N. S. (1987). Relationships between Parts A and B of the Trail Making Test. *Journal of Clinical Psychology*, *43*, 402–409. doi:10.1002/1097-4679(198707)43:4<402::AID-JCLP2270430411>3.0.CO;2-E

Cosentino, S., & Stern, Y. (2013). Consideration of cognitive reserve. In L. D. Ravdin & H. L. Katzen (Eds.), *Handbook on the neuropsychology of aging and dementia* (pp. 11–23). New York: Springer. doi:10.1007/978-1-4614-3106-0_2

D'cruz, S. M., & Rajaratnam, N. (2013). The effect of aging on cognitive function in a South Indian population. *International Journal of Scientific and Research Publications*, *3*(5), 1–5.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168.

Dotson, V. M., Kitner-Triolo, M. H., Evans, M. K., & Zonderman, A. B. (2009). Effects of race and socioeconomic status on the relative influence of education and literacy on cognitive functioning. *Journal of the International Neuropsychological Society*, *15*, 580–589.

Fine, E. M., Delis, D. C., & Holdnack, J. (2011). Normative adjustments to the D-KEFS Trail Making Test: Corrections for education and vocabulary level. *The Clinical Neuropsychologist*, *25*, 1331–1344. doi:10.1080/13854046.2011.609838

Fonseca, R. P., Oliveira, C., Gindri, G., Zimmermann, N., & Reppold, C. (2010). The Hayling Test: A measure of executive components. In C. Hutz (Ed.), *Avaliação psicológica e neuropsicológica de crianças e adolescentes* (pp. 337–364). São Paulo, Brazil: Casa do Psicólogo.

Fonseca, R. P., Zimmermann, N., Pawlowski, J., Oliveira, C. R., Gindri, G., Scherer, L. C., … Parente, M. A. M. P. (2012). Methods in neuropsychological assessment: General, neurocognitive, neuropsycholinguistic, and psychometric aspects of the use and development of assessment instruments. In J. Landeira-Fernandez & S. S. Fukusima (Eds.), *Métodos de pesquisa em neurociência clínica e experimental* (pp. 266–296). São Paulo, Brazil: Manole.

Foubert-Samier, A., Catheline, G., Amieva, H., Dilharreguy, B., Helmer, C., Allard, M., & Dartigues, J. F. (2012). Education, occupation, leisure activities, and brain reserve: A population-based study. *Neurobiology of Aging*, *33*, 423.e15–423.e25.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General*, *133*, 101–135.

Fuster, M. J. (2000). Executive frontal functions. *Experimental Brain Research*, *133*, 66–70. doi:10.1007/s002210000401

Gee, G. C., Walsemann, K. M., & Takeuchi, D. T. (2010). English proficiency and language preference: Testing the equivalence of two measures. *American Journal of Public Health*, *100*, 563–569.

Gorenstein, C., Pang, W. Y., Argimon, I. I. L., & Werlang, B. S. G. (2011). *Manual for the Beck Depression Inventory - BDI-II: Brazilian version*. Itatiba, Brazil: Casa do Psicólogo.

Grieve, S. M., Williams, L. M., Paul, R. H., Clark, C. R., & Gordon, E. (2007). Cognitive aging, executive function, and fractional anisotropy: A diffusion tensor MR imaging study. *American Journal of Neuroradiology*, *28*, 226–235.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. K. Bower (Ed.), *The psychology of learning and motivation* (Vol. 22, pp. 193–225). San Diego, CA: Academic Press.

Head, D., Kennedy, K. M., Rodrigue, K., & Raz, N. (2009). Age differences in perseveration: Cognitive and neuroanatomical mediators of performance on the Wisconsin Card Sorting Test. *Neuropsychologia*, *47*, 1200–1203.

Healey, M. K., Hasher, L., & Campbell, K. L. (2013). The role of suppression in resolving interference: Evidence for an age-related deficit. *Psychology and Aging*, *28*, 721–728.

Huster, R. J., Westerhausen, R., & Herrmann, C. S. (2011). Sex differences in cognitive control are associated with midcingulate and callosal morphology. *Brain Structure and Function*, *215*, 225–235.

Jabłoński, S. (2013). Inhibitory control and literacy development among 3- to 5-year-old children. *L1-Educational Studies in Language and Literature*, *13*(2013), 1–25.

Jang, S. N., Choi, Y. J., & Kim, D. H. (2009). Association of socioeconomic status with successful ageing: Differences in the components of successful ageing. *Journal of Biosocial Science*, *41*, 207–219.

Jefferson, A. L., Gibbons, L. E., Rentz, M. D., Carvalho, O. J., Manly, J., Bennett, A. D., & Jones, N. R. (2011). A life course model of cognitive activities, socioeconomic status, education, reading ability, and cognition. *Journal of the American Geriatrics Society*, *59*, 1403–1411. doi:10.1111/j.1532-5415.2011.03499.x

Jiang, J., Sachdev, P., Lipnicki, D. M., Zhang, H., Liu, T., Zhu, W., … Wen, W. (2014). A longitudinal study of brain atrophy over two years in community-dwelling older individuals. *NeuroImage*, *86*, 203–211.

Johnson, K. J., Lui, L. Y., & Yaffe, K. (2007). Executive function, more than global cognition, predicts functional decline and mortality in elderly women. *Journals of Gerontology: Series A. Biological Sciences and Medical Sciences*, *62*, 1134–1141.

Johnson, R., Simon, E. J., Henkell, H., & Zhu, J. (2011). The role of episodic memory in controlled evaluative judgments about attitudes: An event-related potential study. *Neuropsychologia*, *49*, 945–960.

Kochhann, R., Varela, J. S., Lisboa, C. S. M., & Chaves, M. L. F. (2010). The Mini Mental State Examination review of cutoff points adjusted for schooling in a large Southern Brazilian sample. *Dementia & Neuropsychologia*, *4*, 35–41.

Lecours, A. R., Mehler, J., Parente, M. A. M. P., Caldeira, A., Cary, L., Castro, M. J., … Junqueira, A. M. S. (1987). Illiteracy and brain damage: 1. Aphasia testing in culturally contrasted populations (control subjects). *Neuropsychologia*, *25*, 231–245.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological assessment* (4th ed.). New York, NY: Oxford University Press.

Lu, P. H., Lee, G. J., Tishler, T. A., Meghpara, M., Thompson, P. M., & Bartzokis, G. (2013). Myelin breakdown mediates age-related slowing in cognitive processing speed in healthy elderly men. *Brain and Cognition*, *81*, 131–138. doi:10.1016/j.bandc.2012.09.006

Machado, T. H., Fichman, H. C., Santos, E. L., Carvalho, V. A., Fialho, P. P., Koenig, A. M., … Caramelli, P. (2009). Normative data for healthy elderly on the phonemic verbal fluency task–FAS. *Dementia & Neuropsychologia*, *3*, 55–60.

Manly, J. J., Jacobs, D. M., Touradji, P., Small, S. A., & Stern, Y. (2002). Reading level attenuates differences in neuropsychological test performance between African American and White elders. *Journal of the International Neuropsychological Society*, *8*, 341–348.

Manly, J. J., Schupf, N., Tang, M. X., & Stern, Y. (2005). Cognitive decline and literacy among ethnically diverse elders. *Journal of Geriatric Psychiatry & Neurology*, *18*, 213–217.

Mari, J. J., & Williams, P. (1986). A validity study of a psychiatric screening questionnaire (SRQ-20) in primary care in the city of Sao Paulo. *British Journal of Psychiatry*, *148*, 23–26.

McDonald, S., Hunt, C., Henry, J. D., Dimoska, A., & Bornhofen, C. (2010). Angry responses to emotional events: The role of impaired control and drive in people with severe traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *32*, 855–864. doi:10.1080/13803391003596405

Miyake, A., Friedman, M., Emerson, J., Witzki, A., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex 'frontal lobe' tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. doi:10.1006/cogp.1999.0734

Nascimento, E. (2004). Adaptation, validation and normatization of the WAIS-III for use in a Brazilian sample. In D. Wechsler (Ed.), *WAIS-III: manual para administração e avaliação* (pp. 161–191). São Paulo, Brazil: Casa do Psicólogo.

Owens, S. F., Rijsdijk, F., Picchioni, M. M., Stahl, D., Nenadic, I., Murray, R. M., & Toulopoulou, T. (2011). Genetic overlap between schizophrenia and selective components of executive function. *Schizophrenia Research*, *127*, 181–187.

Parente, M. A. M. P., Fonseca, R. P., & Scherer, L. C. (2008). Literacy as a determining factor for brain organization: From Lecours' contribution to the present day. *Dementia & Neuropsychologia*, *2*, 165–172.

Parente, M. A. M. P., Scherer, L. C., Zimmermann, N., & Fonseca, R. P. (2009). Evidence of the role of education in brain organization. *Revista Neuropsicologia Latinoamericana*, *1*, 72–79.

Pawlowski, J., Fonseca, R. P., Salles, J. F., Parente, M. A., & Bandeira, D. R. (2008). Evidence of the validity of the Brazilian Brief Neuropsychological Assessment Battery Neupsilin. *Arquivos Brasileiros de Psicologia*, *60*, 101–116.

Peña-Casanova, J., Gramunt-Fombuena, N., Quiñones-Úbeda, S., Sánchez-Benavides, G., Aguilar, M., Badenes, D., … Blesa, R. (2009). Spanish multicenter normative studies (NEURONORMA Project): Norms for the Rey-Osterrieth Complex Figure (Copy and Memory), and Free and Cued Selective Reminding Test. *Archives of Clinical Neuropsychology*, *24*, 371–393.

Peña-Casanova, J., Monllau, A., & Gramunt, N. F. (2007). Discussing the psychometrics of dementia. *Neurología*, *22*, 301–311.

Perry, M. E., McDonald, C. R., Hagler, D. J., Gharapetian, L., Kuperman, J. M., Koyama, A. K., … McEvoy, L. K. (2009). White matter tracts associated with set-shifting in healthy aging. *Neuropsychologia*, *47*, 2835–2842. doi:10.1016/j.neuropsychologia.2009.06.008

Persad, C. C., Abeles, N., Zacks, R. T., & Denberg, N. L. (2002). Inhibitory changes after age 60 and their relationship to measures of attention and memory. *Journals of Gerontology: Series B. Psychological Sciences and Social Sciences*, *57*, 223–232.

Pluncevic-Gligoroska, J., Manchevska, S., & Bozhinovska, L. (2010). Psychomotor speed in young adults with different level of physical activity. *Medicinski Arhiv*, *64*, 139–143.

Reitan, R. M. (1992). *Trail Making Test: Manual for administration and scoring*. Mesa, AZ: Reitan Neuropsychology Laboratory.

Riccio, C. A., Homack, S., Jarratt, K. P., & Wolfe, M. E. (2006). Differences in academic and executive function domains among children with ADHD Predominantly Inattentive and Combined Types. *Archives of Clinical Neuropsychology*, *21*, 657–667. doi:10.1016/j.acn.2006.05.010

Ridgel, A. L., Kim, C.-H., Fickes, E. J., Muller, M. D., & Alberts, J. L. (2010). Changes in executive function after acute bouts of passive cycling in Parkinson's disease. *Journal of Aging and Physical Activity*, *19*, 87–98.

Roberts, M. E., Tchanturia, K., & Treasure, J. L. (2010). Exploring the neurocognitive signature of poor set-shifting in anorexia and bulimia nervosa. *Journal of Psychiatric Research*, *44*, 964–970. doi:10.1016/j.jpsychires.2010.03.001

Rodriguez-Aranda, C., & Sundet, K. (2006). The frontal hypothesis of cognitive aging: Factor structure and age effects on four frontal tests among healthy individuals. *Journal of Genetic Psychology*, *167*, 269–287.

Röthlisberger, M., Neuenschwander, R., Cimeli, P., & Roebers, C. M. (2013). Executive functions in 5- to 8-year olds: Developmental changes and relationship to academic achievement. *Journal of Educational and Developmental Psychology*, *3*, 153–167. doi:10.5539/jedp.v3n2p153

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, *103*, 403–428.

Salthouse, T. A. (2009). When does age-related cognitive decline begin? *Neurobiology of Aging*, *30*, 507–514. doi:10.1016/j.neurobiolaging.2008.09.023

Sánchez, J. L., Torrellas, C., Martin, J., & Barrera, I. (2011). Study of sociodemographic variables linked to lifestyle and their possible influence on cognitive reserve. *Journal of Clinical and Experimental Neuropsychology*, *33*, 874–891.

Sarsour, K., Sheridan, M., Jutte, D., Nuru-Jeter, A., Hinshaw, S., & Boyce, W. T. (2011). Family socioeconomic status and child executive functions: The roles of language, home environment, and single parenthood. *Journal of the International Neuropsychological Society*, *17*, 120–132. doi:10.1017/S1355617710001335

Seo, E. H., Lee, D. Y., Choo, I. H., Youn, J. C., Kim, K. W., Jhoo, J. H., … Woo, J. I. (2007). Performance on the Benton Visual Retention Test in an educationally diverse elderly population. *Journals of Gerontology: Series B. Psychological Sciences, 62B*, 191–193.

Ska, B., & Joanette, Y. (2006). Normal aging and cognition. *Médecine/Sciences*, *22*, 284–287.

Spikman, J. M., Kiers, H. A., Deelman, B. G., & van Zomeren, A. H. (2001). Construct validity of concepts of attention in healthy controls and patients with CHI. *Brain and Cognition*, *47*, 446–460. doi:10.1006/brcg.2001.1320

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, *47*, 2015–2028. doi:10.1016/j.neuropsychologia.2009.03.004

Stern, Y., Gurland, B., Tatemichi, T. K., Tang, M. X., Wilder, D., & Mayeux, R. (1994). Influence of education and occupation on the incidence of Alzheimer's disease. *JAMA*, *271*(13), 1004–1010.

Strauss, E., Sherman, E. M., & Spreen, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary*. New York, NY: Oxford University Press.

Tombaugh, T. N. (2004). Trail Making Test A and B: Normative data stratified by age and education. *Archives of Clinical Neuropsychology*, *19*, 203–214.

Tükel, R., Gürvit, H., Ertekin, B. A., Oflaz, S., Ertekin, E., Baran, B., … Atalay, F. (2012). Neuropsychological function in obsessive-compulsive disorder. *Comprehensive Psychiatry*, *53*, 167–175. doi:10.1016/j.comppsych.2011.03.007

Valenzuela, M. J., & Sachdev, P. (2006). Brain reserve and dementia: A systematic review. *Psychological Medicine*, *36*, 441–454.

Varnava, A., & Halligan, P. W. (2007). Influence of age and sex on line bisection: A study of normal performance with implications for visuospatial neglect. *Aging Neuropsychology and Cognition*, *14*, 571–585. doi:10.1080/13825580600826454

Wasylyshyn, C., Verhaeghen, P., & Sliwinski, M. J. (2011). Aging and task switching: A meta-analysis. *Psychology and Aging*, *26*, 15–20. doi:10.1037/a0020912

Wecker, N. S., Kramer, J. H., Hallam, B. J., & Delis, D. C. (2005). Mental flexibility: Age effects on switching. *Neuropsychology*, *19*, 345–352.

Wilson, R., Hebert, L., Scherr, P., Barnes, L., Mendes de Leon, C., & Evans, D. (2009). Educational attainment and cognitive decline in old age. *Neurology*, *72*, 460–465. doi:10.1212/01.wnl.0000341782.71418.6c

Wishart, H. A., Roth, R. M., Saykin, A. J., Rhodes, C. H., Tsongalis, G. J., Pattin, K. A., … McAllister, T. W. (2011). COMT Val158Met genotype and individual differences in executive function in healthy adults. *Journal of the International Neuropsychological Society*, *17*, 174–180. doi:10.1017/S1355617710001402

Wong, C. E. I., Cotrena, C., Cardoso, C., & Fonseca, R. P. (2010). Visual memory: Association with sociodemographic factors. *Revista Mexicana Neuropsicologia*, *5*, 10–18.