The Spanish Journal of Psychology (2020), **23**, e27, 1–10.

doi:10.1017/SJP.2020.30

Age, Education and Intellectual Quotient Influences: Structural Equation Modeling on the study of Benton Visual Retention Test (BVRT)

Joice Dickel Segabinazi[1,2], Josiane Pawlowski[3,4], Adriana Mokwa Zanini[1], Gabriela Peretti Wagner[5], Juliana Burges Sbicigo[1], Clarissa Marceli Trentini[1], Claudio Simon Hutz[1], Jerusa Fumagalli de Salles[1] and Denise Ruschel Bandeira[1]

[1] *Universidade Federal do Rio Grande do Sul (Brazil)*
[2] *Pontifícia Universidade Católica do Rio Grande do Sul (Brazil)*
[3] *Universidade Federal do Rio de Janeiro (Brazil)*
[4] *Universidad de Iberoamérica (Costa Rica)*
[5] *Universidade Federal de Ciências da Saúde de Porto Alegre (Brazil)*

Abstract. This study searched for sociodemographic influences on visual memory and visuoconstructive ability in healthy and clinical samples evaluated with Benton Visual Retention Test (BVRT) in two studies. In Study 1, we searched for changes related to age in children, adolescents, adults and elderly on the performance of the BVRT. In Study 2, we investigated the relations among age, years of education and intellectual quotient (IQ) on the performance of the BVRT using Structural Equation Modeling (SEM). Participants were 624 individuals aged between six and 89 years old ($M = 25.40$; $SD = 22.34$) from the normatization and evidence validity studies at Brazil. We used a sociodemographic questionnaire, BVRT and IQ measure was estimated. Study 1 has shown a performance similar to the developmental graphics with a U-inverted pattern in relation to age: An increase of the visual memory ability in the children and adolescent groups as age increases, a tendency of a decrease in the performance in the adult group that intensifies in the elderly group. Study 2 found that the model for the BVRT performance tested by SEM denoted satisfactory goodness-of-fit indexes, $\chi^2/gl = 2.67$, $p < .001$; CFI = .92; TLI = .93; RMSEA = .004, 90% CI = [.03, .05];WLSMV = 1.79, and corroborated the theoretical assumption. The SEM model confirmed in this study highlight the strong role of years of education in the prediction of BVRT scores.

Received 2 April 2019; Revised 21 June 2020; Accepted 23 June 2020

Keywords: Age, education, structural equation modeling, visual memory, visuo-constructive ability

The effects of age on neuropsychological development, especially memory, are widely studied in different age groups (for a review see Park & Festini, 2017). The execution of a task involving short-term memory of visual stimuli requires the integration of visual features and also the association of various other memory resources that vary according to age (Benton Sivan, 1992; Salles et al., 2016). In general, research indicates that children and the elderly seem to have more difficulty in short-term visual memory tasks compared to young adults, for example (Swanson, 2017).

In addition to age, it is known that other measures, such as intelligence quotient (IQ), is also related to some aspects of memory (e.g., Gray et al., 2017). To contribute to the interpretation of specific results of neuropsychological tasks and tests, IQ measures occupied for a time, prominent place in neuropsychological assessment (Crawford, 2012). However, some studies suggest a portion of shared variance between working memory and IQ measures (e.g. Chuderski, 2015), indicating that better results (above average) in cognitive tasks, such as intelligence tests, would be dependent on the ability to store the information for a short period, and also the ability to process it quickly (Jastrzębski et al., 2018).

Brazilian studies have pointed out the positive and significant ratio between the years studied and performance in different neuropsychological tasks (e.g., Leite et al., 2017). Among the cognitive abilities, it is understood that the ability to remember visual stimuli is related to socio-demographic and socio-cultural aspects

Correspondence concerning this article should be addressed to Joice Dickel Segabinazi. Pontifícia Universidade Católica do Rio Grande do Sul. Curso de Psicologia. Porto Alegre, Rio Grande do Sul (Brazil).

E-mail: jsegabinazi@gmail.com

Conflicts of Interest. None

This work was funded by Programa de Excelência Acadêmica (PROEX) from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

How to cite this article:
Segabinazi, J. D., Pawlowski, J., Zanini, A. M., Wagner, G. P., Sbicigo, J. B., Trentini, C. M., Hutz, C. S., de Salles, J. F., & Bandeira, D. R. (2020). Age, education and intellectual quotient influences: Structural equation modeling on the study of benton visual retention test (bvrt). *The Spanish Journal of Psychology, 23.* e27. Doi:10.1017/SJP.2020.30

(Ardila, 2018). This ability can be assessed by The Benton Visual Retention Test (BVRT), which measure visual memory and also evaluates visuoconstructive abilities through tasks that involves the copy of geometric figures of increasing complexity. Research on the role of the years of education in BVRT performance in Brazil, for example, lead to separated norms for the test considering this variable in children, adolescents and elderly (Salles et al., 2016), results also found in recent research with young adult and intermediaries (Lima, 2014).

Knowing that age, IQ and years of study influence the performance in neuropsychological tasks, we sought to assess the influence of these variables in visual memory and visuoconstructive abilities with BVRT measured in healthy and clinical samples evaluated. According to literature, o BVRT has been used internationally to detect and monitor neurodegenerative diseases, such as Alzheimer's disease and to provide a profile of visual memory and praxis skills in brain injury (Messinis et al., 2009), neurodevelopmental (i.e, ADHD) and psychiatric disorders (Venezia et al., 2018). In all cases, the clinical samples typically present poorest performance than controls. Thus, Study 1 aimed to demonstrate the age-related changes in the performance of children, adolescents, adults and elderly in BVRT. Study 2 investigated the relevance between age, IQ and years of education in the BVRT performance using a structural equation modeling (SEM), controlling the condition group (clinical vs. control). This analysis enables the testing of complex theoretical models and multiple relationships between variables, while most of the studies conducted so far used correlational methods and comparison groups to evaluate the independent effects of these variables (e.g., Lima, 2014; Souza et al., 2012). In addition to researches conducted with the BVRT in Brazilian samples (Salles et al., 2016; Segabinazi et al., 2013; Zanini et al., 2014) this study contributes to investigate the relationships between different variables on performance in visual memory and visuoconstructive abilities.

Method

Design, Participants and Procedures

The study had a quantitative, descriptive and cross-explanatory design. The convenience sample was composed by 624 individuals in a range from 6 to 89 years (M = 25.40, SD = 22.34) and 60% were female. The sample consisted of participants from different surveys (see Segabinazi et al., 2013), and included neurologically healthy people (78%). Exclusion criteria for the healthy group were: (a) Presence of neurological, psychiatric, or medical diseases, (b) lower IQ, (c) more than one failure in school, (d) presence of depressive symptoms, (e) use of benzodiazepines or ilicit psychoactive substances, (f) signs of cognitive impairment. Clinical groups were organized as follows: 58 children and adolescents diagnosed with Attention Deficit Disorder/Hyperactivity Disorder (ADHD) (Duarte Junior, 2012), 45 children diagnosed with anxiety disorder (AD) (Guarnieri, 2014), nine elders with possible Alzheimer's dementia diagnosis (Zanini et al., 2014), and 25 adults and elderly patients with left or right hemispheric stroke (Zortea et al., 2019). Thus, the study included participants from four age groups: Children (n = 256; 49.2% female), adolescents (n = 101; 67.8% female), adults (n = 131; 60% female) and elderly (n = 88; 75% female). Participants with classification below of the 10^{th} percentile in the WASI and in the Raven's Standard Progressive Matrices – General Scale (Campos, 2003), or below of the 25^{th} in the Raven's Coloured Progressive Matrices were excluded from the study. More information about inclusion and exclusion criteria are detailed in the original reports cited. Data collection was conducted individually and in a standardized way by undergraduate and postgraduate Psychology students trained previously. The training consisted of meetings for scoring discussion. Interrater reliability and Kappa coefficient were calculated, and the values found were excellent (Salles et al., 2016).

Typical children were recruited from public and private schools, while children with ADHD and anxiety were selected from a community care program at a hospital where they were diagnosed by a multidisciplinary team (psychiatrists, pedagogues, neuropsychologists, etc.). Elderly individuals with possible diagnosis of Alzheimer's disease were also selected for convenience. 68.75% lived in nursing homes and diagnosis was indicated by a physician (geriatrician, neurologist, or psychiatrist).

All participants were assessed in an appropriate environment in general classrooms or service. Typical children and adolescents were evaluated in schools, adults and elderly in a public university, children with ADHD and AD in public hospitals or schools, stroke patients at a public university or in appropriate rooms in their homes and elderly with possible Alzheimer's dementia in their homes or in geriatric homes.

An informed consent was obtained for all the participants. For children the consent was obtained from parents or guardians and for elderly people who lived in geriatric homes, consent was obtained from the institution responsible or family. The applications took between 15 to 60 minutes. Instruments not relevant to this study were also used during data collection and no interference effects were observed. The study is in accordance with the ethical standards for research in human beings, having previously been approved by the Research Ethics Committee of Universidade Federal do Rio Grande do Sul (PEC 069/2008).

Instruments

Sociocultural Questionnaire: Composed by questions regarding sex, age, years of education, socioeconomic status, health history, etc. The questionnaire was answered by the participants themselves in the group of adults and elderly and by parents or guardians in the group of children and adolescents.

Benton Visual Retention Test – BVRT (Benton Sivan, 1992; Salles et al., 2016, Segabinazi et al., 2013): combinations of Administration A (Form C) were used for evaluation of visual memory, and Administration C (Form D), to assess the visuoconstructive abilities. To better understand the results and following the rules proposed by the Brazilian Handbook BVRT (Salles et al., 2016): Administration A (Form C) was called Administration A (Memory) and Administration C (Form D) was called Administration C (Copy).While in Administration A (Memory) each stimulus are displayed for 10 seconds, in Administration C (Copy) there is no maximum time of exposure to the stimulus. Each form has 10 items, with the first two consisting of one geometric figure, and the other eight of two bigger figures and one smaller peripheral figure. The test was scored by trained psychologists who participated in the test standardization process in Brazil and followed the criteria of the test Brazilian Handbook (Salles et al., 2016). In the database, each stimulus (item) of the two forms has been identified with a score of 1 (item executed correctly) or 0 (item executed with at least one error in any of the six categories of error (Omissions, Distortions, Perseverations, Rotation, Position and Size Exchanges errors). In this study, the reliability (α) of Administration A (Memory) and Administration C (Form D) were .70 and form .72 respectively. The variable included in the model was a Rasch Score from Administration A (Memory) and Administration C (Copy) provided by previous studies (Segabinazi et al., 2014).

IQ Evaluation

Due to the fact that participants were from different age groups and from different surveys, the following tools for evaluating the IQ were used:

Raven's Coloured Progressive Matrices (Angelini et al., 1999): To evaluate the analogical reasoning. It was used in the evaluation of 260 children aged 6 to 11 years and 8 months. The instrument was standardized with a representative sample of Brazilian children (N = 1547) from the city of São Paulo, with ages varying from 5 to 11 ½ years, from public schools (municipal and state) and private schools. The sample was divided into 14 age groups, ranging from 4 years to 9 months and 11 years and 9 months, each range being amplitude of 6 months. The instrument is divided into three series A (the identity and apprehension change in continuous patterns), Ab (apprehension of distinguished figures with all spatially related) and B (apprehension of similar changes in spatially related figures and logically). In each series, it was requested that the child visualize an incomplete picture and identify among six alternatives, which one would adequately complement the design.

Raven's Standard Progressive Matrices – General Scale (Campos, 2003): The instrument has 60 problems divided into five groups (A to E) with 12 items each and was used in 178 adolescents and adults between 12 and 46 years. The problems have increasing difficulty and each series provides five times to understand the method and five progressive assessments of individual capacity for intellectual activity. Thus, the instrument evaluates the participant's ability to develop a systematic method of reasoning to solve the task.

Wechsler Abbreviated Scale of Intelligence Manual – WASI (The Psychological Corporation, 1999; Trentini et al., 2014): the WASI four subtests was used - Vocabulary, Block Design, Similarities and Matrix Reasoning. These four subtests comprised the Full Scale IQ and provide the Total IQ (IQT–4), measuring various aspects of intelligence such as verbal knowledge, processing and visual information, spatial reasoning, non-verbal and crystallized and fluid intelligence. The scale was answered by 111 adults and elderly in a range of 31–75 years.

IQ Estimation

Whereas the data obtained by the Raven Scales do not provide a measure of IQ, an estimation data was searched through a regression analysis having as dependent variables: age, years of education and the Raven score. Data used is these analysis was provided by a sample of 353 participants from the standardization research for WASI in Brazil (see Trentini et al., 2014 for more information) in which, both instruments, WASI and Raven were used (Special Scale or General Scale, depending on age) to seek evidence of validity of WASI. The age range of the validation sample was six to 84 years and no clinical individuals took part. No differences were found by education, but a difference by age (t = 2.50, p < .001) with small effect size (d = .15) between validation' sample and present sample.

Regressions searching to estimate IQ were performed for children and adults. In the children's model, age (β = –.56), education (β =.31) and Raven (β = .74) were significant predictors, explaining 58% of the WASI total variance. Collinearity indices were adequate, with tolerance ranging between .63 to .73 and VIF ranging between 1.47 to 1.53. The equation used to IQ estimation in children was: 62.307 + (Age*–.404) + (Education*.806) + (Raven*1.702). In the adult model, age (β = –.69), education (β = –.63) and Raven (β = 1.35) were significant

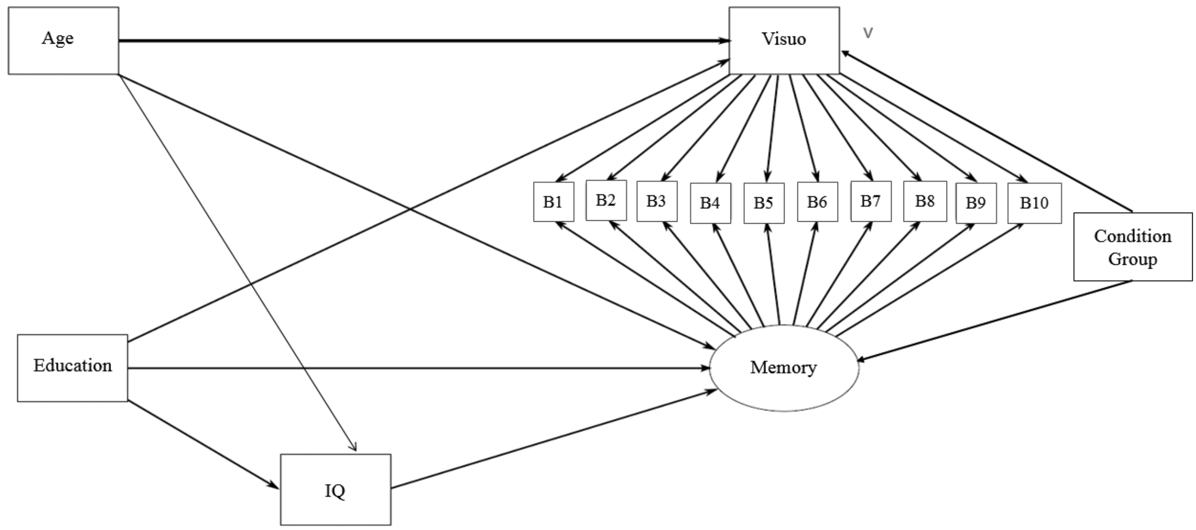

Figure 1. The theoretical model of structural equations with the variables age, years of study (Education),IQ, Visuoconstructive Skills (“Visuo”), and Memory.

predictors again, explaining 76% of the total variance. Collinearity indices also were adequate in this model, with tolerance ranging between .26 to .33 and VIF ranging between 3.02 to 3.82. The equation used to IQ estimation in adults was: 31.489 + (Age*.495) + (Education*–1.635) + (Raven*1.708). Thus, it was possible to predict the IQ scores of participants who had an only evaluation with Raven and that are included in this research. Throughout the text, this variable will be called IQ.

Data Analysis

Study 1

To meet the first objective, that is, to demonstrate the age-related changes in performance BVRT, the descriptive analysis (mean and standard deviation) of age, IQ, years of education and overall performance in BVRT through the Rasch score in Administration A (Memory) and Administration C (Copy), which henceforth will be called "Memory" and "visuoconstructive abilities" ("Visuo") for graphic adequacy purposes. We perform a one-way MANOVA and Games-Howell post hoc testing to compare performance in Rasch scores of the sample in both BVRT administrations, as well as in years of education and IQ. The independent variable was the age group: Children (6 to 12 years), adolescents (13–18 years), adults (19–59 years) and elderly (60–89 years). The effect sizes were calculated using eta-squared (η^2).

Study 2

To contemplate the second objective of the study, which is to investigate the relationship between age, IQ and years of education with the performance BVRT, controlling the condition group (clinical vs control), was tested through structural equation modeling (SEM) models by specifying the items Administration A (Memory) of BVRT (B1 to B10 variables in the graph) as explained by a double imaging scale and the visual memory visuoconstructive abilities of individuals. This variable was estimated from a Rasch analysis with the items from Administration C (copy) of BVRT held in another study (Segabinazi et al., 2014). It is, therefore, a latent variable, but that, having been previously estimated from an independent set of indicators, was inserted as an observable variable in the model (variable "Visuo"). Moreover, the age, years of education and IQ were included in the model as illustrated in Figure 1.

The estimation method chosen was the Weighted Least Squares Adjusted Means and Variances - WLSMV, suitable for measurement models with categorical variables (in this case, the right or wrong answers on each copy and memory item). The software used was the R (R Core Team, 2017), package lavaan (Rosseel, 2012), including group equality constraints with the argument “regressions”. After the investigation of the general theoretical model, considering the expected differences in the different stages of development represented in the overall sample we carried out a multi-group analysis. Whereas relations between model variables could vary according to the different age groups of the total sample (including healthy and clinical participants), we decided to divide the sample into four age groups, as previously mentioned. The fit of the models was evaluated through the following indicators: χ^2/df (chi-square ratio/degrees of freedom); Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and Root Mean Square Error of Approximation (RMSEA). Values of χ^2/df are adequate when less than 2. CFI and TLI above

https://doi.org/10.1017/sjp.2020.30 Published online by Cambridge University Press

Table 1. *Means and Standard Deviations for Years of Education, IQ and BVRT Scores by Age Groups*

	M (*SD*)					
Variables	Children (n = 256)	Adolescents (n = 149)	Adults (n = 131)	Elderly (n = 88)	*F*	η^2
Education	2.32 $(1.51)_{a,b,c}$	8.14 $(1.67)_{a,b,c}$	14.27 $(4.91)_{a,b,c}$	8.77 $(4.74)_{a,b,c}$	531.81**	.73
IQ	104.39 $(14.38)_{a}$	102.02 $(10.21)_{b}$	107.62 $(15.31)_{a,b,c}$	89.46 $(15.60)_{b,c}$	4296.09*	.11
BVRT						
Memory	0.29 $(1.47)_{a,b,c}$	1.47 $(1.39)_{a,b,c}$	1.54 $(2.07)_{a,c}$	−0.34 $(1.84)_{a,b,c}$	34.65**	.16
Visuo	2.47 $(1.37)_{a,b,c}$	3.12 $(0.97)_{a,b,c}$	3.04 $(1.21)_{a,c}$	2.71 $(1.50)_{b,c}$	10.55**	.05

Note. M(SD) = Mean (Standard Deviation); IQ = intellectual quotient; BVRT = Benton Visual Retention Test.
$_{a,\ b,\ c}$ = Same letters indicates significant differences with $p < .001$ between groups.
* $p < 0.05$; ** $p < .001$.

0.95 suggest excellent fit, while values above 0.90 indicate that the fit quality is satisfactory. RMSEA values less than .08 indicate acceptable fit (Hu & Bentler, 1999). We emphasized that to keep the confirmatory nature of the study, the modification indices of templates for each group were not analyzed, although the information could elucidate possible relationships not initially proposed in the model.

Results

The results of Studies 1 and 2 will be presented in the following separate sections.

Study 1

Table 1 presents the mean and standard deviation in IQ variables, age, years of education, the performances in scores of Rasch memory and Rasch copy of BVRT, and the Rasch score equivalent to a standardized score, with *M* = 0 and *DP* = 1 (for more information about the Rasch score was obtained, see Segabinazi et al., 2014). Significant differences were found among the four groups, $F(12, 1734) = 65.25$, $p < .001$; $\eta^2 = .31$. In the Table 1, the values of *F* and $\eta^2$of the MANOVA performed for each variable are described, as well as the results of the *post hoc* analyzes.

The Games-Howell *post hoc* tests corroborated the contrast among the four age groups, since all groups showed significant differences. For the years of education, the group of adolescents and the elderly were the only ones not to present significant differences. As for IQ, the children group showed no significant differences when compared with the group of adolescents and the elderly group. Comparison of scores on Memory and BVRT's Visuo indicated for both measures that groups of adolescents and adults do not differ significantly from each other, to score in Visuo children and elderly did not show significant differences.

Figures 2a and 2b represent the performance of BVRT found in the overall sample (including healthy and clinical) as a function of age. In Figure 2a, we note that an interesting pattern emerge when we plot the age-related data for both scores BVRT because it reflects the variation of visual memory performance ("Memory") with increasing age. It is observed that from 6 to 26 years there is an increase of visual memory ability, but you can see a decline after age 30, which increases after 66 years. Meanwhile, Figure 2b shows a different pattern to visuoconstructive abilities ("Visuo") in relation to age, expressed by a slight increase in the scores among groups of children and adolescents, maintenance of

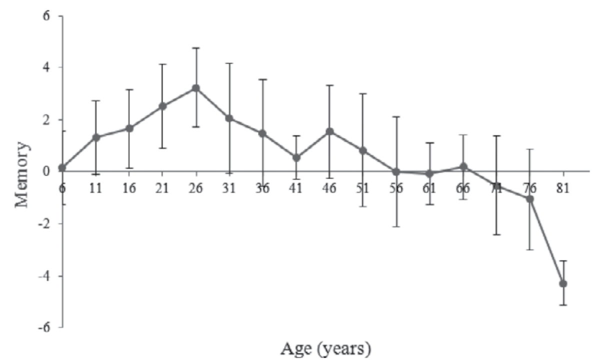

Figure 2a. BVRT Visual Memory Score (Memory) with standard deviation according to age.

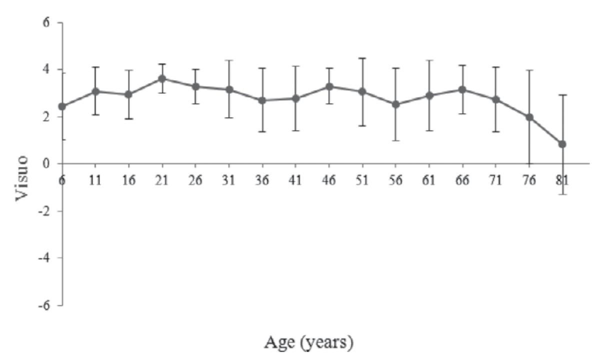

Figure 2b. BVRT Visuoconstructive Skills Score ("Visuo") with standard deviation according to age.

https://doi.org/10.1017/sjp.2020.30 Published online by Cambridge University Press

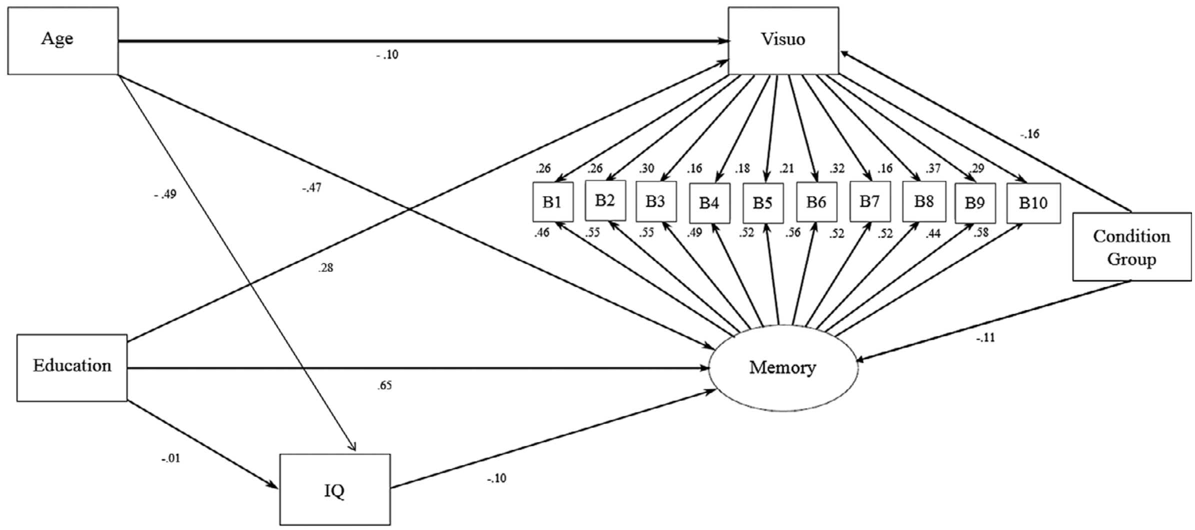

Figure 3. The general model of the relationships between the variables age, years of study, IQ,Visuoconstructive Skills ("Visuo"), and Memory.

performance in adolescents and adults and a decrease in the elderly people, especially after 66 years. We also built graphics excluding clinical population of this study, but significant changes were not observed between the two forms of analysis, only a small reduction in the values of standard deviations. Thus, it was decided to maintain the representation of the total sample in Figures 2a and 2b.

Study 2

Initially, intercorrelations between variables are presented in Table 2. In the total sample, memory was moderately correlated with IQ, while visuo was moderately correlated with memory. Memory and visuo were weakly related to age, education and condition group. The SEM was performed and sought to establish the relationship between age, IQ, years of education and performance in both BVRT administrations. The model showed a good fit to the data, $\chi^2(73) = 130.44$, $p < .001$; CFI = .92; TLI = .93; RMSEA, 90% CI = .04 [.03, .05], $p = .99$ (Figure 3). The values of standardized and non-standardized estimated parameters are presented in Table 3.

A graphic has been built to provide the performance on memory and visuoconstructive abilities (BVRT) in the overall sample (Figure 3), one can observe an increased contribution of years of education in determining the visual memory performance ($\beta = .65$) and visuoconstructive abilities ($\beta = .28$), with the model explained 50% of the variance ($R^2 = .50$). In addition, all relationships were significant ($p < .001$).

Discussion

With regard to BVRT scores, were found significant differences in memory for all groups except among adolescents and adults, and the performance of the latter group was the best of all, followed by adolescents, children and, lastly, the elderly group. The results highlight evidence based on relations to other variables for the BVRT, in this case the ability of BVRT to show developmental changes. The results are in accordance to other cross-sectional study that investigated similar visual memory resources (Murre et al., 2013), which highlighted an increase in visual memory skill with increasing age in the group of children and the group of adults and even a tendency in the adult group (after 20 years) a decrease in this performance that increases in the elderly group. Figures 2a and 2b of this study showed a performance trend similar to developmental charts that feature a U-inverted pattern as a function of age for both variables, memory and copy. However, this was mainly for memory, result that is in accordance with the findings of publications comparing test scores and visual memory tasks in different age groups (Dias et al., 2018). These results also confirm evidence of a decline in visuospatial abilities with increasing age in adults and in the elderly (Hale et al., 2011). It also reinforce the findings regarding the decline of certain cognitive abilities such as the ability to memorize visuospatial stimuli during adulthood, as opposed to the belief that it would begin only after 60 years (Salthouse, 2009). Still, there are several factors that interact in order to minimize possible damage in daily life, changing the trajectory of this relationship. Thus, factors such as motivation, persistence, personality characteristics of the individual and their ability to adapt and change your daily activities, and also the cognitive strategies developed over the years of life may offset some of these losses (Frankenmolen et al., 2017).

https://doi.org/10.1017/sjp.2020.30 Published online by Cambridge University Press

https://doi.org/10.1017/sjp.2020.30 Published online by Cambridge University Press

Table 2. *Intercorrelations between Age Years, Education, IQ, Memory and Visuo*

	M	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Age years	25.40	22.34	1	.49**	–.21**	–.15**	.04	–.03	–.24**	–.22**	–.05	–.13**	–.13**	–.02	.01	–.09*	.03	.06
2. Education	7.13	5.33		1	.25**	.38**	.33**	.26**	.03	.04	.23**	.20**	.17**	.24**	.25**	.18**	.27**	–.23**
3. IQ	103.17	14.49			1	.43**	.22**	.31**	.17**	.13**	.22**	.24**	.24**	.17**	.21**	.24**	.22**	.06
4. Memory Total	.75	1.80				1	.52**	.49**	.42**	.39**	.55**	.57**	.56**	.53**	.57**	.52**	.46**	–.29**
5. B1[a]	.65	.47					1	.31**	.11**	.11**	.22**	.19**	.16**	.20**	.23**	.16**	.31**	–.27**
6. B2[a]	.82	.39						1	.19**	.13**	.21**	.23**	.15**	.16**	.17**	.16**	.32**	–.19**
7. B3[a]	.93	.26							1	.33**	.17**	.22**	.13**	.20**	.12**	.07	.28**	–.13**
8. B4[a]	.91	.29								1	.18**	.16**	.11**	.16**	.13**	.05	.18**	–.18**
9. B5[a]	.56	.50									1	.25**	.21**	.24**	.18**	.17**	.22**	–.10*
10. B6[a]	.57	.50										1	.24**	.22**	.27**	.21**	.23**	–.18**
11. B7[a]	.31	.46											1	.16**	.29**	.35**	.24**	–.13**
12. B8[a]	.61	.49												1	.26**	.16**	.21**	–.12**
13. B9[a]	.41	.49													1	.25**	.31**	–.17**
14. B10[a]	.18	.39														1	.18**	–.04
15. Visuo Total	2.78	1.30															1	–.23**
16. Condition Group[a]	.26	.44																1

Note. B1 to B10 = Observable variables of the SEM model.

[a] = point-biserial correlation.

** $p < .001$.

Table 3. *Values of Non-Standardized and Standardized Estimated Parameters of SEM Model*

Variables	Non-Standardized Coefficients	*SE*	*p*	Standardized Coefficients
Latent Variables				
Memory				
V1	1.000		.492	
V2	1.225	.236	.001	.545
V3	1.261	.258	.001	.555
V4	1.075	.241	.001	.493
V5	1.150	.202	.001	.521
V6	1.264	.228	.001	.563
V7	1.167	.212	.001	.519
V8	1.143	.202	.001	.519
V9	.959	.180	.001	.435
V10	1.323	.267	.001	.579
Regressions				
V1 ~Visuo	.212	.042	.001	.255
V2 ~Visuo	.221	.043	.001	.259
V3 ~Visuo	.261	.046	.000	.302
V4 ~Visuo	.135	046	.003	.163
V5 ~Visuo	.154	.042	.001	.184
V6 ~Visuo	.181	.044	.001	.212
V7 ~Visuo	.277	.047	.001	.323
V8 ~Visuo	.137	.041	.001	.164
V9 ~Visuo	.307	.043	.001	.366
V10 ~Visuo	.251	.056	.001	.288
Visuo ~ Age	–.005	.002	.015	–.095
Visuo ~ Education	.006	.012	.001	.275
Memory ~ Age	–.010	.002	.001	–.472
Memory ~ Education	.058	.010	.001	.649
Memory ~ IQ	–.000	.000	.093	–.093
IQ ~ Age	4.906	.441	.001	.492
IQ ~ Education	–0.460	1.591	.773	–.011
Visuo ~ Condition group	–.475	.108	.001	–.161
Memory ~ Condition group	.118	.053	.025	–.105

The results of analysis using SEM to determine the performance BVRT corroborated earlier studies on the influence of variables such as age and years of education in Brazilian samples and had used less robust statistical analyzes (Lima, 2014; Salles et al., 2016). Even though the analysis using SEM enabled to test multiple relationships in a sample with different age groups, the design of this research is cross-sectional study. So, as much as the results appear to enrich the understanding of the developmental aspect of the visual and visuoconstructive memory abilities, these are differences of age and no age-related changes, like a longitudinal study can show (Sliwinski & Buschke, 1999). Regarding the adjustment of the model, it was well-adjusted and explaining 50% of the variance of visual memory.

The model shown a negative and significant contribution of age to the performance of administrations A and C of BVRT, a finding that is in accordance with results and discussion already presented above and also with other work that proposed a structural model to explain the performance in neuropsychological tests considering this variable (Murre et al., 2013) and other research that investigated aspects of visual memory (Dias et al., 2018). The variable years of education have demonstrated a greater contribution to the performance of BVRT, which is a positive and significant contribution, what agrees to the studies reviewed that emphasize the role of years of education for the best performance neuropsychological tests (eg., Sierra Sanjurjo et al., 2018).

The results of the analyses of differences between groups and the SEM model were consistent with the hypothesis of the age contribution and the magnitude of the relationship of this variable in visual memory and visuoconstructive abilities. Specifically, the SEM model highlighted a strong role of the years of education on visual memory. On the other side, IQ was not related to education or memory. Possibly, in a sample with clinical

https://doi.org/10.1017/sjp.2020.30 Published online by Cambridge University Press

and healthy participants, the relation between IQ and education and, consequently, their relations with visual memory can be different from theoric expectancy, likes in this study, since clinical participants tended to present a minor level of education compared to the healthy.

Is also important to consider the limitations concerning the sample size, instruments used and the fact that the results are applicable to Brazilian subjects only. Besides this fact, and together with the results of other studies that have used cross-sectional and longitudinal design to evaluate the effects of aging on cognition suggest that the cognitive decline associated with age begins relatively early in adulthood (e.g., Swanson, 2017, Figure 1). However, it is important to note that not all cognitive functioning aspects have related declines with age, especially when considering measures based on accumulated knowledge, such as performance on vocabulary or general information tests. A potential limitation of this study was not including other sociocultural variables, besides years of study. Aspects such as socioeconomic status have been shown to be associated with a series of cognitive measures (Ardila, 2018). It is proposed that future research on the role of age, address multivariate relationships in longitudinal studies and consider sociocultural variables.

References

Angelini, A. L., Alves, I. C. B., Custódio, E. M., Duarte, W. F., & Duarte, J. L. M. (1999). *Matrizes Progressivas Coloridas de Raven: Escala especial. Manual* [Raven's Coloured Progressive Matrices: Special scale. Manual]. CETEPP.

Ardila, A. (2018). *Historical development of human cognition: A cultural-historical neuropsychological perspective* (3rd Ed.). Springer.

Benton Sivan, A. (1992). *Benton Visual Retention Test. Manual* (5th Ed.). The Psychological Corporation.

Campos, F. (2003). *Teste das Matrizes Progressivas. Escala geral, Séries A, B, C, D e E* [Test of Progressive Matrices. General scale, Series A, B, C, D e E]. CEPA.

Chuderski, A. (2015). The broad factor of working memory is virtually isomorphic to fluid intelligence tested under time pressure. *Personality and Individual Differences*, *85*, 98–104. http://doi.org/10.1016/j.paid.2015.04.046

Crawford, J. R. (2012). Psychometric foundations of neuropsychological assessment. In L. H. Goldstein & J. E. MacNeil (Eds.), *Clinical neuropsychology: A practical guide to assessment and management for clinicians* (pp. 129–158). Wiley.

Dias, B. F., Rezende, L. O., Malloy-Diniz, L. F., & de Paula, J. J. (2018). Relationship between visuospatial episodic memory, processing speed and executive function: Are they stable over a lifespan? *Arquivos de Neuro-Psiquiatria*, *76*(2), 89–92. http://doi.org/10.1590/0004-282x20170186

Duarte Junior, S. (2012). *Desempenho no Teste de Retenção Visual de Benton entre crianças com e semdiagnóstico de Transtorno de Déficit de Atenção/Hiperatividade* [Performance in the Visual Retention Test of Benton among children with and without diagnosis of Attention Deficit / Hyperactivity Disorder]). (Unpublished manuscript). Instituto de Psicologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil.

Frankenmolen, N. L., Overdorp, E. J., Fasotti, L., Claassen, J. A. H. R., Kessels, R. P. C., & Oosterman, J. M. (2017). Memory strategy use in older adults with subjective memory complaints. *Aging Clinical and Experimental Research*, *29*, 1061–1065. http://doi.org/10.1007/s40520-016-0635-1

Gray, S., Green, S., Alt, M., Hogan, T., Kuo, T., Brinkley, S., & Cowan, N. (2017). The structure of working memory in young children and its relation to intelligence. *Journal of Memory and Language*, *92*, 183–201. http://doi.org/10.1016/j.jml.2016.06.004

Guarnieri, C. (2014). *Teste de Retenção Visual de Benton: Validade relacionada a critério e padrões de convergência em crianças com Transtorno de Ansiedade* [Benton Visual Retention Test: Validity related to criteria and convergence patterns in children with anxiety disorders]. (Unpublished manuscript). Instituto de Psicologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil.

Hale, S., Rose, N. S., Myerson, J., Strube, M. J., Sommers, M., Tye-Murray, N., & Speha, B. (2011). The structure of working memory abilities across the adult life span. *Psychology and Aging*, *26*(1), 92–110. http://doi.org/10.1037/a0021483

Hu, L.-t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Jastrzębski, J., Ciechanowska, I., & Chuderski, A. (2018). The strong link between fluid intelligence and working memory cannot be explained away by strategy use. *Intelligence*, *66*, 44–53. http://doi.org/10.1016/j.intell.2017.11.002

Leite, K. S. B., Miotto, E. C., Nitrini, R., &Yassuda, M. S. (2017). Boston Naming Test (BNT) original, Brazilian adapted version and short forms: Normative data for illiterate and low-educated older adults. *International Psychogeriatrics*, *29*(5), 825–833. http://doi.org/10.1017/S1041610216001952

Lima, M. (2014). *Ainfluência da escolaridade no desempenho no Teste de Retenção Visual de Benton em adultos* [The influence of schooling on performance in the Benton Visual Retention Test in adult] (Unpublished manuscript). Instituto de Psicologia, Universidade Federal do Rio Grande do Sul.

Messinis, L., Lyros, E., Georgiou, V., & Papathanasopoulos, P. (2009). Benton Visual Retention Test Performance in normal adults and acute stroke patients: Demographic considerations, discriminant validity, and test–retest reliability. *The Clinical Neuropsychologist*, *23*(6), 962–977. http://doi.org/10.1080/13854040902740691

Murre, J. M. J., Janssen, S. M. J., Rouw, R., & Meeter, M. (2013). The rise and fall of immediate and delayed memory for verbal and visuospatial information from late childhood to late adulthood. *Acta Psychologica*, *142*(1), 96–107. http://doi.org/10.1016/j.actpsy.2012.10.005

Park, D. C., & Festini, S. B. (2017). Theories of memory and aging: A look at the past and a glimpse of the future. *The Journals of Gerontology: Series B*, *72*(1), 82–90. http://doi.org/10.1093/geronb/gbw066

R Core Team (2017) R: A language and environment for statistical computing. https://www.R-project.org/

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. http://doi.org/10.18637/jss.v048.i02.

Salles, J. F., Bandeira, D. R., Trentini, C. M., Segabinazi, J. D., & Hutz, C. S. (2016). *Manual do Teste de Retenção Visual de Benton: Manual professional* [Manual of Benton Visual Retention Test: Professional manual]. Vetor.

Salthouse, T. A. (2009). When does age-related cognitive decline begin? *Neurobiology of Aging*, *30*(4), 507–514. http://doi.org/10.1016/j.neurobiolaging.2008.09.023

Sierra Sanjurjo, N. S., Saraniti, A. B., Gleichgerrcht, E., Roca, M., Manes, F., & Teresa, T. (2018). The IFS (INECO Frontal Screening) and level of education: Normative data. *Applied Neuropsychology: Adult*, *26*, 1–9. http://doi.org/10.1080/23279095.2018.1427096

Segabinazi, J. D., Junior, S. D., de Salles, J. F., Bandeira, D. R., Trentini, C. M., & Hutz, C. S. (2013). Teste de Retenção Visual de Benton: Apresentação do manual brasileiro [Benton Visual Retention Test: Presentation of the Brazilian manual]. *Avaliação Psicológica*, *12*(3), 421–428.

Segabinazi, J. D., Yates, D. B., Salles, J. F., Trentini, C. M., Hutz, C. S., & Bandeira, D. R. (2014). *Aplicação do Modelo de Rasch na avaliação das propriedades psicométricas do Teste de Retenção Visual de Benton* [Application of Rasch Model in the evaluation of the Psychometric properties of the Benton Visual Retention Test]. Instituto de Psicologia, Universidade Federal do Rio Grande do Sul.

Sliwinski, M., & Buschke, H. (1999). Cross-sectional and longitudinal relationships among age, cognition, and processing speed. *Psychology and Aging*, *14*(1), 18–33. http://doi.org/10.1037/0882-7974.14.1.18

Souza, T. L., Segabinazi, J. D., & Bandeira, D. R. (2012, October). *Explorando modelos explicativos do desempenho de crianças e adolescentes no Teste de Retenção Visual de Benton (BVRT)* [Exploring explanatory models of child and adolescent performance in the Benton Visual Retention Test (BVRT)]. Poster presented at XXIV Salão de Iniciação Científica da UFRGS, Porto Alegre, Brasil. https://lume.ufrgs.br/handle/10183/65324

Swanson, H. L. (2017). Verbal and visual-spatial working memory: What develops over a life span? *Developmental Psychology*, *53*(5), 971–995. http://doi.org/10.1037/dev0000291

The Psychological Corporation (1999). *Wechsler Abbreviated Scale of Intelligence manual.* APA.

Trentini, C. M., Yates, D. B., & Heck, V. S. (2014). *Escala de Inteligência Wechsler Abreviada (WASI)*: *Manual professional* [Abbreviated Wechsler Intelligence Scale (WASI): Manual professional]. Pearson.

Venezia, R. G., Gorlyn, M., Burke, A. K., Oquendo, M. A., Mann, J. J., & Keilp, J. G. (2018). The impact of cognitive reserve on neurocognitive performance in major depressive disorder. *Psychiatry Research*, *270*, 211–218. https://doi.org/10.1016/j.psychres.2018.09.031

Zanini, A. M., Wagner, G. P., Zortea, M., Segabinazi, J. D., Salles, J. F., Bandeira, D. R., &Trentini, C. M. (2014). Evidence of criterion validity for the Benton Visual Retention Test: Comparison between older adults with and without a possible diagnosis of Alzheimer's disease. *Psychology and Neuroscience*, *7*(2), 131–138. http://doi.org/10.3922/j.psns.2014.006

Zortea, M., de Jou, G. I., & de Salles, J. F. (2019). Memory monitoring and memory control in chronic stroke patients Dissociated processes. *Dementia & neuropsychologia*, *13*(1), 44–52. https://doi.org/10.1590/1980-57642018dn13-010005