AGEING AND EXECUTIVE FUNCTIONS: THE SPECIFIC ROLE OF INHIBITION

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1.1. Abstract

One of the most widely studied hypotheses for cognitive ageing assumes that age-related effects can be explained by a less efficient operation of the executive functions and particularly inhibition. According to this hypothesis executive functions are more susceptible to ageing or are the first to be deteriorated with ageing. The present study examined the neuropsychological profile of young adults and older adults in order to understand whether there is a general deficit in executive functions or any changes in cognition (attention, memory and language abilities) that could contribute to a better understanding of the ageing process. Older adults (N=20; *M*=63.45, *SD*=6.21 years old) and young adults (N=20; *M*=18.95, *SD*=1.79 years old) participated in the present study. These age groups were matched by gender and estimated intelligence quotient. Participants were assessed with a comprehensive neuropsychological test battery (including attention, memory, language and executive function measures). Our results indicated that older adults, comparatively to young adults, present: (i) cognitive slowing; (ii) preserved retention and recognition abilities; (iii) preserved naming and comprehension abilities; (iv) preserved selective and divided attention (iv) preserved abstraction and planning; (v) inhibition deficits. Older adults have a greater number of inaccurate responses and require more time to respond accurately than younger adults. However, in some cases, they have a similar or even increased performance than young adults in the neuropsychology tests included in our battery (e.g., the Tower test). This suggest that even some executive functions can be resistant to ageing effects.

Keywords: Cognitive Ageing; Executive Functions; Inhibition; Neuropsychology Assessment.

1.2. Introduction

Among cognitive changes that occur with ageing, executive deficits are predominant (West, 2000) and are an important mediator of the effects of ageing on other cognitive functions (Salthouse, 2003). One of the most influential hypotheses to explain cognitive ageing is the *frontal hypothesis of cognitive ageing* (West, 1996), which proposes that ageing affects more the prefrontal cortex (e.g., reduction of its general volume and synaptic density) than other brain regions (Hedden & Gabrieli, 2004). So, cognitive functions whose anatomic substrate is related to the frontal lobes, and specifically to the prefrontal cortex, are more susceptible to ageing effects than functions related to other brain areas (Andres, Guerrini, Phillips, & Perfect, 2008; Hull, Martin, Beier, Lane, & Hamilton, 2008). In accordance to this hypothesis, cross-sectional and longitudinal studies have found an early and more pronounced decline with normal ageing in executive functions (Albert, Lopez-Martin, Hinojosa, & Carretie, 2013; Linden, 2000, Belleville, Rouleau, & Van der Linden, 2006; Crawford, Bryan, Luszcz, Obonsawin, & Stewart, 2000; Royall, Palmer, Chiodo, & Polk, 2004). In the study of ageing effects on executive functions, it has been emphasized that there is a decline on inhibition processes. Hasher and Zacks' (1988) inhibitory deficit theory not only recognizes the existence of these deficits in inhibition but suggest that these deficits are key mechanisms to several age-related changes (e.g., greater distractibility, greater forgetfulness due to a poor codification of the information to be memorized). Although some studies have found an inhibition deficit (Falkenstein, Hoormann, & Hohnsbein, 2002; Fisk & Sharp, 2004; West & Alain, 2000) and a deficit in other executive functions (Allain et al., 2005; Baudouin, Clarys, Vanneste, & Isingrini, 2009; Lee et al., 2012; Salthouse, Atkinson, & Berish, 2003), the executive deficits are not general and the pattern and course of these age-related changes is still not well defined (Raz, Williamson, Gunning-Dixon, Head, & Acker, 2000; & Isingrini, 2004). The present study aimed to compare the neuropsychological profile of young adults and older adults to examine age-related changes not only in executive functions but also in non-executive cognitive domains comprising attention, language, memory and processing speed. We hypothesized for a specific rather than a general cognitive decline. Specifically, we expect older adults will performance as good as young adults in several cognitive measures, including the ones pertaining to executive functions (Collette & Salmon, 2014). We also expect that inhibition deficits and a reduced processing speed can account for the majority of the age-related differences that we expect to find.

1.3. Methods

1.3.1. Sample

Forty volunteers aged 18-74 participated in this study. A group of young adults (N=20, *M*=18.95, *SD*=1.75 years old) and a group of older adults (N=20, *M*=63.45, *SD*=6.11 years old). An initial interview was administered to all participants to exclude participants with a prior history of neurological or psychiatric illness or/and that were currently taking medications that could interfere with the normal functioning of the central nervous system (e.g., anxiolytics). The Addenbrooke Cognitive Examination - Revised (ACE-R; Hodge & Mioshi, 2005; Firmino, Simões, Pinho, Cerejeira, & Martins, 2008) was administered to exclude participants with general cognitive decline, based on adjusted norms for age and years of education. To estimate the intelligence quotient (IQ), an Irregular Words Reading Test (TELPI; Alves, Simões & Martins, 2012) was used, a Portuguese test similar to the National Adult Reading Test (NART; Nelson 1982). Finally, the presence and severity of depressive symptomatology was assessed with two different tests according to participants' age group: the 30-item Geriatric Depression Scale (Yesavage et al., 1982; Barreto, Leuschner, Santos, & Sobral, 2003) was administered to older adults and the Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996) was administered to young adults. Participants who had a moderate or severe significant depressive symptomatology were excluded. Young adults and older adults were matched for gender (16 women and 4 men in each group) and the IQ [$F(1, 38) < 1$, ns] (see Table 1). The two age groups presented a similar general cognitive capacity [$F(1, 38)=3.875$, $p=.056$], without cognitive decline, and did not present significant depressive symptoms. Regarding functional capacity, although statistically significant differences were observed in the percentage of functional incapacity in the two age groups [$F(1, 38)=20.172$, $p<.01$] (with older adults presenting more functional incapacity than young adults), the analysis of functional incapacity results allowed to conclude that older adults did not present a significant percentage of functional incapacity (<1%).

Table 1. Sample characterization, including gender, estimated intelligence quotient, general cognitive state and the presence and severity of depressive symptomatology. Significant differences are highlighted in bold

Variables	*Young Adults (N=20; 4 male)*		*Older Adults (N=20; 4 male)*		*Differences*	
	M	*SD*	*M*	*SD*	*F*	*p*
TeLPI	118.43	1.909	117.45	3.419	.432	.515
ACE-R	95.85	2.455	94.10	3.127	3.875	.056
IAFAI (% Incapacity)	**.000**	**.000**	**.814**	**.811**	**20.172**	**.000**
BDI-II/GDS-30	5.40	6.581	5.55	3.886		

Note: TelPI=Irregular Words Reading Test; ACE-R=Addenbrooke's Cognitive Examination Revised; IAFAI= Adults and Older Adults Functional Assessment Inventory; BDI-II=Beck Depression Inventory II; GDS-30=Geriatric Depression Scale-30 items.

1.3.2. Materials and Procedure

The neuropsychological tests used in this study were selected in order to assess different functions, such as memory, attention, language or executive functions (see Table 2). For a brief description of each neuropsychological test please see Table A in the Appendix section.

Table 2. Neuropsychological measures and their corresponding assessment domains

Neuropsychological Measures	*Assessment Domains*
Addenbroke's Cognitive Examination Revised (ACE-R; Hodge & Mioshi, 2005; Firmino, Simões, Pinho, Cerejeira, & Martins, 2008).	Cognitive screening
Geriatric Depression Scale 30-items (GDS-30; Yesavage et al., 1982; Barreto, Leuschner, Santos, & Sobral, 2003) / Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996)	Measurement of the level of depressive symptomatology
Irregular Words Reading Test (TELPI; Alves, Simões & Martins, 2012)	IQ estimation
Adults and Older Adults Functional Assessment Inventory (IAFAI; Sousa, Simões, Pires, Vilar, & Freitas, 2008)	Measurement of the level of Functional Incapacity
Coding (WAIS-III; Wechsler, 1997a)	Processing Speed
Word List (WMS-III, Wechsler, 1997b)	Episodic Memory
Verbal Fluency – Phonemic, Semantic and Shifting Fluency (D-KEFS; Delis, Kaplan & Kramer, 2001)	Semantic Memory; Initiation and Cognitive Flexibility
Confrontation Naming (PAL 09; Caplan & Bub, 1990; Portuguese version, PAL-PORT, Festas, Martins, & Leitão, 2007).	Naming
Sentence Comprehension (PAL 09; Caplan & Bub, 1990; Portuguese version, PAL-PORT, Festas, Martins, & Leitão, 2007)	Verbal Comprehension
Telephone Search and Dual Task Telephone Search subtests (TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996)	Selective and Divided Attention
Block Suppression Test (BST; Beblo, Macek, Brinkers, Hartje, & Klaver, 2004) / Digit Suppression Test (DST; Beblo et al., 2004)	Spatial and Verbal Working Memory
Stroop (Stroop, 1935; Castro, Martins & Cunha, 2003)	Inhibition
Tower test (D-KEFS; Delis, Kaplan & Kramer, 2001)	Planning
Similarities (WAIS-III; Wechsler, 1997a)	Abstraction

Young and older adults provided written informed consent to participate in the study and assessment was made in two neuropsychological sessions. In order to avoid fatigue, two sessions of about 1 hour were planned. The two assessment sessions took place on different days, although separated by a maximum of three days. Since we were interested in stablishing a neuropsychological profile with tests spread across two assessment sessions, it is important to reduce the time between the two sessions in order to assure comparability between the mental and emotional state of the participants across the two testing sessions. The 1st testing session began with cognitive screening followed by the assessment of phonemic, semantic and shifting verbal fluency. Then, immediate and short-term episodic memory tests were performed followed by a 20-minute interval filled by the functional capacity and depressive symptomatology questionnaires, and by the gathering of both demographic and clinical information with the structured interview. At the end of this interval, a long-term memory and recognition tests were administered. This session ended with the administration of the processing speed and with IQ estimation measures. Most of the executive function measures were included in the 2nd testing day, with exception for the verbal fluency tests. This session included Confrontation Naming, Sentence Comprehension, Telephone Search and Dual Task Telephone Search, Block Suppression Test, Digit Suppression Test, Stroop test, Tower test and Similarities. All the tests were administered in a counterbalanced order in order to avoid influence of fatigue in the tests' performance. The young adults were assessed in the Laboratory of Memory, Language and Executive Functions (LMLFE; Faculty of Psychology and Educational Sciences of the University of Coimbra). Older adults were assessed in Aposenior (a university of the third age, where they were attending classes regularly), which provided a quiet and appropriate environment for neuropsychological assessments.

Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS version 20.0, SPSS Inc., Chicago, IL). To compare the performances between the age groups using one-way analysis of variance (ANOVA). Pearson correlation coefficients were used to analyse the degree of association between several measures and/or performance indicators.

1.4. Results

1.4.1. Analysis of older adults and young adults' neuropsychological performance

Older and young adults' neuropsychological profiles were compared in order to determine any age-related changes. The results are presented in Table 3.

Table 3. Differences between the two age groups in the neuropsychological assessment tests. Significant differences are highlighted in bold.

Neuropsychological tests		*Young Adults (N=20)*		*Older Adults (N=20)*		*Differences*	
		M	*SD*	*M*	*SD*	*F*	*p*
Word List	**Immediate Recall**	**38.15**	**3.392**	**34.35**	**4.705**	**8.586**	**.006**
	Short Term Recall	**10.30**	**1.658**	**9.00**	**1.556**	**6.510**	**.015**
	Long Term Recall	**10.15**	**1.725**	**9.00**	**1.622**	**4.715**	**.036**
	Retention	88.66	13.844	84.88	14.508	2.287	.139
	Recognition	23.75	.444	23.50	.716	1.610	.312
Verbal Fluency	Phonemic Fluency	36.85	11.811	39.75	12.268	.580	.451
	Semantic Fluency	57.25	10.203	57.05	11.763	.003	.954
	Shifting Fluency (%)	97.90	4.686	98.54	5.258	.165	.687
Confrontation Naming		33.60	2.458	35.35	4.051	2.425	0.128
Sentence Comprehension		53.90	2.409	53.65	2.305	1.303	0.261
Similarities		22.35	3.689	22.15	3.329	.032	0.858
Working Memory (WM)	Visual WM	9.90	3.886	8.95	2.982	.757	0.390
	Verbal WM	9.95	4.110	10.60	3.775	.271	0.605
Coding		**91.95**	**12.742**	**63.20**	**13.501**	**47.967**	**.000**
Stroop	**Total score**	**103.55**	**9.290**	**88.15**	**18.120**	**11.110**	**.002**
	Time	**110.05**	**12.174**	**118.25**	**5.656**	**7.518**	**.009**
Telephone Search	Total score	19.15	1.089	18.50	1.968	1.680	.203
	Time	**53.45**	**12.812**	**69.05**	**16.113**	**8.729**	**.005**
Dual Task Telephone Search	Total score	17.95	1.820	16.40	3.485	3.108	.086
	Time	**59.05**	**16.256**	**71.55**	**19.514**	**4.845**	**.034**
Divided Attention		5.68	5,987	5.739	3.313	.002	.969
Tower	Achievement Score	17.40	3.733	17.40	3.545	.000	1.000
	Nº Movements	**105.05**	**21.680**	**69.70**	**33.288**	**15.836**	**.000**
	Nº of violations	**.15**	**.366**	**1.65**	**1.694**	**14.974**	**.000**
	Movements Accuracy	**1.45**	**.258**	**1.263**	**0.218**	**6.117**	**.018**
	Time per Movement	**3.857**	**.932**	**5.139**	**1.4149**	**11.455**	**.002**

Performance of older adults was similar to young adults sample performance in fourteen of the twenty six neuropsychological measures comprising memory, executive function, language and attention measures. Specifically, no differences were found in long-term retention percentage [$F(1, 38)=2.287$, $p=.139$]; long-term recognition [$F(1, 38)=1.610$, $p=.312$]; Phonemic Verbal Fluency [$F(1, 38) < 1$, *ns*]; Semantic Verbal Fluency [$F(1, 38) < 1$, *ns*]; Shifting Fluency [$F(1, 38) < 1$, *ns*]; Confrontation Naming [$F(1, 38)=2.425$, $p=.128$]; Sentence Comprehension [$F(1, 38)=1.303$, $p=.261$]; Similarities [$F(1, 38) < 1$, *ns*]; Digit Suppression test [$F(1, 38) < 1$, *ns*]; Block Suppression test [$F(1, 38) < 1$, *ns*]; Telephone Search total score [$F(1, 38)=1.680$, $p=.203$]; Dual Task Telephone Search total score [$F(1, 38)=3.108$, $p=.086$]; the achievement score in the Tower test [$F(1, 38) < 1$, *ns*]; and in the divided attention measure [$F(1, 38) < 1$, *ns*].

Performance of older adults was inferior to young adults in twelve of the twenty six neuropsychological measures comprising the assessment of memory, executive function, attention and processing speed. In detail, older adults' performance was worst in the following measures: number of words recalled in the immediate recall [$F(1, 38)=8.586$, $p=.006$], short-term recall [$F(1, 38)=6.510$, $p=.015$] and long-term recall [$F(1, 38)=4.715$, $p=.036$]; Coding [$F(1, 38)=47.967$, $p <.01$]; Stroop total score [$F(1, 38)=11.110$, $p=.002$] and time required to complete the test [$F(1 , 38)=7.518$, $p=.009$]; time required to complete the Telephone Search [$F(1, 38)=8.729$, $p=.005$] and the Dual Task Telephone Search [$F(1, 38)=4.845$, $p=.034$]; number of violations in the Tower test [$F(1, 38)=14.974$, $p<.01$] and time needed per movement [$F(1, 38)=11.455$, $p=.002$].

Performance of older adults was superior to young adults in two measures of the Tower test: total number of movements [$F(1, 38)=15.836$, $p<.01$], with older adults following the instructions of using as less movements as possible, and movements' accuracy [$F(1, 38)=6.117$, $p=.018$], with better accuracy of older adults.

1.4.2. Influence of age in the neuropsychological assessment tests' performance: processing speed and inhibition as possible mediators

In order to better understand the results obtained, and particularly the age-related effects, Pearson correlation coefficients were computed between age and the twelve neuropsychological measures, where age-related differences were found. The results are shown in Table 4 (For a complete description of the correlations found between all the neuropsychological tests and also their correlation with age, see Table B in Appendix section)

Table 4. Pearson correlation coefficients between age and neuropsychological tests in which there were age-related differences (N=40)

Neuropsychological Measures	*Age*	
	R	r^2
Word List - Immediate Recall	-.470**	.220
Word List - Short Term Recall	-.454**	.206
Word List - Long Term Recall	-.394*	.155
Coding	-.790**	.624
Stroop – Total score	-.539**	.290
Stroop – Time	-.421*	.177
Telephone Search – Time	.481**	.231
Dual Task Telephone Search – Time	.353*	.124
Tower – Nº Violations	.550**	.303
Tower – Nº Movements	-.544**	.296
Tower – Time per Movement	.474**	.225
Tower – Movements Accuracy	-.334*	.112

*p<.05; ** p<.01

All correlations were statistically significant but eight were moderately correlated and four were strongly correlated (Cohen, 1988). There was a strong and negative correlation between age and three neuropsychological measures: Coding test [$r(38)= -.790$, $p<.01$]; number of movements in the Tower test [$r(38)= -.544$, $p<.01$]; and the total score on the Stroop test [$r(38)= -.539$, $p<.01$]. There was also a strong but positive correlation between age and the number of violations in the Tower test [$r(38)= .550$, $p<.01$] There were moderate and negative correlations between age and five neuropsychological measures: number of words recalled on Immediate Recall [$r(38)= -.470$, $p<.01$], Short Term Recall [$r(38)= -.454$, $p<.01$] and Long Term Recall [$r(38)= -.394$, $p<.05$]; time needed to complete the Stroop test [$r(38)= -.421$, $p<.05$]; and movements accuracy in the Tower test [$r(38)= -.334$, $p<.05$]. There were also moderate but now positive correlations between age and three neuropsychological measures: the time needed to complete the Telephone Search test [$r(38)= .481$, $p<.01$] and the Dual Task Telephone Search test [$r(38)= .353$, $p<.05$]; and the time per movement in the Tower test [$r(38)= .474$, $p<.01$].

Considering the significant correlation coefficients found, partial correlation coefficients were also computed while controlling for performance in the total score in the Coding test (see Table 5) and later for the total score in the Stroop test (see Table 6). These two tests were chosen as mediators, since performance in these two tests was largely explained by age in our data [62.4 % of the variance in the Coding test' performance, $r^2(38)= .624$, $p<.01$, and 29 % of the variance in the Stroop test' performance, $r^2(38)= .290$, $p<.01$] and taking in account that both Inhibition (measured in the Strop test) and processing speed (measured in the Coding test) have been indicated in previous studies as important mediators of age-related changes in cognition (Hodzik & Lemaire, 2011; Robitaille et al., 2013).

Table 5. Partial correlation coefficients between age and neuropsychological tests in which there were age-related differences, while controlling the total score in the Coding test (N=40)

Neuropsychological Measures	*Age (Controlling for Coding total score)*	
	R	r^2
Word List - Immediate Recall	-.136	.018
Word List - Short Term Recall	-.081	.007
Word List - Long Term Recall	-.019	.0003
Stroop – Total Score	-.112	.012
Stroop – Time	-.010	.0001
Telephone Search – Time	.123	.015
Dual Task Telephone Search – Time	-.152	.023
Tower – Nº Violations	.156	.024
Tower – Nº Movements	-.343*	.118
Tower – Time per Movement	-.087	.008
Tower – Movements Accuracy	-.243	.059

*p<.05; ** p<.01

Table 6. Partial correlation coefficients between age and neuropsychological tests in which there were age-related differences, while controlling the total score in the Stroop test (N=40)

Neuropsychological Measures	*Age (Controlling for Stroop total score)*	
	R	r^2
Word List - Immediate Recall	-.284	.081
Word List - Short Term Recall	-.260	.067
Word List - Long Term Recall	-.131	.017
Coding	-.690**	.476
Stroop - Time	.181	.033
Telephone Search – Time	.241	.058
Dual Task Telephone Search – Time	.157	.024
Tower – Nº Violations	.383*	.147
Tower – Nº Movements	-.389*	.151
Tower – Time per Movement	.299	.089
Tower – Movements Accuracy	-.364*	.132

*p<.05; ** p<.01

The analysis of Table 5 shows that when we controlled for the total score in the processing speed measure, the Coding test, age is not significantly correlated with almost any neuropsychological measure. The exception is the total number of movements in the Tower test that has a moderate and negative correlation with age [$r(38)= -.343$, $p<.05$]. Consequently, increased age is related to a decrease number of movements in the Tower test, even when the total score in the Coding score is controlled.

In relation to the partial correlations while controlling the total score in the Stroop test (see Table 6) just four of the twelve correlations remained significant, with three moderate correlations and one strong correlation (Cohen, 1988). The correlation between age and the Coding test remained strong and negative [$r(38)= -.690$, $p<.01$]. There were moderate and negative correlations between age and two measures form the Tower test: the total number of movements [*r*(38)= -.389, *p*<.01] and movements' accuracy [*r*(38)= -.364, *p*<.01]. There was also a moderate but positive correlation between age and the number of violations in the Tower test [*r*(38)= .383, *p*<.01]. Even when inhibition is controlled, increased age still reflect a lower performance in the processing speed measure and an increased number of violations in the Tower test. On the positive side, when inhibition is controlled, increased age is still associated with higher movement accuracy (i.e., values closest to 1 in older adults).

1.5. Discussion

A deeper understanding of the effects of ageing on executive functions is critical and several studies have been conducted with this purpose (Allain et al., 2005; Fisk & Sharp, 2004; Hull, Martin, Beier, Lane, & Hamilton, 2008; Salthouse et al., 2003; Turner & Spreng, 2012). In the present study it was possible to investigate age-related changes in the performance on several neuropsychological tests by comparing older and young adults' performance. As expected the performance of older adults was worse than the performance of young adults in some neuropsychological tests and was similar to young adults in others. Older adults showed reduced processing speed. Concerning episodic memory, older adults showed a similar capacity for retention and long-term recognition of verbal material but recalled in average less words than young adults in both immediate, short term and long term recall. Older adults were as capable as young adults in language tests assessing confrontational naming and sentences comprehension abilities. Older and young adults' performance was also equivalent in the total score of visual selective attention test and in the divided attention measure suggesting the preservation of these attentional mechanisms with ageing. However, it should be emphasized that the task of divided attention administered in this study involved two different modalities (i.e., visual and auditory), which facilitates the task for older adults (Hein & Schubert, 2004). In respect to inhibition, older adults' had a worse performance in the Stroop test than young adults. In addition to inhibition and divided attention, other functions that could be considered as executive functions were assessed. No differences were found between the older and young adults' performance in neuropsychological tests measuring executive functions such as abstraction, verbal and spatial working memory and cognitive flexibility. In respect to the Tower test mixed results were found. Older adults committed more violations in average during towers construction and needed more time per movement. However, they used a few number of movements and had greater movements' accuracy. As a result, similar results were found for older adults and young adults in the achievement score obtained in the Tower test suggesting equivalent planning abilities.

In our study it was also possible to investigate if processing speed and inhibition can mediate age-related differences. As previous studies, we found a reduced processing speed in older adults (Baudouin et al., 2009; Henninger, Madden, & Huettel, 2010; Rush, Barch, & Braver, 2006; Salthouse, 1996; Yano, 2011). This reduced processing speed was pointed out by Salthouse (1996) as a key mediator of age-related changes in cognition. The results obtained in the present study support Salthouse's (1996) processing speed theory by showing that when processing speed is controlled, age is no longer related to the variance in the performance of most neuropsychological measures in which age-related changes were found.

Another important mediating factor of age-related changes pointed in previous studies is inhibition (Hasher & Zacks, 1988). Older adults presented a lower score in the Stroop test when compared with young adults. So we tested if this lower performance could explain the age-related changes that were previously identified. Our results showed that after controlling the total score on the Stroop test, age was no longer associated with some measures of episodic memory, attention and executive functions in which age-related changes were found.

Overall, the results found replicated previous findings by identifying an age-related cognitive slowing and inhibition deficits and some preserved functions such as retention, recognition, naming or comprehension abilities. Concerning the other executive functions despite inhibition, our results are in line with Collette & Salmon (2014), suggesting that even executive functions are only selectively affected by ageing, with some functions being more resistant to ageing such as divided attention, abstraction or planning. Despite this similarity in test performance, recent neuroimaging studies suggested differences in brain areas activation with ageing (Spreng, Wojtowicz, & Grady, 2010). For example, in respect to executive functions, the prefrontal cortex can be extra activated in order to allow similar levels of task performance, which has been interpreted as a possible compensatory mechanism in older adults.

1.6. Conclusions

Cognitive ageing is accompanied by cognitive slowing and inhibition deficits. Despite these age-related changes, older adults can perform similarly to young adults in different neuropsychological tests (Word List, Telephone Search and Dual Task Telephone Search, Confrontation Naming and Sentence Comprehension), including those pertaining to executive functions assessment (Similarities, Verbal fluency, Tower tests).

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