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The role of age, cognitive functioning and gender on the "attentional activity rate"

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Abstract

The attentional response times influence the capacity to manage cognitive and behavioral activities. This study investigated the age-related changes of the "attentional activity rate", i.e., the speed of the attentional responses in elderly adults. The role of cognitive functioning and gender were also analysed. Participants were 240 old adults aged from 65 to 85 years. The response times during the execution of tasks measuring "selective attention", "focused attention", "divided attention" and "alternating attention" were evaluated. Results showed a decreasing of the speed of the attentional responses with increasing age. The age-related changes of the "attentional activity rate" did not involve all aspects of attention, and presented different characteristics in males and females. Interestingly, the level of cognitive functioning did not directly contribute to the speed of execution of attentional tasks when divided and selective attention were involved. Considering that the speed

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All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Informed consent was obtained from all individual participants included in the study.

at which a mental activity is executed contributes to determine patterns of mental inefficiency in the old adults, the findings of the presents studies could be relevant for the developmental, clinical and experimental fields.

Keywords: Aging; Gender; Attention; Response times.

1. Introduction

“Activity rate” is the speed at which mental activities are performed (Lezak, Howieson, Bigler, & Trane, 2015). Literature reports a slowing of all mental activities in old age (Salthouse, 1985, 1996a, 1996b; Valeriani, Ranghi, & Giaquinto, 2003; Leclerc & Kensinger, 2008; Slessor, Miles, Bull, & Phillips, 2010). Salthouse (1985) assumed that the reduction of the speed of execution of cognitive operations is one of the main factors that contribute to the age-related differences in cognitive functioning. According to the “processing-speed” theory, two distinct mechanisms are responsible for the relation between speed and cognition: the “limited time mechanism” and the “simultaneity mechanism” (Salthouse, 1996a, 1996b). The first mechanism concerns the restriction of the time factor in performing later operations when a large percentage of available time is occupied by the execution of early operations. The second mechanism involves the possibility that the products of early processing may be lost by the time that later processing is completed. Processing deficits could be related to discrepancies between the time course of loss of information and the speed with which mental operations are executed (Salthouse, 1996a, 1996b).

The age-related effects on different speed measures can vary in magnitude (Salthouse & Coon, 1993, 1994). Although increased age is associated with slower performance in a wide range of tasks, there are many contrasting opinions on the grade to which age-related slowing is specific to particular processes or reflects larger and more general influences (Salthouse, 2000). The effect of age on the speed of information processing shows up in delayed reaction times and longer than average total performance times in the absence of a specific disability. Slowing of mental activities reduces the auditory span and performance accuracy. Moreover, it contributes to determining the memory lapses of an elderly person. In this regards, as similarly occurred in the 1990’s, Luszcz and Bryan (1999) demonstrated that the reduction in the speed of information processing is a fundamental contributor to normal age-related memory loss.

The decrease in the speed of information processing also involves attention skills. Attention is an essential component of complex cognitive processes, such as language, reasoning and problem-solving. It is a multi-faceted process (Butter, 1987; Posner & Rothbart, 2007; Rueda, Posner, & Rothbart, 2007; Peterson & Posner, 2012) and includes several activities involving different brain systems (Benton & Silvan, 1984; Raz & Buhle, 2006). There is not a unique definition of attention and its aspects. In this work, “selective attention” is the ability to ward-off distracting stimuli (Sohlberg & Mateer, 1989; Lezak *et al.*, 2015); “focused attention” is the ability to respond discretely to specific stimuli (Sohlberg & Mateer, 1989); “divided attention” is the capacity to maintain two attentional focuses contemporarily. It is related to the optimal allocation of resources between different sets of input by splitting (Hahn, Wolkenberg, Thomas, Ross, Myers, Heishman *et al.*, 2008); “alternating attention” is the ability to shift alternatively focus and tasks (Lezak *et al.*, 2015). It is the rapid shifting of the attentional focus, given the inability to process all available information in parallel (Parasuraman, 1998). Each of these processes implies distinct neural structures and serves different functions in everyday behavior (Rueda *et al.*, 2007; Petersen & Posner, 2012).

The age effect on the individual attention network has been examined using several experimental manipulations (e.g., Brink & McDowd, 1999; Zhou, Fan, Lee, Wang, & Wang, 2011). However, the results of these studies are not univocal. Brink and McDowd (1999) suggested that the age-related differences in the distinct attentional processes demanded by different tasks are not depending on general slowing. Moreover, several differences by age in the execution of tasks involving different aspects of attention were found.

Some studies reported relatively intact alerting and orienting in older adults (Mahoney, Verghese, Goldin, Lipton, & Holtzer, 2010). The immediate span of attention is also a relatively effortless process. It tends to be resistant to the effects of aging and of many brain disorders. However, it slowly decreases after 50 years old. Huttermann, Bock and Memmert (2012) showed that the age-related decrease in attention span depends on the viewing condition, and it is greater when one of the two tasks is steadily fixated. According to these authors, a fixated task engages attention and thus withdraws it from the periphery. They found that elderly adults presented more difficulties than younger ones in situations that required attention in the visual periphery, and hypothesized that the effects of age on attention span are not uniform but are depending on the presence or absence of eye movements and of a steadily fixated task.

Selective attention for spatial tasks is conserved in old age while selective attention for visual search tasks significantly decreases after 60-65 years old (Madden, Turkington, Provenzale, Denny, Langley, Hawk, *et al.*, 2002; Greenwood & Parasuraman, 2004; Commodari, 2006). These observations are consistent with those obtained from brain studies. Posterior brain attention systems responsible for selecting spatial locations are relatively well preserved with advancing age. However, aging is associated with the decline in the efficiency of the neural mechanisms supporting both context and conflict processing (e.g., Mittenberg, Seidenberg, O'Leary, & Di Giulio 1989).

Some studies have shown that older people are penalized by a divided attention situation (e.g., McDowd & Craik, 1988). Salthouse, Fristoe, Uneweaver and Coon (1995) demonstrated that two different explanation could be found on this evidence. According to the first explanation, aging influences complex cognitive processes, such as those involved in the execution of the tasks that require divided attention, more than elementary processes; according to the second explanation, aging directly influences elementary processes and the effect of aging on complex cognitive activities is indirect. However, age-related effects on dual-task performance were reduced when single-task performances were taken into account (Salthouse, 2000).

As seen in most cognitive skills, gender differences in attention have been observed (e.g., Feng, Spence, & Pratt, 2007) and these differences persist in the old age (Commodari & Guarnera, 2010). Some authors (e.g., Gur & Gur, 2002; Munro, Winicki, Schretlen, Gower, Turano, Muñoz, *et al*., 2012) showed that gender differences play a significant role in the aging process. Women presented lower age-related cognitive decline than men (Gur & Gur, 2002). Gender differences in patterns of cognitive test performance have been attributed to many factors, such as sex hormones or sexual dimorphisms in brain structure, that change with normal aging (Munro *et al*., 2012).

Males outperform females in tasks involving spatial attention. Gender differences were also observed in visual recognition tasks, such as symbol substitution tasks (Mittenberg *et al*., 1989), and in visual selective attention task (Merritt, Hirshman, Wharton, Stangl, Devlin, & Lenz; 2007). The role of gender in the functional organization of the hemispheres in conditions of focusing of attention during the memorization of competitively presented verbal information has also been studied (Razumnikova & Vol'f , 2007).

2. Research aim

Although many studies analyzed the effect of age on the attentional performances, the majority of the studies assessed single aspects of attention such as divided or selective attention (Parasuraman, Nestor, & Greenwood, 1989; West, 2004). Moreover, only a little number of researchers studied the speed of the attentional responses (e. g., Salthouse, 1996a, 1996b; Madden *et al*., 2002; Commodari & Guarnera, 2010). This study aimed at addressing some of these limitations. It analyzed the effect of aging on the speed at which attention skills operated and investigated all the key aspects in which attention is articulated.

The first aim of this study was to investigate the age-related changes in the "attentional activity rate," i.e., the speed of the attentional response, in aging. The rate of execution of tasks that involved different aspects of attention was measured, with the purpose to analyze whether the reduction of speed processing related to aging influenced all aspects of attention. "Selective attention," "divided attention," "focused attention," and "alternating attention" were assessed.

Second, the study investigated the presence of differences by gender in the speed at which attentional tasks were executed. Gender influences the speed at which a cognitive activity is executed (Aartsen, Martin, & Zimprich, 2004; De Frias, Nilsson, & Herlitz, 2006) and several differences related to gender during aging are observed (e.g., Gur & Gur, 2002). The study aimed to assess whether the changes in the attentional activity rate in aging involved the same aspects of the attention skills in males and females. Third, the study aimed to verify whether the level of cognitive functioning influenced the "attentional activity rate". Age, in fact, is not the only variable that contributes to the slowing of mental performances. Cognitive slowing is also a typical manifestation of cognitive impairment. The elderly with cognitive deterioration are slower in the execution of mental activities as compared to the cognitively healthy elderly (Gorus, De Raedt, Lambert, Lemper, & Mets, 2008; Phillips, Rogers, Haworth, Bayer, & Tales, 2013; Castellano, Guarnera, & Di Nuovo, 2015). For this reason, one of the purposes of this study was to investigate "attentional activity rate" in elderly adults who present different levels of cognitive functioning.

3. Method

3.1. Participants

Participants were 240 adults aged from 65 to 85 years old (males: 116; females: 124; age mean: 75.27 standard deviation: 6.79) in apparently good physical and psychological health. The participants were recruited in three recreational centers in a large town of Italy, during five days. The participants were selected according to the following criteria. All the 300 persons aged more than 65 who frequented the recreational centers were invited to participate in the study. Of these, 38 subjects who referred serious physical or psychological diseases and/or presented significant limitations of daily activities, as indicated by the manager of each center, were excluded from the study. The remaining 262 subjects participated in the test administration. During test administration, 22 participants failed the training session. These participants were excluded from research.

The 240 participants did not report significant physical problems or cognitive disorders and were able to participate in the activities of the recreational centers. However, after the attentional tasks administration, all participants were assessed for cognitive impairment. The choice to test for cognitive impairment on the participants depended on the evidence that elderly subjects who appear to be healthy and intact have cognitive impairment, which cannot be identified without extensive examination (Valdois, Joanette, Poissant, Ska, & Dehaut, 1990). Thus, a typical “normal” group of the elderly person probably includes, at least, a few people with mild and non-apparent cognitive disorders.

About the education level, participants had, at least, a middle school level of education: 101 subjects graduated middle school (53 males, 48 females), 95 graduated high school (49 males, 46 females), 44 had a university degree (26 males, 18 females). However, the “Milan Overall Dementia Assessment” scores (MODA, Spinnler & Tognoni, 1987; Brazzelli, Capitani, Della Sala, Spinnler, & Zuffi, 1994a, 1994b), which evaluate cognitive functioning, were corrected for the academic grade.

3.2. Measures

The “attentional activity rate” was measured through several computerized tasks, which were included in a multi-task computerized battery (Di Nuovo, 2009). The tasks assessed the speed of attentional responses. Each task measured a different aspect of attention. A multiple task measuring auditory, visual and visual-spatial recognition measured “focused attention;” a computerized version of the classic Stroop test measured “selective attention;” a multiple barrage task assessed “alternating attention;” finally, a simultaneous double task assessed “divided attention.” For each, task, the scores were the median reaction time. Reaction times were counted in second. The scores for each task were the median response times in seconds.

The “Focused Attention” task comprised three sub-tasks. Each sub-task measured the auditory, visual and visual-spatial “focused attention,” respectively. The “auditory focused attention” sub-task required subjects to recognize an auditory target among vocal distractors. Participants had to press a particular computer key following a vocal stimulus. The stimuli were letters (vowels and consonants). The visual sub-task required the recognition of a visual target among a group of distractors (images of common objects) appearing in the sequence. Participants had to press a key when a visual target appears on the screen of the computer. The visual-spatial sub-task was a computerized version of the symbols barrage test. Participants had to delete one symbol in a set of stimuli. The screen showed a set of stimuli which were sequentially ringed. Subjects had to press a computer key when the target is circled. “Selective Attention” task was a computerized version of the Stroop test. It comprised two tasks. The first task was the baseline. Participants had to press a computer key of the same color as the character used to print a word that appeared on the screen. The second task was the interference task. It required subjects to name the color of the ink used to print a word describing a different color, e.g., “red,” written using blue ink. “Divided Attention” task was a simultaneous double task. This task required the subject recognized a visual target and an auditory target contemporarily. “Alternating Attention” task was a multiple barrage task. It was a computerized adjustment of a non-verbal cancelation test. It was composed of two sub-tasks. Each task required the search and cancelation of different targets presented in sets of 90 stimuli. In the first task (verbal task), the stimuli were letters, in the second task (visual-spatial task), the stimuli were small squares with a variously oriented code. This task required a continual shift of attentional focus. For each set of stimuli, there were three targets.

Characteristics psychometric of these tasks were satisfactory. Reliability test-retest on the standardization sample at an interval of 15-20 days was from .88 to .92. Moreover, concurrent validity (*r* values comprised between .80 and .90 for the different tests) was satisfactory (Di Nuovo, 2009). Preliminarily to this research, test-retest reliability on a sample of old persons in apparent good health was calculated. Reliability values for the single subtests were comprised between .83 and .92.

Cognitive functioning has been evaluated through the MODA (Spinnler & Tognoni, 1987; Brazzelli *et al.*, 1994a, 1994b). The MODA is a rapid rating scale generating a global score from 0 to 100. The MODA permits to detect the presence of cognitive impairment and measures the severity of the condition. MODA scores allow distinguish subjects with a normal cognitive functioning from subjects with cognitive impairment. Moreover, it assesses the risk of developing cognitive impairment. The scores are adjusted for age and education. The MODA meets the requirements for a reliable bedside cognitive screening instrument (Spinnler & Tognoni, 1987; Brazzelli *et al.*,1994a). According to the authors, the correlation between the MODA and the Mini-Mental State Examination was .63 in controls and .84 in patients with Alzheimer's dementia. The MODA test-retest reliability was .83 (Brazzelli *et al.*, 1994a).

3.3. Procedures

A psychologist tested the participants during an individual session in a room of the recreational centers. The room was illuminated with overhead fluorescent lighting. In the room, there was a table with a computer. First, the psychologist administered the “attentional activity rate” tasks in an individual session. Only the participants who were able to execute the training session completed the test administration. The participants who failed the training session of at least two tasks were excluded from the study, and the test session has been interrupted. After two days, the psychologist tested the participants for cognitive impairment in a second session.

Participants were seated approximately 57 cm from the monitor of a computer. The tasks required pressing specific computer keys, according to the instruction of the psychologist. The participants used their preferred hand. The psychologist instructed the subjects to maintain fixation on the centre of the screen before start each task and to respond as fast as they accurately can, as soon they detected the appearance of the target stimuli. A training session preceded the administration of each task. However, the tasks were easy and did not require any previous experience in the use of the computer.

3.4. Statistical analysis

Several statistical analyses were conducted. Preliminarily the MODA scores distribution was calculated for the entire sample. The choice to assess this variable, although the participants were in apparent good health and intact, depended on the results of previous studies on elderly people. These studies (e.g., Valdois *et al.*, 1990) showed that often the old individuals present undiagnosed cognitive impairment, and a typical “normal” group of the elderly person probably includes some people with mild and non-apparent cognitive disorders.

Second, means, standard deviation, and *t*-test values by age were calculated. The aim of these analyses was to assess whether the young-old and old-old participants presented significant differences in the speed of responses during the execution of tasks which involved different aspects of attention, Third, differences by gender were evaluated. These analyses aimed to assess whether old male and females significantly differed in the "attentional activity rate." Differences in the "attentional activity rate", with respect to the level of cognitive functioning were also measured.

Finally, several regression analyses were conducted. The aim of these analyses was to identify the contribution of the variables "age" and "level of cognitive functioning" on the speed of attentional responses in aging, both in the males and females. These analyses were conducted separately for the two genders because of the results of the *t*-test analysis, which showed that men and women performed differently in the attentional tasks. Moreover, the findings of previous studies also showed significant gender differences in attention skills both in young and in old people (e.g., Merritt *et al.*, 2007).

3.4.1. Means and standard deviation of the MODA scores

Table 1 shows the means and standard deviation of the MODA scores for the entire sample. As expected, the cognitive assessment revealed that some of the participants obtained a score indicating a condition of cognitive decline. The participants were divided into three groups, according to their MODA score. The first group comprised the 184 subjects who presented an MODA score indicating the absence of cognitive deterioration (normal group). The second group included the 32 subjects who obtained an MODA score showing a borderline condition about the risk of developing a pathological cognitive decline (group at risk of pathology). Finally, the third group comprised the 24 subjects who obtained an MODA score indicating a condition of cognitive decline (pathological group).

Table 1 - *Cognitive functioning of the participants*

Participants	*N*	*M*	*SD*
Normal cognitive functioning (MODA scores ≥ 89)	184	91.53	1.03
Borderline with respect to a risk of cognitive impairment (MODA scores range 88.9-85.6)	24	87.45	.73
Cognitive impairment (MODA scores range ≤ 85.5)	32	75.03	6.30
TOTAL	240		

3.4.2. Means, standard deviation, t test values by age

The means, standard deviation and *t* test values by age were calculated, with the aim to evaluate whether age equally contributes to slowing of the "attentional activity rate", and whether the slowing involved all the aspects of attention skills. Participants were divided into two groups with respect to their age. The first group comprised the subjects aged from 65 to 75 years old (132 subjects), the second group included the subjects aged more than 76 years old (108 subjects). Table 2 presents the results of these analyses. *t* test analysis showed significant differences by age in the "focused attention" (auditory task; $t = -5.21$, $p < .001$), "selective attention" ($t = 2.80$; $p < .001$) and "alternating attention" (symbol task $t = 5.23$, $p < .001$) scores. In all these tasks, the younger participants were faster as compared to the older participants. Interestingly, no significant differences by age were observed in the "focused attention" (visual and visual-spatial) and the "alternating attention" (verbal) scores.

Table 2 - *Means, standard deviations and t test for the "attentional activity rate" scores by age levels*

	Age	*M*	*SD*	*t*	*p*
Focused Attention					
Auditory	65-75	.50	.25	-5.21	< .001
	> 75	.70	.35		
Visual	65-75	.43	.09	-1.42	.15
	> 75	.46	.16		
Visual-spatial	65-75	.37	.14	-1.37	.17
	> 75	.41	.21		
Divided attention	65-75	.66	.25	-4.77	< .001
	> 75	.85	.37		
Selective Attention					
Base line task	65-75	1.03	.12	-4.97	< .001
	> 75	1.40	.84		
Color word interference task	65-75	1.23	.35	2.80	< .001
	> 75	1.12	.20		
Alternating attention					
Verbal	65-75	126.15	28.96	-1.21	.22
	> 75	131.77	42.39		
Visual- spatial	65-75	201.06	82.52	5.23	< .001
	> 75	150.15	64.49		

3.4.3. *Means, standard deviation, and t test values by "gender"*

The means, standard deviation and *t* test values by gender were calculated. Table 3 shows the results of the descriptive analyses and *t* test values. Results showed significant differences by gender in all the scores, except "selective attention" scores.

Table 3 - *Means, standard deviations and t test for the "attentional activity rate" scores by gender*

	Gender	*M*	*SD*	*t*	*p*
Focused Attention					
Auditory	M	.73	.39	7.06	< .001
	F	.46	.13		
Visual	M	.48	.17	4.66	< .001
	F	.41	.03		
Visual-spatial	M	.43	.24	3.46	< .001
	F	.35	.08		
Divided attention task	M	.85	.44	4.88	< .001
	F	.65	.06		
Selective Attention					
Base line task	M	1.41	.80	5.66	< .001
	F	.99	.09		
Color word interference task	M	109.66	38.83	-9.31	< .001
	F	146.47	20.04		
Alternating attention					
Verbal	M	151.92	73.20	-5.24	< .001
	F	202.70	76.53		
Visual spatial	M	30.36	2.01	-6.73	< .001
	F	32.13	2.05		

3.4.4. *Means, standard deviation and t test values by "cognitive functioning"*

Table 4 presents the means, standard deviation and ANOVA for the "activity rate" scores by "cognitive functioning". ANOVA showed that the normal group was faster as compared to the others groups of participants. In particular, the results showed that the subjects who obtained an MODA score indicating the absence of cognitive impairment were speedier than the others participants in several tasks. Significant differences by "cognitive impairment" were observed in the following tasks: "focused attention" (auditory task: $F = 9.26$; $p < .001$; visual task: $F = 2.93$, $p = .05$; visual-spatial task: $F = 4.19$, $p = .01$) and "alternating attention" (verbal task:

$F = 7.80$, $p < .001$; spatial task: $F = 23.73$; $p < .001$). Post hoc analysis with Bonferroni correction confirmed these results. Post hoc analysis showed that these three groups of subjects differed in all the scores.

Table 4 - *Means, standard deviations and ANOVA for each "activity rate" score by cognitive functioning level*

	Cognitive functioning	*M*	*SD*	*F*	*p*
Focused attention					
Auditory	Absence of cognitive impairment	.64	.35	9.26	< .001
	Risk of cognitive impairment	.43	.05		
	Pathological impairment	.44	.04		
Visual	Absence of cognitive impairment	.45	.14	2.93	.05
	Risk of cognitive impairment	.40	.03		
	Pathological impairment	.41	.06		
Visual-spatial	Absence of cognitive impairment	.41	.20	.4.19	.01
	Risk of cognitive impairment	.32	.02		
	Pathological impairment	.34	.01		
Divided attention					
	Absence of cognitive impairment	.77	.36	2.61	.07
	Risk of cognitive impairment	.64	.05		
	Pathological impairment	.68	.00		
Selective attention					
	Absence of cognitive impairment	1.24	.67	2.72	.06
	Risk of cognitive impairment	1.01	.09		
	Pathological impairment	1.07	.13		
Alternating attention					
Verbal	Absence of cognitive impairment	131.57	38.18	7.80	< .001
	Risk of cognitive impairment	131.99	19.69		
	Pathological impairment	102.14	16.77		
Visual-Spatial	Absence of cognitive impairment	164.75	77.29	23.73	< .001
	Risk of cognitive impairment	260.08	55.81		
	Pathological impairment	171.70	47.78		

3.4.5. Regression analyses

According to the results of the t-test analysis, which showed that males and females presented different performances in the attentional “activity rate” tasks, and of the previous literature in this field, regression analyses were calculated separately on the subsamples of males and females. Age and level of cognitive functioning were regressed for each attentional activity rate scores. The results (Tab. 5) showed that age and level of cognitive functioning, as measured by MODA, were significant predictors of the majority of the scores. However, age and cognitive functioning differently influenced the attentional response times in the males and females.

Table 5 - *Regressions analyses for males and females using age and MODA scores as independent variables and the “attentional activity rate” scores as dependent variables*

Dependent Variables	Gender	Indipendent Variables			
		Age	MODA scores		
		t	t	R^2	F
Focused attention Auditory task	M	-.94	-.41	.00	1.86
	F	-.41	-3.63**	.51	66.58**
Focused attention Visual task	M	.26	.11	.02	2.50
	F	-1.6	-4.92**	.31	28.94**
Focused attention Visual-spatial task	M	-2.87*	-5.03**	.16	12.68**
	F	.52	-.30	-.01	.33
Divided attention	M	1.26	-.34	.01	1.73
	F	2.54*	-.92	. 15	12.35**
Selective attention	M	-4.68**	1.07	.27	22.51**
	F	1.74	1.50	.01	1.57
Alternating attention verbal task	M	-.008	2.26*	.04	3.98*
	F	-.20	-6.64**	.43	48.37
Alternating attention spatial task	M	.54	4.32	.16	12.54**
	F	-.35	2.86	.14	11.30**

*$p < .05$; **$p < .001$

The regression analyses on the subsample of the males showed that the independent variables were significant predictors for several attentional response time scores. Both age and level of cognitive functioning were significant predictors for the visual-spatial “focused attention” ($F = 12.682$, $R^2 = 1.83$, $p < .001$). The t values that permit us to evaluate the contribution of the variables to the model showed that the level of the cognitive functioning was the better predictor for the visual-spatial focused attention (t = -5.03, standardized coefficient B = -5.33, p < .001). Age was also a significant predictor for the “selective attention” (F = 22.54, R^2 = .27, p < .001; t = -4.68, standardized coefficient B = .46) and verbal “alternating attention” (F = *3.98*, R^2 = *.06*, p < *.05*; t = *2.26*, standardized coefficient B = *.25*) scores. The MODA scores, which evaluated the level of cognitive functioning, were significant predictors of the visual-spatial “alternating” attention scores (F = 12.54; R^2 = .18, p < .001; standardized coefficient B = .45).

Regression analyses on the subsamples of the females showed that age and MODA scores were significant predictors for the auditory “focused attention” scores (F = 66.58, R^2 = .53, p < .001; t = 4.43, standardized coefficients B = .42, p < .001; t = -3.63, standardized coefficient B = -.34, p < .001, respectively). Age was a significant predictor for the “divided attention” scores (F = 12.35, R^2 = .17, p < .001; standardized coefficient B = .31). Finally, the “level of cognitive functioning” was a significant predictor for the visual “focused attention”, and verbal “alternating attention” scores (F = 28.94, t = -4.42; R^2 = *.32*, standardized coefficient B = -.55, p < .001; F = 48.37, p < .001, t = -6.64, standardized coefficient B = -6.64, p < .001, respectively).

It is known that cognitive impairment influences all behavioral and mental performances. For this reason, the contribution of this variable in determining “attentional activity rate” was expected. Nevertheless, the level of cognitive functioning was not a significant predictor of the speed at which “divided attention” and “selective attention” operated.

Of interest, the regression analyses on the partial samples of males and females showed a different role of the variables age and level of cognitive functioning on the attentional activity rate in the two genders.

4. Discussion

“Activity rate” plays a pivotal role in determining the quality of cognitive performances (Brittain, La Marche, & Reeder, 1991; Salthouse, 1996a, 1996b; Wang, Fu, Greenwood, Luo, & Parasuraman, 2012). The speed of mental activity influences the execution of cognitive and behavioral activities. The decreasing speed of the attentional responses significantly contributes to reducing daily autonomy and capacity to manage cognitive and behavioral activities. In particular, the high speed of the attentional responses plays a pivotal role in the quality of those cognitive and behavioural performances that require fast orienting, the capacity to select a stimulus, and the ability to avoid distracting stimuli.

Results of this study have contributed to better investigate the effect of age on the attentional responses times. First, results showed that “attentional activity rate” decays with aging. This was not a surprising result. Mental response slowing is commonly observable in aging. Effect of age on the response times is consistent with the well-known Processing Speed Theory of cognitive aging (Salthouse, 1996a, 1996b). According to this theory, the reaction times were longer in older people than in younger, especially under the high perceptual load condition. The speed of early perceptual processing is compromised with increasing age, and this effect is greater in the complex task. However, although the reduction in speed at which mental activities are executed may reflect the generalized cognitive slowing in old people (Wang *et al.*, 2012), these results are not unequivocal (Brink & McDowd, 1999). The reduction of the speed at which attention operates did not involve all the aspects of attention skills. The older subjects who participated in the study were slower in the execution of tasks requiring “focused attention,” “selective attention” and “divided attention.” The other aspects of the “attentional activity rate” resisted to the aging effects.

Several differences by gender were also found. Results showed gender-related differences in the majority of the “attentional activity rate” scores, except the “selective attention” scores. Gender did not influence the ability to resist to interfering stimuli. Gender differences in cognitive domains are well documented in the literature (Aartsen *et al.*, 2004; Razumnikova & Vol’f, 2007). Results of the study confirmed that these differences persist in old age.

ANOVA analysis for “level of cognitive functioning” showed that the level of cognitive functioning influenced the “attentional activity rate”. Participants without cognitive impairment were faster in responses as compared to those that were in a condition of cognitive impairment or at risk of developing cognitive impairment. Of interest, the cognitive decline did not influence the “attentional activity rate” in tasks involving “focused attention”, “divided attention”, and “selective attention”. The absence of cognitive impairment did not directly contribute to the attentional response times when “focused,” “divided” and “selective” attention were involved.

The regression analyses supported these considerations. These analyses were separately conducted for males and females with the goal to investigate whether the individual contribution of the variables “age” and “level of cognitive functioning” is the same or different in the two genders.

The regression analyses conducted on the partial samples of the males and females showed that both age and level of the cognitive functioning were significant predictors of the majority of the scores. General cognitive functioning influences all behavioural and mental performances, and it is not surprising the contribution of this variable in determining the attentional response times. Nevertheless, the level of the cognitive functioning was not a significant predictor of the response times in tasks that measure the ability to maintain a dual focus and the ability to control interfering stimuli. Moreover, the effects of age and level of cognitive functioning on the “attentional activity rate” were different in the two genders.

With regard to the males, results of the present study showed the following results. Age influenced both the speed to focus visual-spatial stimuli and the speed in avoiding interfering stimuli and shifting attention, whereas the level of cognitive functioning was a significant predictor of the speed at which visual-spatial “alternating attention” and visual spatial “focused attention” operated.

With regard to the females, results of this research showed that age was a significant predictor of the attentional activity rate when the auditory “focused attention” and “divided attention” were involved. The level of cognitive functioning was a significant predictor for the attentional response times when the auditory and visual “focused attention,” and verbal “alternating attention” were involved.

All these results showed that gender differences contribute to determining the attentive response times at each age and level of cognitive functioning. Moreover, sensory and motor changes characterise ageing, independently from the quality of the cognitive functioning.

These issues permit to formulate some interesting considerations. The speed of information processing plays a pivotal role in several daily activities. However, in a condition of cognitive normality, the attentional response times did not depend on higher or lower cognitive efficiency but prevalently on gender and age.

This result could have interesting practical relevance. It is accepted that coping defects can arise from some neurological, psychiatric, and psychological variables. Moreover, it is well known that deficit in attention plays a pivotal role in determining patterns of mental inefficiency. For this reason, the effect of age on the speed at which attention skills operate should be highly considered in the applicative field. Issues of this study showed that, in a condition of cognitive normality, the increasing of age contribute to reducing the attentional speed. This reduction was relatively independent of the quality of the cognitive functioning but was influenced by the gender. The central role of age and gender in the slowdown of the "attentional activity rate" might be considered especially if a person executes day-to-day activities (for example work activities) that involve high attention level.

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