Endogenous and Exogenous Attention in Alzheimer Type of Dementia: Effect of Target Position

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SUMMARY

Objective: Endogenous attention (EnA) is an ability in goal-driven processes, controlled by top-down mechanisms and exogenous attention (ExA) is an ability in stimulus-driven processes, controlled by bottom-up mechanisms. In the present research, it was aimed to investigate in Alzheimer's disease (AD) the EnA and ExA processes in relation to target position (right/left) by using the Spatial Cueing Paradigm (SCP).

Method: The study was conducted with the participants of 65-90 year age range, consisting of 14 female and 14 male (n=28) participants diagnosed with AD and 12 female and 12 male (n=24) healthy volunteers as controls. The group variable (AD, Control) was tested on the intergroup basis; and the attention type (EnA, ExA), trial type (valid /VT+ and invalid/ VT-) and the target position (left/right) variables were tested on the intra-subject basis (within subject design). Two separate factorial ANOVAs were conducted for mean reaction time and accuracy measures obtained from SCP.

Results: In comparison to the control group, the AD group participants gave slow and wrong reactions to stimuli for EnA and ExA. The AD group responses were faster in the VT+s and more accurate in the VT-s to stimuli on the left as compared to those on the right; and the responses of AD patients to the stimuli on the left as compared to those on the right was more accurate in VT-s under ExA condition.

Conclusions: AD causes impairment of EnA and ExA. Faster reactions by AD participants to the target on the left in VT+s and more accurate reactions to the target on the left in VT-s are in agreement with reports in the literature on the lateralization of visual-spatial attention (VSA) in the right hemisphere. In this study, also in agreement with previous reports, lateralization in AD was noted in favour of the stimuli on the left in ExA.

Keywords: Alzheimer's disease, attention, right hemisphere, lateralization

INTRODUCTION

Alzheimer's disease (AD) is a progressive disease that starts with memory disorders and progresses with impairments in other cognitive functions (McKhann et al. 2011). It is known that impairments in attention and executive functions present immediately after memory disorders, which are the primary clinical symptoms of the disease, and just before impairments in other cognitive functions (Perry and Hodges 1999). Reports on the appearance of attention deficits in the early or middle stages of AD have been increasing (Emik and Cangöz 2012, Faust and Balota 1997, Langley et al. 2001, Peretti et al. 2008, Simone and Baylis 1997, Tales et al. 2002).

Classifications of endogenous attention (EnA) and exogenous attention (ExA) made for the first time in 1984 by Posner et al., represent, respectively, the top-down and the bottom-up processes (Chica et al. 2013). The characteristic features of EnA and ExA in AD are examined with respect to the components of visual-spatial attention (VSA) on the *spatial cueing paradigm* (SCP). In this paradigm, visual spatial cues indicating left or right are used for orienting EnA and ExA. In the valid trials (VT+), the target stimulus appears at the direction indicated by the cue, whereas in the invalid trials (VT-) it appears from the direction opposite to that indicated by the cue. Depending on whether or not the target appears

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at the side indicated by the cue, three different cognitive attention operations are described as *engagement* or orienting of attention to the position indicated by the cue, *disengagement* or withdrawal of attention from the position indicated by the wrong cue and *shifting of attention* or switch of attention to the current position of stimulus (Posner et al. 1984).

It is possible to pay attention covertly to different locations of the visual space even when the eyes are fixated on a certain spot (Chica et al. 2014, Greenwood et al. 1993, Posner et al. 1984, Wagner et al. 2014). Therefore, Posner (1980) designed SCP for covert attention independent of eye movements. In studies using the SCP (Oken et al. 1994, Parasuraman et al. 1992) it was shown that in AD the engagement skill was preserved, but the skills of disengagement and shifting of attention were impaired under conditions of VT-.

Investigation of Position as a Variable in Visual-Spatial Attention Studies

One of the important questions in attention studies is on the allocation of attention in the visual-spatial area (Peelen et al. 2004). Studies have indicated that the anatomical differences between brain hemispheres cause variations in the distribution of attention to the spatial area and this finding is also supported by both behavioral and physiological measurements (Kim et al. 1999, Peelen et al. 2004, Schotten et al. 2011).

In humans, the right hemisphere is dominant in the VSA skills (Posner and Petersen 1990, Schotten et al. 2011). In a simple visual target detection task, AD participants did not have problems in detecting the target position, whereas in a two-featured target detection task the patients were faster in detecting the stimulus at the left side of the screen in comparison with that on the right side (Foster et al. 1999). Also, the reaction time was slower in VT-s when the target appeared on the left in comparison to that appearing on the right (Buck 1997 cited in Foster et al. 1999). Investigation of lateralization in shifting of attention by brain SPECT imaging has shown that the *right parietal* brain areas are responsible for the spatial components of visual data and the shifting of attention, whereas the *left parietal* areas are responsible for object-based shifting of attention (Buck et al. 1997). This was supported by the observation that patients with single sided left hemisphere lesion experienced difficulties in shifting of attention among objects, and that patients with single sided right hemisphere lesion experienced difficulties in spatial shifting of attention to the left (Egly et al. 1994). In summarizing, while the *left parietal* lobe of the brain is responsible for object-based shifting of attention, the *right parietal* lobe is responsible for spatial-based shifting of attention (Buck et al. 1997, Egly et al. 1994).

However, in another study, AD patients did not show EnA related lateralization differences in SCP (Caffara et al. ,1997). While VSA differentiation in AD was not detected with respect to lateralization in EnA (Caffara et al. 1997), it was observed in ExA (Buck et al. 1997).

Inconsistent results in EnA (Caffara et al. ,1997), ExA (Buck et al., 1997) and in selective attention (Foster et al., 1999) have been reported by the investigations of AD on the differences of hemispheric function. These inconsistencies in relation to lateralization may be due to methodological differences in the details of the duration of cue presentation and the reaction screen amongst others. This study is designed based on the results reported in the literature with the aim to investigate the effect of AD on the subcomponents of the orientation system and the EnA and ExA processes in lateralization. All subtypes of VSA have been compared on the basis of target position in a single controlled experiment, thus differing from the study by Kaçar (2014) in using the same paradigm and participants to investigate the effect of emotional context on attention. The unique aspect of the present study is the adaptation of the stimulus durations in the original SCP used by Posner, (1980) to elderly individuals thus enabling the use of a paradigm to investigate comprehensively the different components of attention in older adults. The hypotheses of the study were expectations of differences in the reaction time and accuracy scores of the AD and control participants (1) under the conditions of VT+ and VT- in EnA and ExA; and (2) in responding to target stimuli appearing on the right and left sides of the visual space.

METHOD

Participants

A total of 52 volunteers between the ages of 65-90 participated in the study, consisting of 28 patients diagnosed with AD (14 females, 14 males) and 24 healthy elderly individuals (12 females, 12 males). Participants with AD were selected among individuals who consulted the geriatric psychiatrics polyclinic of a university hospital and were diagnosed with mild and moderate level of AD on the basis of the international diagnosis criteria of the NINCDS-ADRDA [the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's Disease and Related Disorders Association (ADRDA)] working group (McKhann et al. 2011). All participants were right handed and had normal or corrected visual acuity. The participants of the AD and control groups did not differ significantly on the basis of education in years (M_{AD} = 6.846, $M_{Control}$ = 5.833, $t(44.14)$ = -0.882, p = 0.383). Information of the study was given to all participants and their caregivers and written informed consents were obtained. The inclusion and exclusion criteria of the study have been summarized in Table 1.

Table 1. The Inclusion and Exclusion Criteria

Inclusion Criteria

* Being at the age of 65 years or more.
* Being literate
* MMSE score ≤25 (for AD group)
* MMSE score >25 (for control group)
* FAQ≥5 (score taken from two or more activities for the age group of 60-69 years) (for AD group)
  FAQ≥9 (score taken from three or more activities for the age group of 70 or more years) (for AD group)
* FAQ<5 (score taken from two or more activities for the age group of 60-69 years) (for control group)
  FAQ<9 (score taken from three or more activities for the age group of 70 or more years) (for control group)
* GDS score ≤14
* ECR score ≤41 (for AD group)
* ECR score >41 (for control group)

Exclusion Criteria

* Being nonvoluntary for the participation of the study
* Presence of any physical disability (visual, auditory or motor loss, etc.) that prevents the administration of psychiatric scales and cognitive tests
* Not satisfying the criteria of psychiatric scales and cognitive tests
* Presence of the history of head injury that leads to loss of consciousness
* Presence of any other psychiatric or neurological diagnosis different from AD like depression, psychosis or Parkinson's disease, etc.
* Being unsuccessful three times in the practice trials of the experiment

Note. MMSE: Mini Mental State Examination, FAQ: Functional Activities Questionnaire, GDS: Geriatric Depression Scale, ECR: Enhanced Cued Recall Test

Materials

Neuropsychological Assessment Battery: For the purposes of cognitive evaluation the AD and control group participants were assessed on a neuropsychological battery comprising the Mini Mental State Examination (MMSE) (Folstein et al. 1975, Güngen et al. 2002), the Functional Activities Questionnaire (FAQ) (Preffer et al. 1982, Selekler et al. 2004), the Geriatric Depression Scale (GDS) (Yesavage and Scheikh 1986, Ertan and Eker 2000) and the Enhanced Cued Recall Test (ECR) (Grober et al. 1988, Saka et al. 2006). Validity and reliability studies of all the tests/scales used in the study have already been conducted in order to adapt them to the Turkish culture and language. Scores of the two groups on these tests and scales differed significantly, with indications by the Attention and Calculation sub-test score of MMSE of impaired attention independently of VSA in the AD group (Table 2).

Spatial Cueing Paradigm (SCP): The SCP paradigm measures EnA and ExA independently of eye movements, on the basis of visual-spatial skills. It was developed by Posner during the early 1980s. On the SCP, attention can be guided endogenously by predictable central cues of arrows pointing to the right or left, or exogenously by the spatial cues of flashes on and off in a frame (located on right or left of the screen) before the appearance of the target stimulus. While the participant is looking at the fixation point on the screen, a target stimulus (e.g. the *sign) which the participant is required to detect is shown either on the right or left of the screen right after the cue. The cues are either valid for the target (VT+) which appears at the position indicated by

Table 2. Means and Standard Deviations of the Scores of the AD and Control Group Participants on the Neuropsychological Test Battery

		Mean	SD	t	df	p
MMSE (Total Score)	AD	19.00	4.07	9.879	35.51	p < 0.001
	Control	27.21	1.53			
MMSE (Attention and Calculation Sub-Test Score)	AD	2.76	1.29	2.46	50	p = 0.017
	Control	3.667	1.37			
FAQ	AD	16.68	9.15	-9.115	28.4	p < 0.001
	Control	0.71	1.37			
GDS	AD	6.36	3.81	-4.161	47.87	p < 0.001
	Control	2.63	2.62			
ECR	AD	23.96	10.97	10.877	28.1	p < 0.001
	Control	46.75	1.45			

Note. MMSE: Mini Mental State Examination, FAQ: Functional Activities Questionnaire, GDS: Geriatric Depression Scale, ECR: Enhanced Cued Recall Test the cue, or invalid (VT-) if the target appears at a different position.

Procedure

The Ethics Council Approval (dated 09.07.2013 and numbered 46004091/302-14) was acquired prior to starting the study from the Ethics Council of the university where the study was carried out. The experiments were carried out in an optimally illuminated and silent room. Starting with the demographic questionnaire, the neuropsychological assessment battery was completed. Visual stimuli were prepared using the *E-prime 2.0 Professional* software (Psychology Software Tools, ABD) and presented on the 1366x768 pixel high resolution screen of a 14-inch laptop. The participants were asked to sit straight looking at the center of the screen from a distance of about 60 cm.

The experiments were started with a practice run comprising 24 trials. Each participant was asked to practice at least 3 times in order to ensure that the instructions had been understood fully and that the participants knew how to perform the task. After the practice stage, the experimental stage, including a total 216 trials comprising 113 trials on endogenous attention and 113 trials on exogenous attention were undertaken. In compliance with the requirements of the commonly used SCP, the ratio of the VT+s and VT-s were determined as 89%, 11%, respectively (Faust and Balota 1997, Posner 1980, Posner et al. 1984). Before starting the experiments, the participants were informed verbally and in writing that the target will mostly come from the direction indicated by the cue (VT+s). Initially, a cross sign indicating the fixation point appears on the screen, which the participants were instructed to look at continually throughout the experiment. The visual angle of the fixation point was arranged as 0.2°. The endogenous (central) or exogenous (peripheral) cues appeared on the screen after the fixation point with the cross sign had remained on the screen for 1000 ms. The central cue for generating EnA, shaped as an arrow of 0.25° size, stayed for 470 milli seconds (ms) on the screen, whereas the cue generating the ExA was the peripheral luminance increment on the frames situated at a 7° distance from the central fixation point on the right and left of the screen, and remained on the screen for 150 ms. Task durations adapted to the elderly individuals were determined by referring to the relevant background literature (Chakravarthi and VanRullen 2011, Danckert et al. 1998). All stimuli were displayed on a white background. The flow diagrams summarizing the sequence of events are given in Figure 1 and 2. The positions of the target stimuli on the right and the left side of the screen were balanced and their sequence of appearance was adjusted to be random.

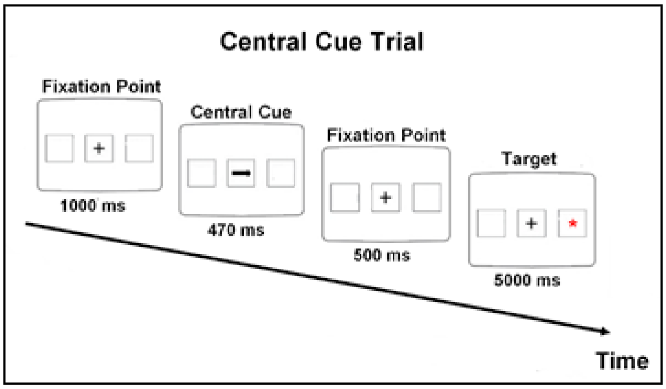

Figure 1. The Screen Flow of One Central Cue Trial

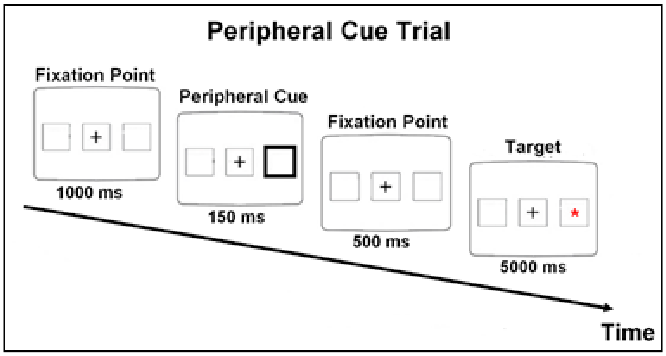

Figure 2. The Screen Flow of One Peripheral Cue Trial

RESULTS

On the basis of the statistical *t*-test, the difference between the mean ages of the AD and the control groups was significant (M_{AD} = 77.71, $M_{Control}$ = 70.35, $t(50) = -5.38$, $p < 0.001$). Hence, age was included as a new variable in the experimental design in order to control its confounding effect on the results. Accordingly, mixed-design ANOVAs were carried out as 3 (Age: 72 and below, between 72.01-78, 78.01 and above) x 2 (Group: AD and control) x 2 (Attention type: EnA and ExA) x 2 (Trial type: valid trial/VT+ and invalid trial/VT-) x 2 (Position of the target: right and left) with repeated measures at the last three factors. Two separate ANOVAs were carried out for reaction time and accuracy measurements. Accuracy measurements were made by calculating the average of the correct (1) and incorrect (0) reactions of the participants. Since all variables had 2 levels, *sphericity* assumption could not be calculated and the results were reported with the *Greenhousse-Geisser* correction (as cited by Field, 2009). The age variable does not have a statistically significant main effect based on the ANOVA results for the reaction time ($F(2, 46) = 0.567$, $p = 0.571$, $\eta_p^2 = 0.024$). The interaction effect of age, group and trial type was statistically significant ($F(2, 46) = 3.97$, $p = 0.026$, $\eta_p^2 = 0.15$). There were not any statistically significant differences between the AD and control groups on the bases of VT+ and VT- in three different age groups according to *Post-hoc* analyses (Table 3). Significant pairwise

Table 3. Results of Post Hoc Analyses on the Interaction Effect of Age, Group, Trial Type Variables with Respect to Age Comparisons (Bonferroni Correction)

Group	Trial Type	Age (Pairwise comparisons)		Mean Difference	SE	p
AD	Valid	72 and below	between 72.01-78	-80.416	160.904	1.000
			78.01 and above	4.962	163.041	1.000
	Invalid	72 and below	between 72.01-78	-177.847	187.914	1.000
			78.01 and above	-226.330	190.410	0.722
Control	Valid	72 and below	between 72.01-78	-43.701	188.508	1.000
			78.01 and above	-135.211	188.508	1.000
	Invalid	72 and below	between 72.01-78	-179.748	220.152	1.000
			78.01 and above	-96.134	220.152	1.000

comparisons were given in Table 4. In summarizing, the age factor did not have a statistically significant impact on the reaction time. Similarly, the main effect of age on accuracy measurements was also not statistically significant ($F(2, 46) = 0.470$, $p = 0.628$, $\eta_p^2 = 0.020$).

Group: The responses of the AD group participants were significantly slower and more incorrect in comparison to the responses of the control group participants ($F(1, 46) = 14.214$, $p < 0.001$, $\eta_p^2 = 0.236$ for reaction time; $F(1, 46) = 5.888$, $p = 0.019$, $\eta_p^2 = 0.113$ for accuracy) (Table 5).

Trial type: The reactions in VT-s were slower and more incorrect at a statistically significant level in comparison with the reactions in VT+s (for reaction time $F(1, 46) = 13.366$, $p = 0.001$, $\eta_p^2 = 0.225$; for accuracy $F(1, 46) = 10.198$, $p = 0.003$, $\eta_p^2 = 0.181$) (Table 5). Participants with AD gave slower and more incorrect responses at a statistically significant level in comparison with the control group in both VT+s (*Bonferroni* correction for reaction time $p < 0.001$, for accuracy $p = 0.038$) and in VT-s (*Bonferroni* correction for reaction time $p = 0.002$; for accuracy $p = 0.052$) (Table 5).

Attention type: Participants with AD reacted slower and more incorrect at EnA in comparison with the control group (*Bonferroni* correction for reaction time $p < 0.001$, for accuracy $p = 0.003$) (Table 5). On the other hand, only the reaction time is different at ExA (*Bonferroni* correction for reaction time $p = 0.001$, for accuracy $p = 0.226$) (Table 5).

Target Position: Whereas no difference was observed in the control group for both reaction time and accuracy measurements with regard to whether the stimulus comes from the right or left ($p > 0.05$), participants with AD responded faster to stimulus coming from the left in VT+s (*Bonferroni* correction, $p = 0.054$) and more accurately in VT-s (*Bonferroni* correction, $p = 0.053$) (Table 6). Participants with AD responded more accurately to stimulus coming from the left at the VT-s of the ExA condition (*Bonferroni* correction, $p = 0.023$) (Table 6).

Table 4. Results of Post Hoc Analyses on the Interaction Effect of Age, Group, Trial Type Variables with Respect to Group and Trial Type (Bonferroni Correction)

Age	Pairwise Comparisons		Mean Difference	SE	*p*
72 and below	Valid	AD	+467.869	152.813	0.004
		Control			
	Invalid	AD	+370.735	178.465	0.043
		Control			
Between 72.01-78	Valid	AD	+504.584	195.125	0.013
		Control			
78.01 and above	Invalid	AD	+500.931	229.941	0.035
		Control			
72 and below	Control	Valid	-62.828	31.478	0.052
		Invalid			
Between 72.01-78	Control	Valid	-198.875	77.104	0.013
		Invalid			
78.01 and above	AD	Valid	-196.986	40.266	0.000
		Invalid			

Table 5. Means and Standard Errors of the ANOVA Results Related to the Group, Trial Type, Attention Type Variables

		Reaction Time		Accuracy	
		Mean	**SE**	**Mean**	**SE**
Group	AD	1525.596*	65.617*	0.920*	0.013*
	Control	1102.154*	91.154*	0.973*	0.018*
Trial type	Valid	1271.270*	52.755*	0.968*	0.012*
	Invalid	1356.480*	61.611*	0.924*	0.014*
Group-Trial type	Valid /AD	1487.961*	61.641*	0.942*	0.014*
	Valid / Control	1054.578*	85.631*	0.993*	0.019*
	Invalid /AD	1563.230*	71.988*	0.896*	0.016*
	Invalid / Control	1149.729*	100.006*	0.951*	0.022*
Group-Attention type	Endogenous / AD	1522.321*	64.043*	0.907*	0.014*
	Endogenous / Control	1099.021*	88.967*	0.982*	0.019*
	Exogenous / AD	1528.871*	70.505*	0.932	0.015
	Exogenous / Control	1105.288*	97.944*	0.964	0.021

* Values related to significant comparisons

Table 6. Means and Standard Errors of the ANOVA Results Related to the Position Variable

		Mean	**SE**
Group-Trial type-Position	AD / Valid / Right	1527.563 (RT)	75.627 (RT)
	AD / Valid / Left	1448.360 (RT)	51.816 (RT)
	AD / Invalid / Right	0.876 (ACC)	0.020 (ACC)
	AD / Invalid / Left	0.918 (ACC)	0.018 (ACC)
Group-Trial type-Attention type-Position	AD / Invalid / Exogenous attention / Right	0.888 (ACC)	0.021 (ACC)
	AD / Invalid / Exogenous attention / Left	0.952 (ACC)	0.025 (ACC)

RT: Reaction time, ACC: Accuracy

DISCUSSION

The results regarding the slower and less accurate reactions of AD group participants in comparison to the control participants indicate a general regression in the attention task, meaning that AD causes impairment of VSA.

The statistically significant main effect of trial type on reaction time and accuracy shows the successful use of SCP (Posner 1980) in the present study as well as indicating the emergence of an *orienting effect* (Festa-Martino et al. 2004). While the task of orienting attention to the direction of the target is satisfactory with VT+, target appearance from a different direction to that indicated by the cue requires disengagement and shifting of attention. Irrespective of their grouping the participants of the study performed these 3 tasks included in the sub-components of the orienting system.

Slower and incorrect reactions of the AD group participants to stimuli in both VT+s and VT-s in comparison to the control group demonstrate an impairment in all three sub-components of the attention orienting system. Although these results of the study disagree with those reporting in the literature the preserved engagement skill in AD, there is still agreement with the previously reported results of impaired disengagement and shifting skills (Ishizaki et al. 2013, Oken et al. 1994, Parasuraman et al. 1992).

Endogenous and Exogenous Attention

Participants with AD display a lower performance of reaction time and accuracy in EnA as compared to the controls, which reflect impairment in the top-down processes in AD. This finding is in parallel with the fMRI study showing that the activity difference in the *dorsal attention* network together with the findings on behavioral impairments have been found to be a strong indicator separating AD patients and healthy controls (Li et al. 2012). Since the participants with AD cannot make use of contextual cues, they cannot resist distractions in EnA which is reflected in the lowering of reaction speed and accuracy (Perry and Hodges 1999) as also seen in the results of the present study.

On the other hand, equivalent performance of the participants with AD to the healthy control group participants by not compromising accuracy in their slowed down response in ExA may be an indication of less impairment of automatic attention in comparison to the process of controlled attention. This result when evaluated together with EnA performance points out that EnA, which is a high-level cognitive skill requiring more cognitive effort, is impaired more in comparison to ExA. Thus, AD causes impairments at varying degrees on different sub-components of attention in a visual-spatial task.

Effect of Position

The results demonstrated that the target position variable was not effective by itself on the reaction time of patients with AD; but significant differences in reaction time have been seen between right and left target positions depending on the trial type. Participants with AD reacted faster in VT+s when the target appeared on the left of the screen as against appearing on the right. The findings related to the effect of position on reaction time are in accordance with those of Foster et al. (1999). While position had no impact in the simple detection task used by Foster et al. (1999), the effect of position can be observed in the spatial cueing task since it is more difficult to detect the target stimulus in discrimination task. Hence SCP in the present study can be classified as a discrimination task as the AD group have responded faster to stimuli given from the left as compared to those given from the right side of the visual field.

Reacting correctly in ExA with VT-s by disengaging attention from the right and shifting attention to the left, when the target appears on the left side after the cue points to the right side, indicated an advantage of the AD patients over the opposite skills in orenting attention. Despite the disagreement of this result with that favouring the right hemisphere of AD patients for VT- in ExA, it supports the observation that the right hemisphere is responsible for shifting of attention (Buck et al. 1997). Also, observing a lateralisation difference not in EnA but in ExA agree with respectively, the results of Caffara et al. (1997) and by Buck et al. (1997).

Limitations of the Study and Conclusion

Not having assessed the simple reaction time in order to control the possibility of the intergroup differences being associated with psychomotor speed as against attention can be considered as a limitation of this study. However, there are researchers who carried out simple reaction time measurement in studies using SCP (Greenwood et al. 1997) as well as those who did not (Buck et al. 1997, Castel et al. 2003, Danckert et al. 1998, Festa-Martino et al. 2004).

In this study, observation of more accurate reactions in AD to stimuli coming from the left in general with VT- and specifically in ExA with VT- can be attributed to taking greater share of the existing resources of attention system/systems, which are not affected by atrophy in the brains of AD patients, whereas the limited attention resources in healthy brains are allocated balancedly to integrated working systems such as general alertness, orienting and executive attention systems localized in various regions (Andrewes 2009, Posner et al. 2016, Weaver et al. 2009). However, the absence of any brain imaging data which can support this argument is another limitation of the study. Not observing lateralization differences in the control group, may be due to being only one sub-test on visual spatial orienting in MMSE used for evaluating the general cognitive functions of the participants, which might not have been sensitive enough to determine the visual-spatial dimension in the control group. Functionalities of the participants related to daily life activities were measured by FAQ. However, subjective declarations were not obtained with regard to the daily life experiences in favour of the stimuli coming from the left as against the stimuli coming from the right as well as the lack of a more comprehensive neuropsychological assessment, including a test for evaluating visual-spatial attention, are other limitations of the study.

In conclusion, the study shows that AD causes impairments in the sub-components of the orienting system in EnA and ExA. In AD, the target coming from the left was detected faster as compared to the target appearing on the right. Given the VSA systems in AD, this lateralization arising from right hemisphere dominance in favour of the stimuli appearing on the left was seen in ExA, which is a bottom-up process.

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