Journal of
Alzheimer's Disease & Parkinsonism

De Lucia et al., J Alzheimers Dis Parkinsonism 2016, 6:4
http://dx.doi.org/10.4172/2161-0460.1000244

Research Article Open Access

Constructional Apraxia is related to Different Cognitive Defects across Dementia

Natascia De Lucia[1]*, Silvio Peluso[1], Anna De Rosa[1], Elena Salvatore[1], Giuseppe De Michele[1] and Dario Grossi[2]

[1]*Department of Neurosciences, Reproductive and Odontostomatological Sciences, "Federico II" University, Naples, Italy*
[2]*Department of Psychology, Second University of Naples, Caserta, Italy*

Abstract

Background: In visuo-constructional copying tasks, individuals with dementia can reproduce distorted or simplified figures resulting in the so-called 'Constructional apraxia' (CA) impairment. CA has been often described in Alzheimer's disease (AD), Vascular dementia (VAD), or Fronto-temporal dementia (FTD), and less often in patients with Parkinson's disease and associated dementia (PDD). There have been suggestions that different cognitive mechanisms could account for CA in different forms of dementia, but this hypothesis has not been directly verified. In the present study we explored visuo-constructional abilities in a sample of AD, VAD, FTD and PDD patients. We also investigated the cognitive factors associated to CA in these patients' groups.

Methods: We enrolled 72 AD patients, 61 VAD patients, 33 FTD patients and 32 PDD patients. All the patients underwent a copying drawings task to assess CA, and an extensive neuropsychological assessment of frontal/executive, visuo-spatial, and memory skills.

Results: FTD patients showed significant higher scores on drawing copying task compared to all other groups, whereas similar scores were observed between AD, VAD and PDD patients. Moreover, CA was strongly related to visuo-spatial impairments in AD and PDD patients and to frontal/executive impairments in VAD and FTD patients.

Conclusion: Our findings suggest that CA could be ascribed to distinctive cognitive defects in the different forms of dementia.

Keywords: Drawing; Alzheimer's disease; Parkinson disease; Dementia; Constructional apraxia; Vascular dementia; Fronto-temporaldementia

Introduction

In visuo-constructional copying tasks demented patients may perform poorly on drawing, producing simplified figures, alterations in spatial relationships among the parts, lack of perspective, or failure in correctly integrating single elements in a coherent whole. Such behaviours can all be described with the term of "Constructional apraxia" (CA), which was first proposed by Kleist [1] to designate a specific disturbance "which appears in formative activities (such as assembling, building, or drawing) in which the spatial form of the task is missed, although there is no apraxia of the single movements".

In the subsequent years, copying drawing performances have received revamped attention in literature being used increasingly for the identification of cognitive impairments especially in elderly [2,3]. Indeed, the occurrence of constructional impairments in copying drawing tasks has been often considered as a neuropsychological marker for diffuse cognitive deterioration, after lesions in either left or right hemisphere [4,5].

Drawing disorders have been observed in focal brain-damaged patients [6-8], and more often described and investigated in patients with progressive mental deterioration [9-15]. Among demented patients, visuo-constructional impairments have been usually considered one of the most common behavioural alterations in individuals with Alzheimer's disease (AD) [7]. However, no converging data would seem clarify the cognitive mechanisms underlying constructional impairment in AD patients. Indeed, some neuropsychological and neuroimaging findings ascribe a crucial role to the spatial-constructional processing and bilateral parietal atrophy on a hand, or planning abilities and fronto-temporal-parietal atrophy, on the other hand [13,16].

A few studies explored constructional impairments in individuals with Fronto-temporal dementia (FTD). These studies compared performances on copying figures in FTD and AD patients, but reported contrasting findings. Some authors [11] observed that FTD and AD patients showed similar scores in copying geometrical figures, but more recently other authors [12,17] reported that FTD patients were more accurate in copying figures compared to AD patients.

Similar conflicting results concern patients with Vascular dementia (VAD), where performances have been reported similar [18] or poorer than AD patients [19].

In individuals with Parkinson's disease and associated dementia (PDD) only a few studies explored the constructional apraxia. It has been reported that that early impairment of pentagon drawing is a predictor of faster cognitive decline in patients with Parkinson disease [20].

Based on the literature above reported, it would appear that no univocal findings are available on the constructional impairments across the different forms of dementia. Therefore, in the present study we explored the visuo-constructional impairments on a copying drawing task in a sample of AD, VAD, FTD and PDD patients. Moreover, we tried to assess whether specific cognitive dysfunctions could be associated with graphic constructional defects in the different

***Corresponding author:** Natascia De Lucia, Department of Neurosciences, Reproductive and Odontostomatological Sciences, "Federico II" University, Naples, Italy, Tel: +39 0817463711; E-mail: natascia.delucia@unina2.it

Received June 09, 2016; **Accepted** June 23, 2016; **Published** June 30, 2016

Citation: De Lucia N, Peluso S, De Rosa A, Salvatore E, De Michele G, et al. (2016) Constructional Apraxia is related to Different Cognitive Defects across Dementia. J Alzheimers Dis Parkinsonism 6: 244. doi: 10.4172/2161-0460.1000244

forms of dementia. Thus, the present study could contribute to clarify the cognitive mechanisms underlying visuo-constructional copying performances in demented patients.

Methods

Participants

To qualify for the present study we included individuals who met the following inclusion criteria: i) clinical diagnosis of 'probable' AD, according to the NINCDS-ADRDA diagnostic criteria [21], VAD, according to the Romàn et al.'s criteria [22], FTD, according to the Neary et al.'s diagnostic criteria [23], or PDD, according to the UK Parkinson's Disease Society Brain Bank's diagnostic criteria [24] and to the Emre et al.'s diagnostic criteria [25] for dementia associated with PD; ii) mild-to-moderate general cognitive impairment (raw score ranging 10-23 on the Italian version of the Mini Mental State Examination; MMSE) [26]; iii) formal education of at least two years. Exclusion criteria were: i) history of previous traumatic brain injury, stroke or psychiatric disorders; ii) concomitant severe organ insufficiency or neoplastic disease.

A total of 198 patients satisfied the inclusion and exclusion criteria. AD sample included 72 patients (mean age: 76.7 ± 6.5 years; mean education: 5.4 ± 2.9 years; mean MMSE score: 16.09 ± 4.2), VAD sample consisted of 61 patients (mean age: 76.2 ± 6.4; mean education: 5.8 ± 3.1; mean MMSE score: 17.09 ± 4.0), FTD sample included 33 patients (mean age: 74.4 ± 8.1; mean education: 5.3 ± 2.3; mean MMSE score: 16.66 ± 6.4); PDD sample consisted of 34 patients (mean age: 73.5 ± 5.8; mean education: 4.3 ± 1.6; mean MMSE score: 18.34 ± 1.3; mean Hoehn and Yahr's scale [27]: 1.76 ± 0.8; UPDRS-III scale [28]: 19.1 ± 7.8.

The patients were similar for age and education ($p>0.05$), and all (or their caregive[illegible]ve their written informed consent to participate to the study, whi[illegible]nducted in accordance with the Ethical standards of Helsinki Declaration.

Neuropsychological assessment

In addition to MMSE (above mentioned), all the participants underwent a neuropsychological assessment to examine frontal/executive, visuo-spatial and anterograde memory skills; all the tests were administered according to the Italian normative data. Frontal/executive functions were assessed by means of the Frontal Assessment Battery (FAB) [29], and the Phonological Verbal Fluency (PVF) test [30]. FAB includes six subtests assessing conceptualization, mental flexibility, motor planning, sensitivity to interference, inhibitory control, and environmental independency, and provides a global measure of cognitive and motor frontal control (score range: 0-18). PVF requires to produce as many words beginning with the letter "F", "A", and "S" as they can in one minute, and provides a measure of the self-organized strategy and shifting (score is the sum of the words correctly produced). Visuo-spatial functions were assessed by means of the Corsi span forward [31] and by Clock drawing task [32]. Corsi span requires reproducing block-tapping sequences of increasing length, and provides a measure of visuo-spatial memory (score range: 0-9). The Clock drawing task requires completing a shape of a clock by putting in all the numbers and setting the hands for 2 and 45 and requires a wide range of visuo-spatial skills (score range: 0-10). Anterograde memory was assessed by means of the immediate and delayed recall of 15-Word learning test [30] for the verbal domain (score range: 0-75, and 0-15, respectively), and by means of the delayed reproduction of the Rey Complex Figure [33] for the visuo-spatial domain (score range: 0-36).

Assessment of visuo-constructional copying ability

Visuo-constructional performances were assessed for in response at a copying drawings test [31]. This task required patients to reproduce seven black-and-white geometrical figures (e.g. square, diamond, cube, triangle, circle and nonsense figures), each printed in the upper half of a vertically arranged A4 sheet and each presented, one at time, on a table top aligned with the patient's body midline. Subjects were required to copy each stimulus in the lower half of the sheet-model. For each graphic response, drawing accuracy was scored assigning 2 points in case of correct reproduction, 1 point in case of partially correct reproduction (i.e., presence of simplification, or alterations of spatial relationships but still recognizable) and 0 points in case of incorrect reproduction (i.e., not recognizable). Since copying drawing test comprised seven models the score range was 0-14 points.

Data analysis

To compare performances on accuracy of graphic reproductions (related to CA) between the four patients' groups, we ran an analysis of variance (ANOVA), with the patients' group (AD vs. VD vs. FTD vs. PDD) as independent between-subject variable, and the accuracy on copying drawing test as dependent variable. Bonferroni's pairwise comparisons were used for *post-hoc* contrasts (setting the level of significance at $p<0.05$).

Moreover, to test any possible association between CA and neuropsychological scores, we computed the Pearson's correlation coefficients among scores on copying drawing task and the raw scores on MMSE, frontal/executive, visuo-spatial, and memory tests.

Last, to identify the cognitive abilities associated to CA in each patients' group, we ran separate logistic regression models, entering all the neuropsychological scores as independent variables and the occurrence of CA as the dependent variable (absence of CA was coded as 0 and presence of CA was coded as 1, based on the Italian normative data). To run these statistical models, we first calculated Z-values (based on the sample's mean values) for MMSE and neuropsychological scores, and then computed composite indices as average Z-values for frontal/executive scores (including FAB and PVF), visuo-spatial scores (including Corsi span forward, and Clock drawing task), and memory scores (including immediate and delayed recall of the 15-Word learning test, and delayed recall of the Rey Complex Figure test).

Results

ANOVA showed that the patients' group factor had a significant effect on accuracy of graphic reproductions, $F(3,198)=6.420$, $p<0.001$, $\eta_p^2=0.090$. *Post-hoc* analysis revealed that FTD patients' group were significantly more accurate in copying figures than AD patients ($p<0.001$), VAD patients ($p=0.03$), or PDD patients ($p=0.002$). AD patients, VAD patients and PDD patients achieved similar scores on drawing copying task (Figure 1).

Pearson's coefficients are reported in Table 1. A significant and positive correlation with MMSE was observed in all patients' group. Moreover, in AD patients the accuracy on drawing copying task significantly and positively correlated with performances on Corsi span forward, Clock drawing task, and delayed recall of the Rey Complex figure. In VAD patients, copying scores were significantly correlated with performances on FAB, PVF test, and Clock drawing test. In FTD patients, graphic performances positively correlated with FAB, PVF test, and immediate recall of the 15-Word learning test. In PDD patients, accuracy of graphic performances significantly correlated with Corsi span forward and Clock drawing task.

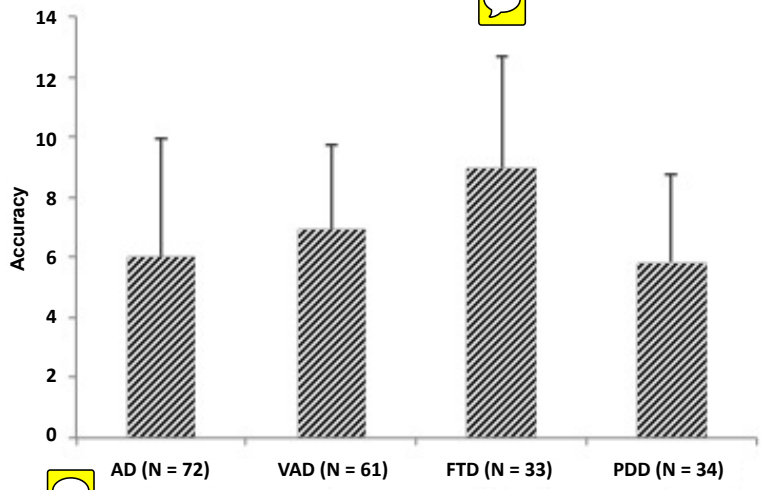

Figure 1: AD patients, VAD patients and PDD patients achieved similar scores.

	AD (n=72)	VAD (n=61)	FTD (n=33)	PDD (n=32)
General cognitive functioning				
Mini Mental State Examination	0.469**	0.289*	0.524**	0.414**
Frontal/executive functions				
Frontal assessment Battery	0.189	0.308*	0.383*	-0.074
Phonological verbal fluency	0.177	0.280*	0.381*	-0.022
Visuo-spatial functions				
Corsi span forward	0.457**	0.125	0.015	0.580*
Clock drawing task	0.480**	0.563**	-0.044	0.559*
Anterograde memory functions				
15-Word learning test – immediate recall	0.099	0.193	0.558**	0.204
15-Word learning test – delayed recall	0.199	0.233	0.055	0.193
Rey Complex figure – delayed recall	0.262*	0.163	0.239	-0.104

Note: AD: Alzheimer's Disease; VAD: Vascular Dementia; FTD: Fronto-Temporal Dementia; PDD: Parkinson's Disease with Dementia; **significant at $p<0.005$; *significant at $p<0.05$

Table 1: Pearson's correlation coefficients between accuracy on copying drawing task and raw scores on the neuropsychological tests in AD, FTD, VD and PDD patients.

Results from logistic regressions exploring the association between CA and neuropsychological scores revealed that in AD patients the model was statically significant [χ^2 (4)=20.55; $p<0.001$; Cox and Snell R^2=0.248]; the MMSE Z-score (odds ratio, OR: 0.375; confidence intervals, 95% CI: 0.171-0.820; p=0.01), and the visuo-spatial composite Z-score (OR: 0.303; 95% CI: 0.120-0.766; p=0.01) were significant predictors of the accuracy in copying drawing task. In VAD patients, regression showed that the model was statically significant [χ^2 (4)=20.87; $p<0.001$; Cox and Snell R^2=0.285]; the frontal/executive composite Z-score was the only significant predictor of the visuo-constructional dysfunction (OR: 0.034; 95%CI: 0.008-.0446; $p<0.001$). In FTD patients, the model was statically significant [χ^2 (4)=19.65; $p<0.001$; Cox and Snell R^2=0.313]; the frontal/executive composite Z-score was the only significant predictor of the presence of constructional disorders (OR: 0.009; 95% CI: 0.000-0.482; p=0.02). In PDD patients, the model was statistically significant [χ^2 (4)=10.89; p=0.02; Cox and Snell R^2=0.289]; drawing accuracy was significantly associated to visuo-spatial composite Z-score (OR: 0.055; 95% CI: 0.004-0.723; p=0.02).

Discussion

In the present study we explored visuo-constructional copying skills across different forms of dementia, including individuals with AD, VAD, FTD, and PDD. To this aim we employed a visuo-constructional copying task that would have high sensibility for detecting visuo-constructional defects [2,16]. Our results revealed significant differences between patients' groups, such that FTD patients produced more accurate copies than all other groups, and that similar performances occurred between AD, VAD and PDD patients. These findings would confirm that in FTD patients the visuo-constructional copying performances would be better than AD patients as reported in some previous studies [12,17], and clarified that drawing abilities do not significantly differ between AD and VAD patients [18]. However, our results additional revealed that visuo-constructional copying abilities would be relatively preserved in FTD patients compared with the other forms of dementia. In our study, we also tried to explore possible correlates of constructional impairments in our demented patients. Results from correlation analysis revealed that there was a strong correlation of accuracy on drawing copying task with MMSE. These results would suggest that in AD, VAD, FTD and PDD individuals, constructional disability appears to develop proportionately to the general cognitive impairment. However, when we statistically weighted out the individual contribution of the cognitive variables on the accuracy of graphic reproduction, by adopting the logistic regression analysis, we observed specific pattern of findings according to the specific form of dementia. Indeed, we

found that in AD patients constructional impairments were strongly related to visuo-spatial defects. Moreover, correlation analysis also showed a positive association between scores on Corsi span forward, Clock drawing test, and delayed recall of the Rey Complex figure. All these tasks involved visuo-perceptual and visuo-spatial working memory skills that are early defective in AD patients [16]. Similarly, we observed that visuo-spatial dysfunctions were associated to visuo-constructional accuracy in PDD patients too. In these patients scores on Corsi span forward and Clock drawing test were positively correlated with scores on copying drawing task. Taken together, these results would suggest that both in AD and PDD patients, the cognitive defects underlying constructional impairment could involve the visuo-spatial cognitive domain and in particular the spatial-constructional processing, likely exploration and judgment of spatial relationship. Frontal/executive dysfunctions, instead, would be more strongly related to constructional impairments in both VAD and FTD patients. Indeed, our results from correlation analysis showed that scores on FAB, and PVF test were significantly and positively correlated to graphic accuracy. Moreover, drawing abilities were also correlated to scores on Clock drawing test in VAD patients, and delayed recall of the 15-Word learning test in FTD patients. However, when we specifically explored the individual contributions of the different cognitive domains, by means of the logistic regression analysis, we observed that the only significant predictor of the constructional impairments was the frontal/executive dysfunction in both VAD and FTD patients. These findings would suggest that in VAD and FTD patients the drawing defects would be prevalently ascribed to frontal control processes requiring planning, organization, and attention skills in addition to problem-solving strategies.

Some limitations of the present study should be taken into account. First, we enrolled patients with mild-to-moderate level of dementia to select comparable samples but this choice did not allow to fully exploring the effect of dementia severity on visuo-constructional impairments; further studies are needed to elucidate the relationships between drawing performances and progression of cognitive impairments. Second, although we used well-established clinical criteria for the clinical diagnosis of our participants, these criteria might be insufficient to identify patients; thus inclusion of neuroimaging data in future studies will increase the likelihood of creating strongly homogeneous patient samples. Third, in the present study we did not explore the specific type of error in copying drawing test, thus further studies could consider performing a qualitative analysis of the patients' production in relationship to specific form of dementia; this last investigation could provide additional elements for differential diagnosis of degenerative dementia. Finally, it seems worthy to explore whether the different pathological pattern of constructional apraxia could play a predictive role in pre-dementia state. Inclusion in future studies of patients with initial cognitive impairment (i.e., mild cognitive impairment, vascular cognitive impairment-no dementia) and prolonged observation up to a specific diagnosis can solve this issue.

References

1. Kleist K (1934) Gehirnpathologie. Barth, Leipzig.
2. Gainotti G (1985) Constructional apraxia. Handbook of Clinical Neurology. JAMFredericks, Elsevier, Amsterdam.
3. Ericsson K, Forssell LG, Holmén K, Viitanen M, Winblad B (1996) Copying and handwriting ability in the screening of cognitive dysfunction in old age. Arch Gerontol Geriatr 22: 103-121.
4. Borod JC, Carper M, Goodglass H (1982) WAIS performance IQ in aphasia as a function of auditory comprehension and constructional apraxia. Cortex 18: 199-210.
5. Benowitz LI, Moya KL, Levine DN (1990) Impaired verbal reasoning and constructional apraxia in subjects with right hemisphere damage. Neuropsychologia 28: 231-241.
6. Arrigoni C, De Renzi E (1964) Constructional apraxia and hemispheric locus of lesion. Cortex 1: 170-197.
7. Carlesimo GA, Fadda L, Caltagirone C (1993) Basic mechanisms of constructional apraxia in unilateral brain-damaged patients: Role of visuo-perceptual and executive disorders. J Clin Exp Neuropsychol 15: 342-358.
8. Chechlacz M, Novick A, Rotshtein P, Bickerton WL, Humphreys GW, et al. (2014) The neural substrates of drawing: A voxel-based morphometry analysis of constructional, hierarchical and spatial representation deficits. J Cogn Neurosci 26: 2701-2715.
9. Rouleau I, Salmon DP, Butters N (1996) Longitudinal analysis of clock drawing in Alzheimer's disease patients. Brain Cogn 31: 17-34.
10. Binetti G, Cappa S, Magni E, Padovani A, Bianchetti A, et al. (1998) Visual and spatial perception in the early phase of Alzheimer's disease. Neuropsychology 12: 29-33.
11. Rascovsky K, Salmon DP, Ho GJ, Galasko D, Peavy GM, et al. (2002) Cognitive profiles differ in autopsy-confirmed fronto-temporal dementia and AD. Neurology 58: 1801-1808.
12. Thompson JC, Stopford CL, Snowden JS, Neary D (2005) Qualitative neuropsychological performance characteristics in fronto-temporal dementia and Alzheimer's disease. J Neurol Neurosurgical Psychiatry 76: 920-927.
13. Ahn HJ, Seo SW, Chin J, Suh MK, Lee BH, et al. (2011) The cortical neuroanatomy of neuropsychological deficits in mild cognitive impairment and Alzheimer's disease: a surface-based morphometric analysis. Neuropsychologia 49: 3931-3945.
14. De Lucia N, Grossi D, Maria Fasanaro A, Carpi S, Trojano L (2013) Frontal defects contribute to the genesis of closing-in in Alzheimer's disease patients. J Int Neuropsychol Soc 19: 802-808.
15. Amodeo S, Mainland BJ, Herrmann N, Shulman KI (2015) The times they are a-Changin': Clock drawing and prediction of dementia. J Geriatr Psychiatry Neurol 28: 145-155.
16. Serra L, Fadda L, Perri R, Spanò B, Marra C, et al. (2014) Constructional apraxia as a distinctive cognitive and structural brain feature of pre-senile Alzheimer's disease. J Alzheimers Dis 38: 391-402.
17. Possin KL, Laluz VR, Alcantar OZ, Miller BL, Kramer JH (2011) Distinct neuroanatomical substrates and cognitive mechanisms of figure copy performance in Alzheimer's Disease and behavioral variant Fronto-temporal Dementia. Neuropsychologia 49: 43-48.
18. Graham NL, Emery T, Hodges JR (2004) Distinctive cognitive profiles in Alzheimer's disease and subcortical vascular dementia. J Neurol Neurosurg Psychiatry 75: 61-71.
19. Fukui T, Lee E, Kitamura M, Hosoda H, Bokui C, et al. (2009) Visuo-spatial dysfunction may be a key in the differentiation between Alzheimer's disease and sub-cortical cognitive impairment in moderate to severe stages. Dement Geriatr Cogn Disord 28: 288-294.
20. Kaul S, Elble RJ (2014) Impaired pentagon drawing is an early predictor of cognitive decline in Parkinson's disease. Mov Disord 29: 427-428.
21. McKhann G, Drachman D, Folstein M, Katzman R, Price D, et al. (1984) Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. Neurology 34: 939-944.
22. Román GC, Tatemichi TK, Erkinjuntti T, Cummings JL, Masdeu JC, et al. (1993) Vascular dementia: diagnostic criteria for research studies. Report of the NINDS-AIREN International Workshop. Neurology 43: 250-260.
23. Neary D, Snowden JS, Gustafson L, Passant U, Stuss D, et al. (1998) Fronto-temporal lobar degeneration: A consensus on clinical diagnostic criteria. Neurology 51: 1546-1554.
24. Gibb WR, Lees AJ (1988) The relevance of the Lewy body to the pathogenesis of idiopathic Parkinson's disease. J Neurol Neurosurg Psychiatry 51: 745-752.
25. Emre M, Aarsland D, Brown R, Burn DJ, Duyckaerts C, et al. (2007) Clinical diagnostic criteria for dementia associated with Parkinson's disease. Mov Disord 22: 1689-1707.

26. Measso G, Cavarzeran F, Zappala` G, Lebowitz BD, Crook TH, et al. (1993) The mini-mental state examination: Normative study of an italian random sample. Dev Neuropsychol 9: 77-85.

27. Hoehn MM, Yahr MD (1967) Parkinsonism: Onset, progression and mortality. Neurology 17: 427-442.

28. Fahn S, Elton RL; Members of the UPDRS Development Committee (1987) Recent developments in Parkinson's disease. S. Fahn, C.D. Marsden, D. Calne, M. Goldstein (eds), Florham Park, NJ, Macmillan.

29. Appollonio I, Leone M, Isella V, Piamarta F, Consoli T, et al. (2005) The frontal assessment battery (FAB): Normative values in an Italian population sample. Neurol Sci 26: 108-116.

30. Carlesimo GA, Caltagirone C, Gainotti G (1996) The group of the standardization of the mental deterioration battery the mental deterioration battery: Normative data, diagnostic reliability and qualitative analyses of cognitive impairment. Europ Neurol 36: 378-384.

31. Spinnler H, Tognoni G (1987) Standardizzazione e taratura italiana di tests neuropsicologici. Ita J Neurolog Sci 6: 8-96.

32. Mondini S, Mapelli D, Vestri A, Bisiacchi PS (2003) Esame neuropsicologico breve. Una batteria di test per lo screening neuropsicologico, Raffaello Cortina Editore.

33. Caffarra P, Vezzadini G, Dieci F, Zonato F, Venneri A (2002) Rey-Osterrieth complex figure: Normative values in an Italian population sample. Neurol Sci 22: 443-447.

Citation: De Lucia N, Peluso S, De Rosa A, Salvatore E, De Michele G, et al. (2016) Constructional Apraxia is related to Different Cognitive Defects across Dementia. J Alzheimers Dis Parkinsonism 6: 244. doi: 10.4172/2161-0460.1000244