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Planning Ability in Dementia of Alzheimer's Type Patients Evaluated with the Zoo Map Test

Capacidad de planificación en pacientes con demencia tipo Alzheimer evaluados con la prueba del mapa del zoo

Capacidade de planejamento em pacientes com demência de Alzheimer avaliados com o teste do mapa do zoológico

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Abstract

Background: The Zoo Map Test evaluates the ability of executive planning. There are few studies that address its execution in patients with dementia. The objective of this research study was to evaluate and study the planning ability through the Zoo Map Test in patients with Alzheimer's Dementia. **Method:** 50 patients with dementia of Alzheimer's type and 60 participants without neurocognitive affectation, both groups with similar sociodemographic characteristics. The planning ability was evaluated through parts A and B of the Zoo Map Test. **Results:** As for part A there were significant differences ($p < .01$) between the two groups insofar as the total score, time, and number of errors were concerned. As for part B there were differences between the two groups insofar as the total score, sequence, time and number of errors were concerned ($p < .01$). **Conclusions:** Planning ability showed to be impaired in dementia of Alzheimer's type patients. It would be advisable in future studies to evaluate the planning ability in DAT patients with different degrees of severity.

Key words: Dementia of Alzheimer's type; Executive Functions; Neuropsychological Assessment; Planning Evaluation; Test the Zoo Map.

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Resumen

Antecedentes: La prueba del mapa del zoo evalúa la capacidad de la planificación ejecutiva, sin embargo, existen pocos estudios que aborden su aplicación en pacientes con demencia. El objetivo de este estudio fue evaluar y estudiar la capacidad de planificación a través de la prueba del mapa del zoo en pacientes con demencia tipo Alzheimer. **Método:** 50 pacientes con demencia de tipo Alzheimer y 60 participantes sin afectación neurocognitiva, ambos grupos con características sociodemográficas similares. La capacidad de planificación se evaluó a través de las partes A y B de la prueba del mapa del zoo. **Resultados:** en cuanto a la parte A, hubo diferencias significativas (p <.01) entre los dos grupos en lo que respecta a la puntuación total, el tiempo y la cantidad de errores. En cuanto a la parte B, hubo diferencias entre los dos grupos en lo que respecta a la puntuación total, la secuencia, el tiempo y la cantidad de errores (p<.01). **Conclusiones:** la capacidad de planificación se encontró afectada posiblemente por la enfermedad de Alzheimer. Sería recomendable en estudios futuros evaluar la capacidad de planificación en pacientes con DAT con diferentes grados de gravedad.

Palabras clave: Demencia tipo Alzheimer; Funciones ejecutivas; Evaluación neuropsicológica; Evaluación de la planificación; Prueba el mapa del zoo.

Resumo

Contexto: O teste do mapa do zoológico avalia a capacidade de planejamento executivo, no entanto, existem poucos estudos que abordam sua aplicação em pacientes com demência. O objetivo deste estudo foi avaliar e estudar a capacidade de planejamento através do teste do mapa do zoológico em pacientes com demência de Alzheimer. **Método:** 50 pacientes com demência de Alzheimer e 60 participantes sem afetação neurocognitiva, ambos os grupos com características sociodemográficas semelhantes. A capacidade de planejamento foi avaliada através das partes A e B do teste do mapa do zoológico. **Resultados:** Em relação à parte A, houve diferenças significativas (p & lt; 0,01) entre os dois grupos em relação à pontuação total, o tempo e o número de erros. Em relação à parte B, houve diferenças entre os dois grupos em relação ao escore total, a seqüência, o tempo e o número de erros (p & lt; 0,01). **Conclusões:** a capacidade de planejamento possivelmente foi afetada pela doença de Alzheimer. Seria aconselhável em estudos futuros avaliar a capacidade de planejamento em pacientes com DA com diferentes graus de gravidade.

Palavras-chave: demência tipo Alzheimer; Funções executivas; Avaliação neuropsicológica; Avaliação de planejamento; Teste do mapa do zoológico.

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There is a whole body of scientific literature pointing out that Dementia of Alzheimer's Type (DAT) patients tend to show impaired performance in certain tasks related to executive functioning (e.g., Allain, Etcharry-Bouyx, & Verny, 2013; Belleville, Rouleau, &Van der Linden, 2006; Clark et al., 2012).

By executive functions we mean a set of cognitive and behavioral processes such as verbal reasoning, problem solving, planning, sequencing, sustained attention, resistance to interference, use of feedback, multitasking, cognitive flexibility and the ability to respond to new stimuli. The executive functions' cognitive components that are most frequently affected in DAT patients are inhibition ability and resistance to interference (Vasconcelos et al., 2014), motor programming (Smits et al., 2014), cognitive flexibility (Godefroy et al., 2014), reasoning and abstraction (Leyhe et al., 2011), information processing speed (Warkentin et al., 2008), working memory (Gagnon, & Belleville, 2011) and verbal fluency (Bertola et al., 2014). Planning ability is another component of the executive functions that can be altered in DAT patients (McGuinness et al., 2010; Rainville et al., 2002).

Luria (1978) defined planning process as the ability to organize behavior in order to achieve a specific goal that can be broken down into a series of sub-objectives or intermediate steps. It consists of the ability to identify and organize the steps and elements required to achieve a goal (Lezak, Howieson, & Loring, 2004).

It has been proposed that with regards to planning ability two levels can be distinguished, formulation and execution (Grafman, 1989; Shallice, 1982). Formulation refers to the ability to mentally develop a logical strategy to predetermine the course of action towards the achievement of a specific goal. Execution consists of the competence to follow up and guide the execution of the plan to arrive at a successful conclusion (Grafman, 1989; Shallice, 1982). To carry out a task or action, it is not enough to have will, initiative and creativity, it is necessary to plan and organize action plans that lead to the fulfillment of an objective. It is also required of you to be able to formulate hypotheses, perform calculations and cognitive estimates. Planning entails setting a goal, developing and implementing the chosen strategy and assessing the achievement or non-achievement of the goal in question. The ability to plan or to organize one's life, is crucial if you want to lead an independent life. Many everyday acts can be extremely complex and require executive control of their attainment (Stuss, & Alexander, 2000). Activities such as dressing or bathing, which may seem elementary and lacking in difficulty, are themselves propositional acts or directed to an end; as such they involve planning, monitoring and suppression of internal and external influences that may divert our actions from the objective pursued.

To assess planning ability tasks such as the Tower of London and the Tower of Hanoi, the Labyrinths of Porteus and the Luria Motor Series can be used. The Zoo Map Test of Behavioural Assessment of Dysexecutive Síndrome (Wilson, Alderman, Burgess, Emslie, & Evans, 1996) is frequently used in clinical practice to study planning ability and has been regarded as a valid instrument for such purpose (Oosterman, Wijers, & Kessels, 2013). It involves a highly demanding task and consists of two parts, one with no specific task execution guidelines, and another with specific guidelines for performing the task (Wilson et al., 1996). It has been observed that AD patients when performing this test tend to make more errors in the formulation phase than in the execution phase of a plan, which could indicate a difficulty in the developing of logical strategies related to changes in behavior (Allain et al., 2005;

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Allain et al., 2007). This is an ecological test (Wilson, et al., 1996), but There are few studies in which the test has been applied to DAT patients.

The objective of this research was to assess and study DAT patients planning ability when submitted to the Zoo Map Test.

Methods

Participants

Two groups of participants, a DAT patients group and a comparative group (CG) of participants without any cognitive impairment, were studied. All participants took part in the study voluntarily and signed their informed consent in writing.

All participants were evaluated by an interdisciplinary team composed of a neurologist, a neuropsychologist and a clinical psychologist.

To be included in the study DAT patients were to meet the following criteria: (i) a clinical diagnosis of dementia by a Neurologist: (ii) diagnostic criteria for probable DAT as established by the NINCDS-ADRDA (McKhann et al., 1984) and by DSM-IV-TR (APA, 2002); (iii) diagnosis of dementia done less than years ago; (iv) got a score of < 24 on the Cognoscitive Exam (Lobo et al., 2002); (v) obtain a cut off score of < 69 in the Cambridge Cognitive Examination (Spanish adaptation) - CAMCOG- (López-Pousa, Llinás, Amiel, Vidal, & Vilalta, 1990);

The criteria for participants to be part of the CG were as follows: (i) diagnosis of dementia ruled out (validated by a Neurologist); (ii) got a score > 25 on the Cognoscitive Exam (Lobo et al., 2002); (iii) got a score of > 70 on on the CAMCOG.

In addition, the participants of both groups had to have at least 5 years of schooling; no history of other clinically demonstrable neurological, neurosurgical, neurocognitive and/or psychopathological disorders.

The sociodemographic characteristics of all the participants including DAT and CG groups are presented in table 1. There are no statistically significant differences between the two groups in terms of gender, years of schooling and hand preference (p> .05). There were differences in age ($t_{(108)}$= 5.71, p< .001).

As for the scores obtained in the tests used in the inclusion criteria, significant differences were found in the MMSE (t(108)= -13.71; p< .001) and CAMCOG (t(108)= -15.41; p< .001) between both groups.

Instruments

For selecting the participants the following instruments were used: (i) *Cognoscitive Exam* (Lobo et al., 2002); (ii) *The Cambridge Cognitive Examination, Spanish version - CAMCOG-* (López-Pousa et al., 1990) belonging to the *Cambridge Exam for Mental Disorders in Old Age* - CAMDEX (Roth et al., 1986).

To evaluate participants planning ability, the Zoo Map Test of Behavioral Assessment of the Dyssexecutive Syndrome Battery (BADS) was used (Wilson et al., 1996). It is based on the plan of a zoo where the participant must show how he/she would visit a series of indicated locations, while following certain rules in the route planning. These rules included: to start at the entrance and to end at the picnic area, and use the unshaded paths of the zoo only once and the shaded paths as many times as needed. The test comprised two parts (A and B), the first one did not offer specific guidelines on how to develop the task, while in the second, the participant should only follow the instructions, to be able to produce a route without errors (Wilson et al.,

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1996). Part A included a highly demanding task, in that the participant to be able to minimize errors, must have previously planned the order in which he/she will visit the indicated places. Part B was a task of low demand, in which the participant simply had to follow the instructions to be able to execute the task without errors.

Table 1. Participants Sociodemographic Characteristics

Variable	Category	DAT (n=50)	CG (n=60)	Statistic	*p*
Gender	Female	74.0%	76.7%	Chi^2= .11	.746
	Male	26.0%	23.3%		
Age		79.64 7.33	71.00 8.35	t= 5.71	.000** **
Years of schooling		7.92 3.83	7.73 2.91	t= .29	.772
Hand preference	Wright	96.0%	95.0%	Chi^2= .20	.906
	Left	2.0%	3.3%		
	Ambidextrous	2.0%	1.7%		

** = Significant at 1% (*p*< .01)
DAT: Dementia of Alzheimer's Type; **CG:** comparative group

In Part A, the task was to plan a route around the Zoo to visit all the places indicated in the instructions, recording the time spent in planning and the total time that also included the time dedicated to the execution of the drawing of the route. The number of errors committed in the sequence of places visited was also recorded. In Part B, instructions were given that involved an orderly sequence of places through which the route must pass, time and error being recorded as in Part A.

For each of the parts (A and B) we have included the following variables: (i) *total score* (sum total of the sequence minus the number of errors); it is a significant predictor of planning ability (Oosterman et al., 2013); (ii) *sequence*, (order in which the different locations are visited); it is a measure of executive functioning (Lezak, Howieson, & Loring, 2004); (iii) *total time* (planning time plus runtime in minutes); it is used as an estimate of processing speed (Oosterman et al., 2013); (iv) *number of errors* (failures in sequencing or when a rule is broken); the number of errors indicates the lack of adherence to standards (Wilson et al., 1996).

Data analysis

ANOVA of one factor to compare yields between both groups. To analyze the possible distorting effect of variable "age" on the results, a parametric statistical test

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(ANCOVA) was used. In all cases, the effect size was estimated to assess the magnitude of the observed differences. The effect size was reported according to Cohen's (1988) criteria (small effect= .1; medium effect= .3; large effect= .5)

Results

Part A

We found statistically significant differences ($p< .01$) between DAT patients with and CG with regards to *total score, time and errors*. The effect size was between *moderate* (total score) and *large* (time and errors). See Table 2. No differences were registered with regards to *sequence.*

Table 2. ANOVA

ZOO MAP TEST	Groups	Mean (SD)	F	p	Effect Size R^2
Part A					
Total Score	DAT	-.3 (3.3)	11.65	.001*	.097
	CG	1.6 (2.6)			
Sequence	DAT	4.1 (2.3)	.04	.832	.000
	CG	4.0 (1.8)			
Time	DAT	3.2 (1.7)	37.8	.000*	.259
	CG	1.7 (.7)			
Errors	DAT	4.4 (1.8)	39.7	.000*	.269
	CG	2.4 (1.6)			
Part B					
Total Score	DAT	3.9 (3.4)	41.5	.000*	.278
	CG	6.9 (1.2)			
Sequence	DAT	7.3 (1.5)	12.39	.001*	.103
	CG	8 (0.0)			
Time	DAT	2.6 (1.4)	54.75	.000*	.328
	CG	1.2 (0.5)			
Errors	DAT	3.4 (2.8)	35.91	.000*	.245
	CG	1.1 (1.2)			

*= Significant at 1% ($p< .01$); **DAT:** Dementia of Alzheimers' Type ; **CG**: Comparative Group

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In the analysis of covariance, a significant effect of *age* on the *total score and sequence* ($p < .01$), along with a *moderate* size effect, was observed (Table 3).

Table 3. Covariance Analysis. Factor Age

Zoo Map Test	Quadratic Mean	F	p	Effect Size R^2
Part A				
Total Score	86.67	11.01	.001 *	.093
Sequence	39,90	10.32	.002 *	.088
Time	.17	.10	.756	.001
Errors	7.51	2,67	.105	.024
Part B				
Total Score	4.96	.81	.371	.007
Sequence	.003	.003	.959	.000
Time	.07	.07	.796	.001
Errors	4.72	1,1	.298	.010

*= Significant at 1% (p< .01)

Part B

In all variables considered, *total score, sequence, time and errors*, there are statistically significant differences between both groups (p <.01). Table 2. *Age* has no effect on any of the variables considered (p> .05) (Table 3)

Discussion

Our results show that in part (version) A, where there were no instructions on how to develop the task, DAT patients differ significantly from participants without cognitive impairment as far as the *total score, time and number of errors* are concerned. There are no differences between the two groups as far as the order in which they visit the different locations (sequence) is concerned. In part (version) B where the participants were to follow the instructions to make a route without errors, the yields in all the variables, total score, sequence, time and errors are significantly worse in the DAT patients than in the participants of the comparison group . Our findings would be in line with those obtained by other authors who point out that DAT patients have more difficulties in developing strategies and executing complex plans (Allain et al., 2007; Piquard, Derouesné, Lacomblez, and Siéroff, 2004). The data

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elicited by this research showed that the planning ability of DAT patients is deteriorated. The yields obtained in the *total score*, part A and B, were significantly lower than expected, with a moderate and *high* size effect respectively. *Total score* was considered to be a predictor of planning ability (Oosterman et al., 2013).

T*otal time* (planning time plus run time), considered as an estimate of the processing speed (Oosterman et al., 2013) was significantly higher in DAT patients than in the comparison group participants. A frequent finding found in the research literature was the slow processing speed in DAT patients (Amieva, Rouch-Leroyer, Fabrigoule, & Daetigues, 2000; Nebes, & Madden, 1988; Phillips, Rogers, Haworth, Bayer, & Tales, 2013). Both groups took longer to complete part A than part B. In the former, the participants did not have specific implementation guidelines, they had to formulate an action plan before doing the task, which required more time, whereas in the latter, time needed was shorter due to the existence of specific guidelines.

DAT patients made more mistakes (sequencing failures or non-compliance of a rule) when executing both parts (A and B) of the test. It has been pointed out by other authors that the number of errors indicated a lack of adherence to established standards (Wilson et al., 1996). Failure to comply with a rule results in greater errors and executive planning problems, a characteristic of executive dysfunction observed in DAT patients (Mack and Patterson, 1994). Studies using the Tower of London or the Labyrinths of Porteus, have obtained similar results (Franceschi et al., 2007, Mack and Patterson, 1994, Rainville et al., 2002). It has been observed that DAT patients make more errors in the formulation phase than in the task execution phase, which could indicate a difficulty in the creation and usage of adequate strategies (Allain et al., 2005; Al., 2007).

When controlling for age, we observed that it had a significant effect on total score and sequence of part A. With regards to sequence, when looking at the means of the groups, there did not seem to be a clear correlation and it is possible that this result was probably due to chance.

Planning requires proper functioning of other executive components, such as working memory, inhibition, cognitive flexibility and reasoning, which are often affected in DAT patients and can lead to greater difficulty in correctly executing the task. Emmanouel et al. (2014) pointed out that the performing of this test may involve the participation of other higher processes, as is the case of visual scanning, visuoperceptive integration, visuospatial skills, or of some mnesic components whose deficits could be evidenced in DAT patients and that in turn would affect their test performance.

We consider that the Zoo Map Test is a task of remarkable interest to be applied in DAT patients, since it allows assessing different components of planning ability, aspect highly compromised in performance of daily living activities. Even if it´s a test of simple administration, as mentioned before, it involves different cognitive processes. DAT patients suffer from a progressive cognitive impairment affecting not only episodic memory but also executive functions, as working memory, inhibition ability, cognitive flexibility and reasoning, attentional processes and planning of action sequencing. Also, other non-executive cognitive components, as visuo-perceptive and visuospatial integration abilities, can be impaired. Considering that all these processes mentioned participate in this task, a low performance in this test could show different deficits related to them.

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Conclusions

Based on the results of our research we can conclude that planning ability is affected in DAT patients. The fact that DAT patients present these planning difficulties can lead a decrease in their functional independency. A correct executive functioning is needed to get along in our environment and pursue our goals. Executive impairment is related to a functional condition and reduction of quality of life that prevent the subject from maintaining his independency and affecting the planning of daily living activities ability, social relationships and leisure. When comparing to healthy subjects, DAT patients show troubles in following the order of visiting the different locations (Part B of the Zoo Map Test sequence) what could indicate difficulties in daily organization and planning abilities, as tooth brushing, taking a shower or getting dressed, by omitting steps or varying the logical order, aspects that compromises the functional independency. Thus, due to the high implication of planning ability in functional field, we consider that it would be interesting to include the Zoo Map Test in assessment protocols and DAT patient's follow-up.

It would be advisable in future studies to evaluate the planning ability in DAT patients with different degrees of severity. Research literature shows that alterations in the executive functions could be present from the early stages of the disease process (Allain et al., 2013; Chapman et al., 2011; Grober et al., 2008; Salmon, 2012) and that they are related to the Dementia's degree of severity (Amieva et al., 2004; Gibbons et al., 2012).

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Ethical statement

Valentina Ladera, Ricardo García, Manuel Cañas, & Mª Victoria Perea, declare that they have no conflict of interest.

Compliance with Ethical Standards

Ethical approval: 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.

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