Neurol Sci (2013) 34:173–180
DOI 10.1007/s10072-012-0975-3

ORIGINAL ARTICLE

The Multiple Features Target Cancellation (MFTC): an attentional visual conjunction search test. Normative values for the Italian population

C. Marra · G. Gainotti · E. Scaricamazza · C. Piccininni · M. Ferraccioli · D. Quaranta

Received: 17 December 2011 / Accepted: 3 February 2012 / Published online: 19 February 2012

Abstract Several studies, showing that attention disorders during encoding reduce later memory performance, have stressed the critical role of attention for the formation of durable memory traces. Accordingly, some studies suggest that attentive disturbances, together with declarative memory defects, can constitute the earliest cognitive disorders in Alzheimer's disease. Therefore, the analysis of these disorders can contribute to identify different forms of dementia and to detect demented patients characterized by a faster cognitive decline. In this study, we report the normative data (gathered in a large Italian population) of a short test that assess the ability to detect stimuli characterized by a conjunction of features: the 'Multiple Features Targets Cancellation' task (MFTC). Our sample of 465 subjects was composed by urban and rural people. Multiple linear regression analyses revealed significant relation of false alarms with age and educational level, and of time of execution with age, educational level and gender. Regression analyses on accuracy scores did not show any significant correlation with demographics variables. Based on non-parametric techniques, cutoff scores were obtained on the corrected scores of the patients, and equivalent scores were derived for each measure. The MFTC task represents a useful tool that explores attentional disorders (and in particular conjunction search disturbances) and that could be helpful both in discriminating different forms of dementia and to detect mild cognitive impairment patients at risk of conversion to dementia.

C. Marra (✉) · G. Gainotti · E. Scaricamazza · C. Piccininni · M. Ferraccioli · D. Quaranta
Department of Neuroscience Policlinico Gemelli, Center for Neuropsychological Research, Catholic University, l.go A. Gemelli, 8, 00168 Rome, Italy
e-mail: cmarra@rm.unicatt.it

Keywords Attention · Visual search · Alzheimer's disease · MCI

Introduction

Attention is one of the core issues in cognitive neuropsychology and a wealth of works has investigated its components in several experimental sets. Furthermore, and somehow following a parallel stream, the clinical interest toward the relevance of attentional disturbances in psychiatric and neurological diseases has been growing.

Thus, several studies have addressed the topic of attention deficits in demented subjects. In particular, AD patients perform worse than healthy controls in tasks exploring selective attention, i.e., the ability to screen out non-relevant stimuli [1–3] and divided attention, i.e., the ability to focus attention at the same time on more than one remarkable information or to divide the attentive resources on more mental activities contemporarily [4, 5].

The most common experimental paradigms adopted to investigate selective attention rely upon visual search tasks [6], in which participants search for a target item among distractors. The administration of search tasks to normal subjects has allowed identifying at least two modalities of visual search. The first is called "feature search" and is involved in the identification of targets with a unique feature. The second modality, called "conjunction search", is involved in the identification of targets based on a conjunction of features [1]. In recent years, several studies have explored the dissociation of (single) features search from conjunction search in demented subjects, showing that early AD patients and even subjects with mild cognitive impairment (MCI) [3] are more impaired in conjunction than feature search tasks [7, 8]. Furthermore, it has been suggested that other factors (such as target-distractors similarity) could explain these difficulties of AD patients. As a matter of fact, Porter et al. [8] have shown that AD patients who were administered feature and conjunction search task comparable as for target-distractors similarity made a significant number of false alarms exclusively in the conjunction task. From the theoretical point of view, it has been suggested that the impairment of conjunction search in AD could be due to depletion of attentional resources [9, 10] or to a reduced ability to access resource-saving strategies [1, 9].

The evidence of these specific attentional disturbances in AD comes from rather sophisticated investigations that are difficult to apply in clinical settings. Thus, an easy-to-administer neuropsychological test, exploring conjunction search, would be useful in assessing early AD and MCI subjects.

Our group has developed the Multiple Features Targets Cancellation task (MFTC) [11], a visual search task, in which subjects are requested to identify a target item in an array of distractors. The target consists of a square (side = 1 cm), with two segments, one stemming perpendicular from the midpoint of the base, and the other stemming from the left upper corner with a 45° angle. Both segments are about 0.5 cm long and oriented toward the center of the square; distractors have different orientation or origins of the two lines. Thus, the identification of the targets requires the elaboration of a conjunction of perceptual features (side and orientation of the segments inside or outside the square). The characteristics of targets and distractors in our task make difficult the perceptual grouping of distractors, which is supposed to play a role in classical feature search tasks [2].

As previously reported [11], AD subjects produced more false alarms than multi-infarct dementia (MID) patients and healthy controls on MFTC, and were slower than controls in completing the task, while they showed similar accuracy and slightly higher time of execution than controls in a single feature visual search test (line cancellation). This is in agreement with results of studies, in which conjunction search was investigated with more refined methods [3, 7, 8].

Focused attention, conjunction search, divided and sustained attention are part of the 'executive functions', which include several other motivational, cognitive and behavioral components. The study of exectuive functions plays an important role in detecting AD patients with a less favourable course of disease [12–15]. Also, MFTC has been shown to identify AD patients with a less favorable course of the disease [16].

To date, the lack of standardized scores of MFTC prevents neuropsychologists from using this task routinely for the diagnosis of dementia and also in predicting the evolution of dementia.

The aim of our study was to standardize and supply with normative data the MFTC, in order to obtain a useful diagnostic tool for the assessment of AD.

Materials and methods

Subjects

The investigation was carried out on 465 normal subjects (239 women) who varied in age and education (Table 1). Subjects were recruited among the relatives of patients afferent to the Neuropsychology Unity of the Policlinico Gemelli in Rome, coming from the metropolitan area of Rome and from its province and from various districts of Central and Southern Italy.

All participants were community dwelling individuals living independently. Exclusion criteria were: educational level below 3 years of schooling; any current or prior neurological disease affecting CNS (e.g., brain injury or stroke); current or past history of alcohol or drug abuse; current depression or major psychiatric diseases; familiarity for dementia; chronic medical conditions potentially affecting CNS (e.g., hypothyroidism, renal or hepatic failure). Furthermore, subjects were excluded from the study if their corrected MMSE score was below 24 [17].

Procedures

In this short "paper-and-pencil" test, subjects are presented with an array of 80 small squares, each containing two variously oriented lines, and requested to cancel as quickly as possible all the 13 items identical to a model placed immediately above the array, disregarding the 67 distractors (Appendix). The examiner starts the computation of the time of execution from the first item crossed out and stops when the subject has finished.

Three scores are obtained: time of execution, number of false alarms and accuracy. The latter is obtained using the following formula:

$$\text{Accuracy} = \frac{\left(\frac{\text{correct answers}}{13} + \frac{(67 - \text{false alarms})}{67}\right)}{2}$$

Results

Mean age of the sample was 62.10 ± 20.955 years (range 20–92) and mean education was 8.92 ± 5.322 years (range 3–17). Table 1 reports the distribution of subjects according to gender, age and education.

Mean accuracy of the whole sample was 0.94 ± 0.058 (range 0.77–1.00); mean number of false recognition was 0.52 ± 1.011 (range 0–7) and the mean time of execution was 80.95 ± 40.072 (range 20–206). For a descriptive presentation of mean scores of the three measures, according to the age and educational level, see Table 2.

The raw scores obtained on MFTC were set as dependent variables into several linear regression models, in

Table 1 Demographic distribution of the sample

Education (years)	Age (years) 20–29	30–39	40–49	50–59	60–69	70–79	80–89	>89	Total
3–5	–	4 (M = 2; F = 2)	6 (M = 2; F = 4)	7 (M = 2; F = 5)	47 (M = 23; F = 24)	86 (M = 45; F = 41)	56 (M = 24; F = 32)	9 (M = 2; F = 7)	215 (M = 101; F = 114)
6–8	3 (M = 0; F = 3)	2 (M = 1; F = 1)	2 (M = 1; F = 1)	4 (M = 2; F = 2)	17 (M = 6; F = 11)	28 (M = 18; F = 10)	6 (M = 6; F = 0)	2 (M = 1; F = 1)	64 (M = 35; F = 29)
9–13	8 (M = 5; F = 3)	7 (M = 5; F = 2)	8 (M = 4; F = 4)	10 (M = 5; F = 5)	15 (M = 9; F = 6)	15 (M = 8; F = 7)	18 (M = 11; F = 7)	1 (M = 0; F = 1)	82 (M = 47; F = 35)
>13	55 (M = 18; F = 37)	18 (M = 5; F = 13)	11 (M = 6; F = 5)	6 (M = 4; F = 2)	6 (M = 2; F = 4)	5 (M = 5; F = 0)	3 (M = 3; F = 0)	0 (M = 0; F = 0)	104 (M = 43; F = 61)
Total	66 (M = 23; F = 43)	31 (M = 13; F = 18)	27 (M = 13; F = 14)	27 (M = 13; F = 14)	85 (M = 41; F = 44)	134 (M = 76; F = 58)	83 (M = 44; F = 39)	12 (M = 3; F = 9)	465 (M = 226; F = 239)

order to assess the relative influence of age, education and gender. Age and education entered into regression analyses after several transformations (inverse, logarithmic, square root, quadratic, subtraction).

Accuracy

The accuracy in completing the task was not significantly influenced by age (best model after transformation as [ln (100 − age)]: $F_{(1,463)} = 1.054$; $P = 0.305$) or gender ($t_{463} = 1.630$; $P = 0.104$).

On the other hand, education had the highest effect after inverse transformation (1/education duration) ($F_{(1,463)} = 17.337$; $P < 0.001$). However, the amount of variance explained by the regression model was very low (adj$R^2 = 0.034$).

In order to overcome this limitation, and since only one variable seemed to influence the accuracy score, we tried to identify different cutoff points according to the level of education, choosing a parametric approach that is setting the cutoff points at 1.5 SD below the mean value of each group. The sample was subdivided on the basis of educational level into four groups: 3–5 years ($N = 215$); 6–8 years ($N = 64$); 9–13 years ($N = 82$); >13 years ($N = 104$). Then, we performed a one-way ANOVA with post hoc Tukey's tests to assess if contiguous groups achieved similar results or if it was necessary to identify a different cutoff point for each group.

As expected, there was a statistically significant difference between performances of the groups ($F_{(3,461)} = 5.264$; $P = 0.001$); subjects with 3–5 years of education obtained a mean score significantly different from the mean scores obtained by subjects with 6–8 and 14–17 years of education ($P = 0.003$ and $P = 0.041$, respectively). On the other hand, the mean scores obtained by the groups with more than 5 years of schooling were not significantly different. Thus, we identified two parametric cutoff points for subjects with 3–5 years of education (cutoff point: accuracy = 0.838) and for subjects with more than 5 years of education (mean accuracy = 0.95 ± 0.054; cutoff point = 0.869) (Table 3).

False alarms

The number of false alarms was not influenced by gender ($t_{463} = 1.298$; $P = 0.195$); age showed the best predictive power after transformation as [ln (100 − age)] ($F_{(1,463)} = 53.049$; $P < 0.001$); the best transformation for education was as 1/education ($F_{(1,463)} = 45.833$; $P < 0.001$).

The final model was:

$$\text{False alarms} = 0.585 - 0.428 * [\ln(100 - \text{age}) - 3.48] + 1.667 * \left(\frac{1}{\text{education}} - 0.16\right)$$

Table 2 Descriptive statistics of scores obtained on MFTC stratified for age and education

	Accuracy								
	Age								
	20–29	30–39	40–49	50–59	60–69	70–79	80–89	>89	Total
Education									
3–5	–	0.89 (0.054)	0.91 (0.058)	0.95 (0.061)	0.95 (0.059)	0.93 (0.058)	0.92 (0.065)	0.90 (0.054)	0.93 (0.061)
6–8	0.90 (0.080)	0.94 (0.022)	0.98 (0.027)	0.92 (0.079)	0.97 (0.034)	0.96 ()0.040	0.96 (0.023)	0.91 (0.076)	0.96 (0.046)
9–13	0.95 (0.036)	0.95 (0.062)	0.90 (0.071)	0.93 (0.054)	0.95 (0.058)	0.92 (0.059)	0.97 (0.036)	0.96 (–)	0.94 (0.055)
>13	0.93 (0.058)	0.95 (0.056)	0.95 (0.060)	0.99 (0.016)	0.96 (0.075)	0.98 (0.052)	0.96 (0.035)	–	0.95 (0.057)
Total	0.93 (0.057)	0.94 (0.058)	0.93 (0.065)	0.95 (0.059)	0.95 (0.055)	0.94 (0.057)	0.93 (0.061)	0.91 (0.054)	0.94 (0.058)
	False alarms								
	Age								
	20–29	30–39	40–49	50–59	60–69	70–79	80–89	>89	Total
Education									
3–5	–	0.0 (0)	0.0 (0)	0.14 (0.378)	0.74 (1.224)	0.73 (1.192)	1.11 (1.216)	1.33 (1.118)	0.80 (1.184)
6–8	0.0 (0)	0.50 (0.707)	0.0 (0)	0.0 (0)	0.29 (0.588))	0.36 (0.731)	1.00 (1.549)	2.00 (2.828)	0.41 (0.886)
9–13	0.25 (0.463)	0.0 (0)	0.25 (0.707)	0.30 (0.675)	0.20 (0.561)	0.53 (0.915)	0.56 (1.688)	0.0 (–)	0.34 (0.971)
>13	0.13 (0.336)	0.06 (0.236)	0.09 (0.302)	0.0 (0)	0.50 (0.548)	0.0 (0)	0.67 (0.577)	–	0.13 (0.343)
Total	0.14 (0.346)	0.06 (0.250)	0.11 (0.424)	0.15 (0.456)	0.54 (1.007)	0.60 (1.069)	0.96 (1.338)	1.33 (1.371)	0.52 (1.011)
	Time of execution								
	Age								
	20–29	30–39	40–49	50–59	60–69	70–79	80–89	>89	Total
Education									
3–5	–	68.75 (20.565)	63.83 (7.985)	68.29 (16.840)	93.21 (38.964)	98.38 (40.183)	116.45 (39.379)	116.67 (35.000)	100.23 (40.110)
6–8	66.00 (34.828)	47.50 (3.536)	54.00 (5.657)	48.75 (9.605)	86.12 (39.928)	81.18 (34.675)	105.83 (58.001)	165.00 (21.213)	82.78 (40.774)
9–13	52.38 (12.059)	53.57 (17.348)	62.13 (18.635)	61.90 (26.363)	53.33 (25.466)	73.80 (26.737)	78.56 (29.766)	120.00 (–)	65.26 (26.653)
>13	47.40 (15.147)	57.89 (37.175)	52.09 (18.897)	56.83 (24.326)	60.33 (29.777)	57.00 (21.679)	78.33 (5.774)	–	52.36 (22.754)
Total	48.85 (16.139)	57.65 (30.220)	57.81 (16.534)	60.48 (21.723)	82.44 (39.367)	90.49 (38.698)	106.08 (41.202)	125.00 (35.802)	80.95 (40.072)

Table 3 Cutoff points for scores derived from MFTC

Score	Cutoff
Accuracy	
Education ≤5 years	0.838
Education >5 years	0.869
False alarms	2.77
Time of execution	135.73

where 3.48 is the mean value of [ln (100 − age)] and 0.16 the mean value of 1/education.

Since parametric statistics are not suitable in the case of corrected scores, non-parametric tolerance limits were determined according to Walsh's procedure [18]. Corrected score of each individual was computed according to the equation reported above and then ordered from the worst to the best performance. The position of the inner and outer tolerance limits, defining the uncertainty region, depends upon the sample dimension; in the case of 465 subjects, the outer tolerance limit (corresponding to the cutoff point) is the 16th worst observation, and the inner tolerance limit is the 32nd observation.

The outer and inner limits obtained for the number of false alarms were 2.77 and 1.97, respectively. Table 4 reports the correction grid determined for the most common combinations of age (by a 5-year step) and education (according to the Italian scholastic system).

Time of execution

All the demographic variables taken into account influenced the time of execution of MFTC; there was a significant difference between mean time used by female and male subjects to complete the task (85.85 ± 43.877 s vs. 75.77 ± 34,966 s; $t_{463} = 2.746$, $P = 0.006$, respectively).

Age showed the best predictive power after quadratic transformation (age^2) ($F_{(1,463)} = 163.936$; $P < 0.001$); education had the highest predictive value when transformed as $\sqrt{education}$ ($F_{(1,463)} = 145.619$; $P < 0.001$).

The final model was:

$$\text{execution time} = 70.298 - 12.284 * \text{gender } (M = 1, F = 0) + 0.006 * \text{age}^2 - 14.422 * (\sqrt{\text{education}} - 2.84)$$

where 2.84 is the mean value of $\sqrt{education}$.

The outer and inner limits obtained for the time of execution were 135.73 and 121.97, respectively. Table 4 reports the correction grid determined for the most common combinations of age and education stratified by gender.

Conclusions

The clinical investigation of attention deficits has been assuming a great relevance in recent years. In fact, significant disturbances in attention have been reported since the early phases of AD and in MCI subjects [1, 3, 5, 7, 8, 11, 19]. Furthermore, the presence of attentional deficits could predict a faster cognitive decline in AD [16].

Gainotti et al. [11] showed that a different pattern of impairment can be detected in AD and vascular forms of dementia in performing the MFTC. The former were less accurate with a higher number of false alarms but normal time of execution, whereas the latter were characterized by an opposite behavior, with accuracy only slightly affected and the time of execution significantly lengthened with respect to control subjects.

Consequently, MFTC may suggest a useful tool in assessing deficits occurring in the early stages of dementia, since it could help in distinguishing both among different forms of dementia and in identifying subjects with a less favorable course of the disease.

On these grounds, in the present study we provide measures of accuracy, false alarms and time of execution of the MFTC that, as mentioned above, are not homogeneously affected in the different forms of dementia. Thus, the availability of standardized scores of the MFTC could add new support to the differential neuropsychological diagnosis of dementia. Our study shows that the different measures obtained in an attentional task are not homogeneously influenced by age, sex and educational level.

In our sample, the accuracy of target detection is not significantly influenced by age and gender, whereas there is an effect of educational level. The absence of a significant effect of age on target identification has been frequently reported [2, 20, 21]. In fact, a differential effect of age and education on memory and attention has been previously reported by Gomez-Perez and Ostrosky-Solis [22], who reported that age mainly affected memory functions, whereas attention was mainly influenced by education.

On the other hand, the production of false alarms was influenced by age and educational level but not by sex. An increase of false alarms in selective attention tasks in older age has been previously reported [21]. Finally, the time of execution of the task depends on age, educational level and gender.

Behavioral slowing in older subjects is one of the hallmarks of normal aging. It has been attributed to the impairment of sensory–perceptual and response processes [20, 23, 24]. Furthermore, older subjects are reported to be more "cautious" in performing cognitive tasks [25]; this attitude is subsumed by the realization of specific strategies in order to maintain accuracy, such as the increase of saccades during visual search [26]. This effect is particularly evident as for conjunction search tasks [2, 20, 27].

Neurol Sci (2013) 34:173–180

Table 4 Correction grid of false alarms and time of execution for the commonest combinations of age and education

	False alarms[1]														
	Age														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
Education															
3	0.10	0.07	0.04	0.01	−0.03	−0.06	−0.10	−0.15	−0.20	−0.26	−0.32	−0.40	−0.50	−0.62	−0.79
5	0.32	0.29	0.26	0.23	0.20	0.16	0.12	0.07	0.02	−0.03	−0.10	−0.18	−0.27	−0.40	−0.57
8	0.44	0.42	0.39	0.36	0.32	0.28	0.24	0.20	0.15	0.09	0.02	−0.05	−0.15	−0.27	−0.45
13	0.52	0.50	0.47	0.44	0.40	0.36	0.32	0.28	0.23	0.17	0.10	0.03	−0.07	−0.19	−0.37
17	0.55	0.53	0..50	0.47	0.43	0.39	0.35	0.31	0.26	0.20	0.13	0.06	−0.04	−0.16	−0.34
	Time of execution[2]														
	Age														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
Education															
3															
M	−6.09	−7.44	−9.09	−11.04	−13.29	−15.84	−18.69	−21.84	−25.29	−29.04	−33.09	−37.44	−42.09	−47.04	−52.29
F	−18.38	−19.73	−21.38	−23.33	−25.58	−28.13	−30.98	−34.13	−37.58	−41.33	−45.38	−49.73	−54.38	−59.33	−64.58
5															
M	1.17	−0.18	−1.83	−3.78	−6.03	−8.58	−11.43	−14.58	−18.03	−21.78	−25.83	−30.18	−34.83	−39.78	−45.03
F	−11.11	−12.46	−14.11	−16.06	−18.31	−20.86	−23.71	−26.86	−30.31	−34.06	−38.11	−42.46	−47.11	−52.06	−57.31
8															
M	9.72	8.37	6.72	4.77	2.52	−0.03	−2.88	−6.03	−9.48	−13.23	−17.28	−21.63	−26.28	−31.23	−36.48
F	−2.57	−3.92	−5.57	−7.52	−9.77	−12.32	−15.17	−18.32	−21.77	−25.52	−29.57	−33.92	−38.57	−43.52	−48.77
13															
M	20.92	19.57	17.92	15.97	13.72	11.17	8.32	5.17	1.72	−2.03	−6.08	−10.43	−15.08	−20.03	−25.28
F	8.64	7.29	5.64	3.69	1.44	−1.11	−3.96	−7.11	−10.56	−14.31	−18.36	−22.71	−27.36	−32.31	−37.56
17															
M	28.39	27.04	25.39	23.44	21.19	18.64	15.79	12.64	9.19	5.44	1.39	−2.96	−7.61	−12.56	−17.81
F	16.10	14.75	13.10	11.15	8.90	6.35	3.50	0.35	−3.10	−6.85	−10.90	−15.25	−19.90	−24.85	−30.10

[1] Regression model: false alarms $= 0.585 - 0.428^{*}[\ln(100 - \text{age}) - 3.48] + 1.667^{*}\left(\frac{1}{\text{education}} - 0.16\right)$

[2] Regression model: time of execution $= 70.298 - 12.284^{*}\text{gender (M = 1, F = 0)} + 0.006^{*}\text{age}^2 - 14.422^{*}\left(\sqrt{\text{education}} - 2.84\right)$

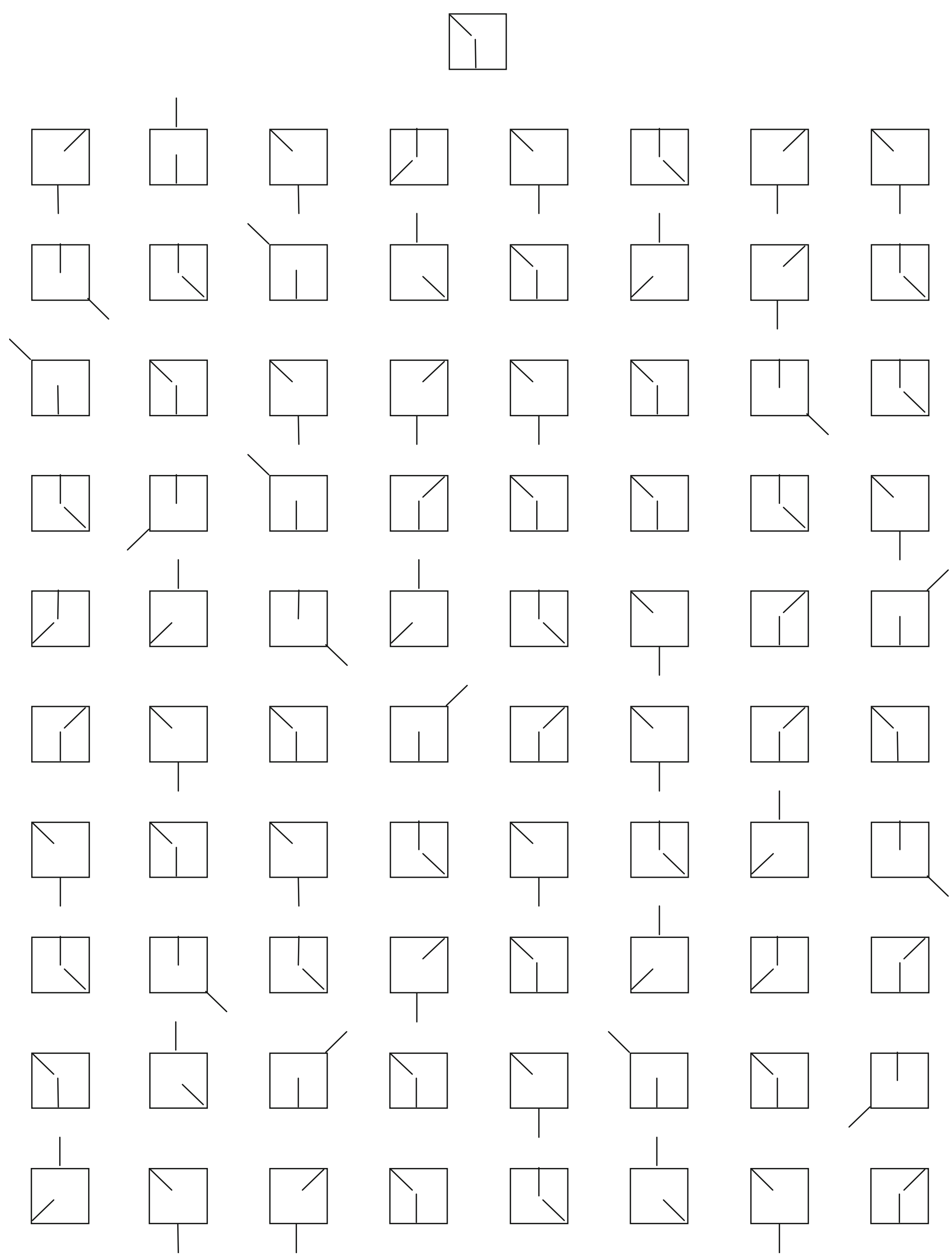
Finally, differences in attitude (and organization of the neural network) of men and women undergoing attentional tasks have already been reported in the past [28, 29].

The perceptual characteristics of stimuli used in the construction of the MFTC make it a plausible model of paper-and-pencil visual search task based on a conjunction search strategy. The difficulty to perform a perceptual grouping of distracters [2] make a serial scan of stimuli necessary, and the identification of targets is based on the conjunction of position and orientation of two segments.

In our opinion, the availability of measures of accuracy, false alarms (linked to a defect of control functions) and time of execution (related to elementary psychomotor defects) in an attentional task like MFTC is an additional tool that could help to distinguish among the different patterns of impairment observed in different forms of dementia.

Appendix

MULTIPLE FEATURES TARGETS CANCELLATION



References

1. Perry RJ, Hodges JR (1999) Attention and executive deficits in Alzheimer's disease. A critical review. Brain 122(Pt 3):383–404
2. Porter G, Tales A, Troscianko T, Wilcock G, Haworth J, Leonards U (2010) New insights into feature and conjunction search: I. Evidence from pupil size, eye movements and ageing. Cortex 46(5):621–636
3. Tales A, Haworth J, Nelson S, Snowden RJ, Wilcock G (2005) Abnormal visual search in mild cognitive impairment and Alzheimer's disease. Neurocase 11(1):80–84
4. Camicioli R, Howieson D, Lehman S, Kaye J (1997) Talking while walking: the effect of a dual task in aging and Alzheimer's disease. Neurology 48(4):955–958
5. Perry RJ, Zeki S (2000) The neurology of saccades and covert shifts in spatial attention: an event-related fMRI study. Brain 123(Pt 11):2273–2288
6. Davis ET, Palmer J (2004) Visual search and attention: an overview. Spat Vis 17(4–5):249–255
7. Tales A, Butler SR, Fossey J, Gilchrist ID, Jones RW, Troscianko T (2002) Visual search in Alzheimer's disease: a deficiency in processing conjunctions of features. Neuropsychologia 40(12): 1849–1857
8. Porter G, Leonards U, Wilcock G, Haworth J, Troscianko T, Tales A (2010) New insights into feature and conjunction search: II. Evidence from Alzheimer's disease. Cortex 46(5):637–649
9. Foldi NS, Schaefer LA, White RE, Johnson R Jr, Berger JT, Carney MT, Macina LO (2005) Effects of graded levels of physical similarity and density on visual selective attention in patients with Alzheimer's disease. Neuropsychology 19(1):5–17
10. Sebastian MV, Menor J, Elosua MR (2006) Attentional dysfunction of the central executive in AD: evidence from dual task and perseveration errors. Cortex 42(7):1015–1020
11. Gainotti G, Marra C, Villa G (2001) A double dissociation between accuracy and time of execution on attentional tasks in Alzheimer's disease and multi-infarct dementia. Brain 124(Pt 4): 731–738
12. Tabert MH, Manly JJ, Liu X, Pelton GH, Rosenblum S, Jacobs M, Zamora D, Goodkind M, Bell K, Stern Y, Devanand DP (2006) Neuropsychological prediction of conversion to Alzheimer disease in patients with mild cognitive impairment. Arch Gen Psychiatry 63(8):916–924
13. Buccione I, Perri R, Carlesimo GA, Fadda L, Serra L, Scalmana S, Caltagirone C (2007) Cognitive and behavioural predictors of progression rates in Alzheimer's disease. Eur J Neurol 14(4): 440–446
14. Fleisher AS, Sowell BB, Taylor C, Gamst AC, Petersen RC, Thal LJ (2007) Clinical predictors of progression to Alzheimer disease in amnestic mild cognitive impairment. Neurology 68(19):1588–1595
15. Palmer K, Lupo F, Perri R, Salamone G, Fadda L, Caltagirone C, Musicco M, Cravello L (2011) Predicting disease progression in Alzheimer's disease: the role of neuropsychiatric syndromes on functional and cognitive decline. J Alzheimers Dis 24(1):35–45
16. Marra C, Silveri MC, Gainotti G (2000) Predictors of cognitive decline in the early stage of probable Alzheimer's disease. Dement Geriatr Cogn Disord 11(4):212–218
17. Measso G, Caverzan F, Lebowitz BD, Crooke TH, Pirozzolo FJ, Amaducci LA, Massari D, Grigoletto F (1993) The mini-mental state examination. Normative study of an Italian random sample. Dev Neuropshychol 9:77–85
18. Spinnler H, Tognoni G (1987) Standardizzazione e taratura di test neuropsicologici. Ital J Neurol Sci 8(Suppl 6):1–120
19. Rizzo M, Anderson SW, Dawson J, Myers R, Ball K (2000) Visual attention impairments in Alzheimer's disease. Neurology 54(10):1954–1959
20. Madden DJ, Whiting WL, Cabeza R, Huettel SA (2004) Age-related preservation of top-down attentional guidance during visual search. Psychol Aging 19(2):304–309
21. Solbakk AK, Fuhrmann Alpert G, Furst AJ, Hale LA, Oga T, Chetty S, Pickard N, Knight RT (2008) Altered prefrontal function with aging: insights into age-associated performance decline. Brain Res 1232:30–47
22. Gomez-Perez E, Ostrosky-Solis F (2006) Attention and memory evaluation across the life span: heterogeneous effects of age and education. J Clin Exp Neuropsychol 28(4):477–494
23. Cerella J (1985) Information processing rates in the elderly. Psychol Bull 98(1):67–83
24. Salthouse TA (1996) The processing-speed theory of adult age differences in cognition. Psychol Rev 103(3):403–428
25. Rush MC, Panek PE, Russell JE (1987) Cautiousness and visual selective attention performance among older adults. J Genet Psychol 148(2):225–235
26. Watson DG, Maylor EA, Bruce LA (2005) Search, enumeration, and aging: eye movement requirements cause age-equivalent performance in enumeration but not in search tasks. Psychol Aging 20(2):226–240
27. Whiting WL, Madden DJ, Pierce TW, Allen PA (2005) Searching from the top down: ageing and attentional guidance during singleton detection. Q J Exp Psychol A 58(1):72–97
28. Bell EC, Willson MC, Wilman AH, Dave S, Silverstone PH (2006) Males and females differ in brain activation during cognitive tasks. Neuroimage 30(2):529–538
29. Rubia K, Hyde Z, Halari R, Giampietro V, Smith A (2010) Effects of age and sex on developmental neural networks of visual-spatial attention allocation. Neuroimage 51(2):817–827