UNIVERSITY OF BERGAMO

Faculty of Educational Studies

PhD Course in Clinical Psychology

A NEW TEST FOR

TOPOGRAPHIC DISORIENTATION IN ELDERLY PEOPLE.

PRELIMINARY RESULTS IN A HEALTHY SAMPLE

PhD Coordinator:

Prof.ssa Valeria UGAZIO

Tutor:

Prof.ssa Maria Luisa RUSCONI

PhD Candidate: Claudia ZAMIN

Registration Number: 1008687

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ABSTRACT

In the physiological aging, a reduction in processing speed, episodic memory and working memory have been well established. However, little is known about navigational abilities in elderly people and a few ecological tools are available. Recently, some evidences (Cushman & Stein, 2008; Hort et al., 2007) have suggested topographic disorientation (TD) as a possible marker of conversion from amnesic Mild Cognitive Impairment (a-MCI) to Alzheimer's disease (AD). The purpose of this research was to create a new ecological instrument in healthy elderly subjects to be subsequently used in clinical setting.

Sample: 38 healthy volunteer participants were enrolled, mean age 67.05 (*SD* = 8.06), 18 males and 15 females. All of them were right-handed.

Instruments: a neuropsychological standard battery and experimental tasks that consist of Bidimensional stimuli and the Plastic City with several subtests have been administered. The role of cognitive reserve in navigation abilities has been also evaluated by a recent standardized questionnaire (CRIq) (Nucci, Mondini & Mapelli, 2011).

Results: significant correlations among the experimental tests, spatial planning tasks and executive functions have been found. In navigation testing, no differences were detected according to gender, while age resulted to play an important role. Younger elderly showed better performances in execution times, learning of different paths and remembering landmarks met in the previous way. Participants who made many navigational mistakes showed worse scores in cognitive reserve and in visual-spatial memory task (Map Replacement, Recall Replacement on Map and Bidimensional stimuli).

Conclusion: according to the previous studies (deIpolyi, Rankin, Mucke, Miller & Gorno-Tempini, 2007; Cushman & Stein, 2008), remembering the correct place of landmarks seems to be an important ability in orientation, along with age and cognitive reserve. These preliminary interesting results support going on the research in elderly navigation; however the Plastic City needs to be improved and subsequently test and re-test. In future research, the Plastic City deserves to be applied also in MCI and early AD patients.

Keywords: aging, topographic disorientation, assessment.

To my grandparents

ABBREVIATIONS

AAICADD	Alzheimer's Association International Conference on Alzheimer's Disease
AD	Alzheimer's Disease
a-MCI	Amnestic Mild Cognitive Impairment
CIND	Cognitive Impairment No Dementia
CSF	Cerebrospinal Fluid
DSM-IV-TR	Diagnostic Statistical Manual of Mental Disorders Text Revised, IV Edition
DLB	Lewy-Body Dementia
FTLD	Fronto-Temporal Dementia
fRMI	Functional Magnetic Resonance Imaging
HAROLD	Hemispheric Asymmetry Reduction in OLDer Adults
HERA	Hemispheric Encoding Retrieval Asymmetry
HF	Hippocampal Formation
ICD 10	International Classification Disorders, 10 Edition
LTM	Long-Term-Memory
MCI	Mild Cognitive Impairment
MRI	Magnetic Resonance Imaging
MTL	Medial Temporal Lobe
NINCDS-ADRDA	National Institute for Neurologic Disorders and Stroke-Alzheimer's Disease Related Disorders Associations
non-a-MCI	Non Amnestic Mild Cognitive Impairment
PASA	Posterior-Anterior Shift in Aging
PET	Positron Tomission Tomography
SMI	Subjective Memory Impairment
SPECT	Single Photon Emission Computerized Tomography
STM	Short-Term-Memory
TD	Topographic Disorientation
Vad	Vascular Dementia
WM	Working memory
VR	Virtual reality

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INTRODUCTION

This research aims at investigating the navigation skills in healthy elderly people, suggesting a new and ecological instrument to assess it. Some evidences (deIpolyi, Rankin, Mucke, Miller & Gorno-Tempini, 2007; Cushman & Stein, 2008) support the role of topographic disorientation (TD) as a forerunner of cognitive degeneration. Some of the most known challenges for the current research concern the discovery of main features of physiological aging and the prevention-coping of neurodegenerative illness. Over 65 population is increasing, life expectancy is lengthening and, at the same time, births decline. This demographic flow raises some issues from social, psychological and health point of views. In this context, the study of normal and pathological aging, the markers of the transition from a normal stage to a pathological one are important topics (Craick & Salthouse, 2008; Dennis & Cabeza, 2008; Salthouse, 2010).

In the first chapter, an overview about normal and pathological aging has been provided. How cognitive functions change during life span have been illustrated, along with normal cerebral compensation networks discovered by current studies. The role of cognitive reserve has been also discussed as a recent and important factor to be considered in elderly.

The first and the second chapter share the role of hippocampus as an important area both for long-term memory and spatial skills.

Impairments in spatial memory have been discussed in the second chapter as possible marker of degenerative illness, and international research data have been provided. A brief overview of main instruments to evaluate orientation has been illustrated along with some limits.

The third chapter addresses to research: The Plastic City and Bidimensional stimuli have been presented as new and more ecological instruments useful for the assessment of navigation skills and visual-spatial abilities. The experimental design, all the instruments, the sample and results have been presented.

In the last chapter discussion, conclusion, limitations and suggestions for future research are provided.

CHAPTER 1

PHYSIOLOGICAL AND PATHOLOGICAL AGING

1.1 Physiological aging

1.1.1 Trajectories of cognitive functions

Several longitudinal studies have been conducted in order to understand cognitive changes in late normal adulthood (Duff & Grabowski, 2008). The best known are MOANS (Mayo's Older American Normative Studies), OKLAHOMA (Oklahoma Longitudinal Assessment of Health Outcomes in Mature Adults), CHAP (The Chicago Health and Aging Project), SALSA (Sacramento Area Latino Study on Aging), Seattle Longitudinal Studies, Victoria Longitudinal Studies and Berlin Aging studies.

The results show different cognitive profiles in normal elderly; in fact, only some abilities become worse during life span. As Schaie (1994) noted, perceptual speed and numerical abilities start to modify into the 25s while verbal memory, verbal ability and inductive reasoning decrease around about 53s. It's well known that perceptual speed and verbal fluency, as well as episodic memory, decline with the passing of time (70–100 years old) (Singer, Verhaeghen, Ghisletta, Linderberger & Baltes, 2003; Royall, Palmer, Chiodo & Polk, 2005; Albert, 2008). An association has been observed among decline in working memory, episodic memory and perceptual speed modification, while short–term and semantic memory are less sensitive to changes in normal aging.

Summarizing, in the elderly people there is a reduction in processing speed, episodic memory and working memory as compared to priming, short–term, autobiographic, semantic and implicit memory (Dennis & Cabeza, 2008). Several neuroanatomic explanations for this framework have been proposed. Some studies have established a global reduction of nearly 5% per decade after the age of 40 in the normal cerebral weight and volume, with a worst serious decline over 70 years (Godin et al., 2009; Shankar, 2010): this phenomenon seems to represent one the main reason for the speed slowdown. On the other hand, the thinning of gray matter leads to a decline in the dendritic arborization and cortical atrophy, especially in the dorsolateral prefrontal cortex implicated in working memory (see fig. 1.1).

Fig. 1.1 Dorso prefrontal cortex and medial temporal lobe

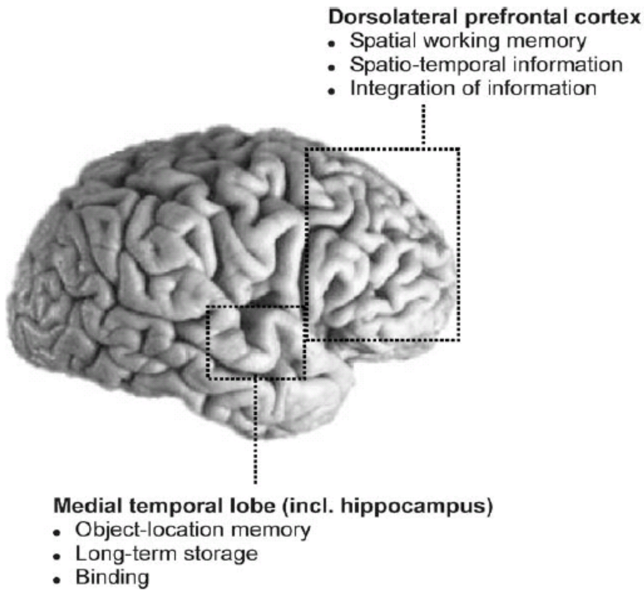
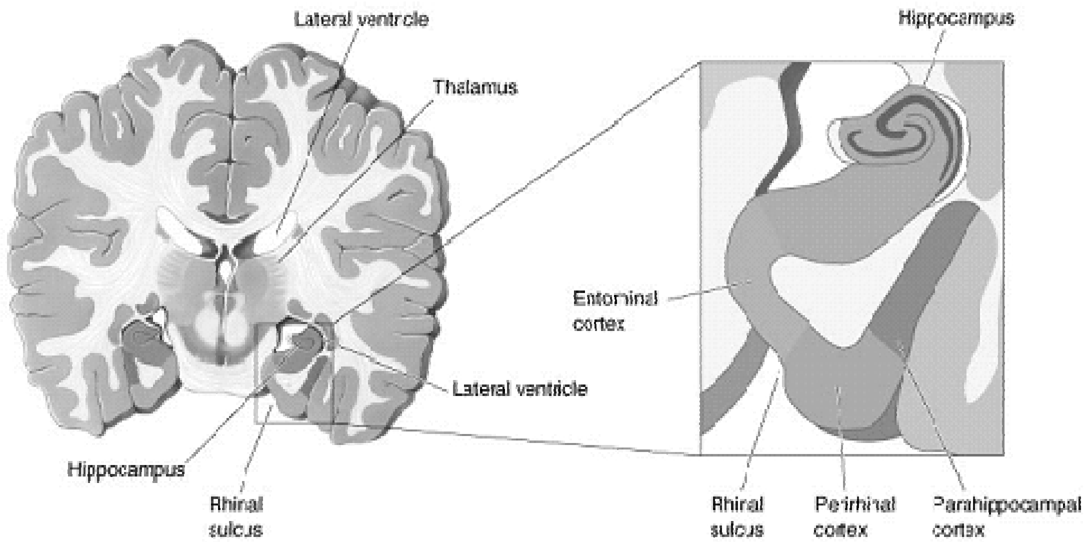


Image retrieved by (Kessels & Postma, 2006, p. 233)

The gray matter of fronto-parietal cortex and striatum is more damaged than temporal cortex and hippocampus. In fact, the volume of hippocampus drops by of 3%

every ten years (see fig. 1.2), differently from the frontal lobe that decreases of 1% every year (Salat, Kaye & Janowsky, 1999).

Fig. 1.2 Medial temporal lobe and hippocampus



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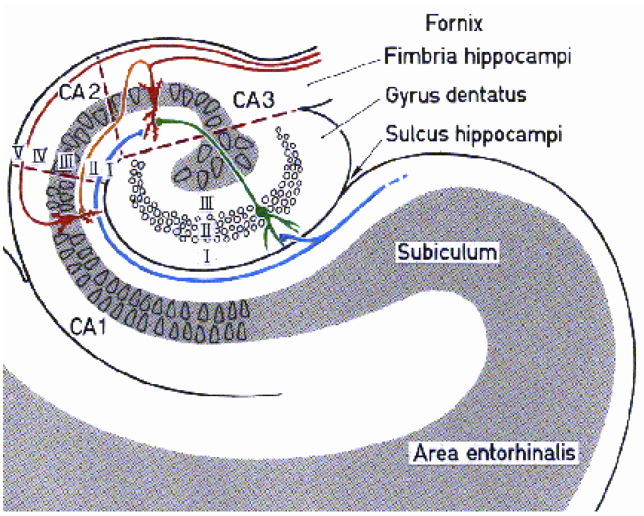
1.1.2 Memory: the crucial role of hippocampus

The hippocampus formation (HF) is a bilateral structure in the medial temporal lobe consisting of the hippocampus itself (CA1, CA2, CA3), dentate gyrus and subiculum. Enthorinal, perirhinal and parahippocampal cortices are next to hippocampus and surround rhinal sulcus (Lavenex & Amaral, 2000). Sensory information are processed by perirhinal (visual stimuli) parahippocampal (visual–spatial and movement information) and enthorinal areas that send input to dentate gyrus who projects it directly to area CA3 (see fig. 1.3): on its turn, it sends to CA1 and subiculum. CA1 then project backs to enthorinal, perirhinal and parahippocampal cortices: they are the major communication link between widespread areas of motor and sensory association cortex on the one hand and HF on the other.

Fig. 1.3 Hyppocampal Formation



Since the first researches in long-term memory (LTM) (Scoville & Milner, 1975), the crucial role of the hippocampus has been established within the memory neural system.

Memory has a multicomponent organization depending on different behaviors and cognitive functions, on the type of information and knowledge, on different neural mechanisms and differences in the timing of their appearance in phylogenetic and ontogenetic development (Tulving, 1984; Bradley & Kapur, 2010). According to the span of which information is retained, memory is usually divided into short-term memory (STM), working memory (WM) and long-term memory (LTM). The first two forms store limited information for less than a minute, in particular, working memory allows the manipulation of a piece of information to perform complex cognitive tasks. LTM is still much various. Considering the level of awareness and the content of a piece of information, LTM is composed of implicit (or non declarative) and explicit (or declarative) memory. Non declarative memory can be described as unintentional, automatic or without awareness. Procedural memory (learning and physically skills, e.g. riding a bike), priming, classical conditioning are examples of implicit memory. Tulving (1972) introduced two types of declarative memory: episodic and semantic. The last one includes language, world knowledge, meanings, concepts, and it manipulates symbols hoarded in the lifespan; in other words, semantic memory consists of the corpus of knowledge and information shared by the members of the same society (Dalla Barba, Traykov, & Baudic, 2008). On the contrary, episodic memory concerns events related to a person's past experience and happening in a specific spatial and temporal context. From a phylogenetic point of view episodic memory is developed by semantic one, so that they are partially overlapped as regard the type of information and neural correlates. Explicit memory, unlike the implicit, requires awareness of coding and retrieval.

Various clinical and research studies agree about role of the different components of memory processing (e.g. encoding, storage and retrieval) (Alberini, 2011; Craik & Lockhart, 1972; Calton & Taube, 2008; Inda, Muravieva & Alberini 2011) with consequent specific impairments evaluated in different ways. For example, according to neuroimaging researches by Dennis and Cabeza (2008), encoding studies can be divided in three main groups: intentional encoding, incidental encoding and subsequent memory studies. In the first one, subjects are scanned during learning of words, faces, routes. In incidental encoding studies, participants are required to make a judgment concerning the presented stimuli. Finally, in subsequent memory tasks, neural activity associated with successful encoding arises from the comparison of the activity from items that are subsequently remembered to items forgotten. As with encoding, retrieval can be divided into three categories: recall, recognition and context memory. In recall studies, subjects have to freely recall items learned in encoding phase; in recognition, participants have to judge if items are new or the same presented in encoding phase. Studies about context memory require subjects to remember the context (e.g. temporal order, location or color) in which the items have been presented.

1.1.3 The HAROLD and PASA models

The activation of the hippocampus and frontal lobe undergoes changes during the course of life. In adulthood it is observed a lateralization, so the encoding is due to left hippocampus activation (for verbal stimuli) and left prefrontal areas (for visual stimuli) while the retrieval is associated to right frontal lobe activity (the so called *HERA model - Hemispheric Encoding Retrieval Asymmetry),* (Nyberg, Cabeza & Tulving, 1996). On the contrary, in normal aging there is a sort of “compensation”, so that right and left hippocampus are both operative during the encoding phase, while prefrontal left cortex is less active (see table 1.1). Similarly, in retrieval, both left and right prefrontal areas are equally involved. Cabeza et al. (1997) defined all these observations *the HAROLD model* (*Hemispheric Asymmetry Reduction in OLDer Adults*) (Cabeza et al., 1997; Cabeza, 2002). The described data have been further studied: one hypothesis suggests the reduction of attentional resources during the encoding (*ibidem*) as a consequence of a little or bad recruitment of frontal structures, a difficulty in the use of automatic attention and lower inhibitory abilities. A superficial encoding leads to a poor recovery so that, in retrieval, the elderly should to involve frontal areas to support the most demanding of attentional resources.

Tab. 1.1 Neural activity in healthy elderly subjects

Episodic memory	Adulthood	Normal aging
Encoding	Left prefrontal areas Left Hippocampus	Prefrontal left areas: less active Left hippocampus: less active Right hippocampus: very active (Diffuse bilateral activation)
Retrieval	Right prefrontal areas	Right and left frontal activation (Diffuse bilateral activation)
	HERA Model	*HAROLD Model*

Other studies have recently found a reduction in lateralization also with regard to perceptual functions and motor activities in aging. The reduction in occipital activity causes an increased activation of frontal lobes. Davis, Dennis, Daselaar, Fleck, and Cabeza (2008) called this pattern *PASA* (*Posterior – Anterior Shift in Aging*). The diffuse bilateral activation of frontal lobes can also be explained with the reduction of neural activity and alteration of synaptic signals due to a dopamine reduction in these regions. These signals are more indiscriminate and inaccurate, and this turns into a less specific information processing. This entails a greater attentional control in order to complete an adequate processing (Li, 2005).

1.1.4 Cognitive reserve

The concept of "reserve" has traditionally been considered a buffer of a brain damage in different clinical outcomes, like HIV (Farinpour et al., 2003), schizophrenia (Barnett, Salmond, Jones & Sahakian, 2006) and brain injury (Kesler, Adams, Blasey, & Bigler, 2003).

More recently this construct has been studied in elderly (Bickel & Kurz, 2009; Nucci, Mondini & Mapelli, 2011; Perneczky, Diehl-Schmid, Drzega & Kurz, 2007). For instance, higher rates of Alzheimer's disease neuropathology at post mortem examinations were seen in individual who were not clinically demented but possessed heavier brains and higher counts of large neurons (Katzman et al., 1998). This mismatch between brain pathology and clinical expression means that there is a sort of "resistance" to the clinical expression of neuropathology. Literature is used to distinct among brain reserve, cognitive reserve, neural reserve and neural compensation (Stern, 2009).

Brain reserve concerns individual differences in the brain itself and it is useful to cope with the brain pathology. It deals with quantitative aspects like larger brain, more neurons and synapses; moreover experiences in life span can promote neurogenesis that counteracts apoptosis or empowers neural plasticity. Cognitive reserve is an individual differences too, and it concerns people's performance in different tasks. It could explain why some people with cerebral pathology can cope better than others with a same problem.

Instead, neural reserve and neural compensation deal with inter-individual variability; the first is about efficiency and flexibility in the healthy brain networks. In other words, a person with efficient networks might be more skilled of coping with brain pathology. Finally, neural compensation is the ability to compensate for brain pathology's disruption of standard networks by using networks not normally used by people with intact brain.

From a neuropsychological point of view, cognitive reserve is an interesting construct and it can traditionally be evaluated by means of education level, work, physical activity and leisure time; unfortunately all of these aspects have been assessed alone and without standardized procedures.

Recently, Nucci et al., (2011) have provided a questionnaire for a standardized measure of cognitive reserve accumulated by an individual trough his/her lifespan: the CRIq. It includes demographic data and items grouped into three sections: education, working activity and leisure time, each of which returns a subscore. Up to date, CRIq has been employed in healthy people, but it is a promising tool for clinical practice.

In appendix D the protocol is available.

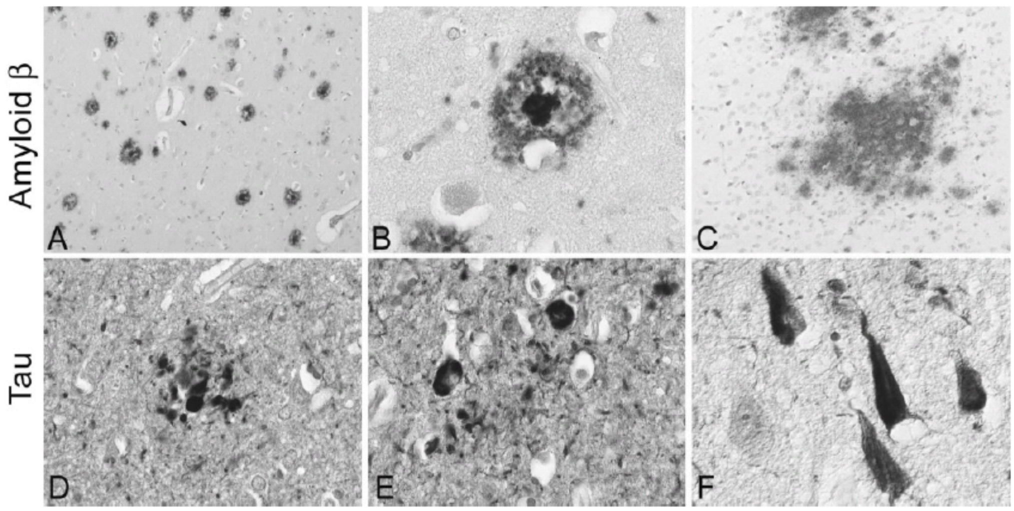
1.2 Pathological aging: from MCI to AD

The persistent loss of mental functions that affects multiple cognitive and behavioral aspect is defined “dementia” (Mendez & Cummings, 2003; Palmer, Musicco & Calatagirone, 2010). Symptoms have usually a gradual onset and progressive deterioration interferes with the daily-living activities. As Rossor (2009) highlights, literature provides several definitions of dementia based on which cortical functions are affected. Besides, different epidemiology data are available and they are influenced by which diagnostic criteria is involved (ICD-10; DSM-IV-TR; NINCCDS-ADRDA). Nowadays there is a vast debate about revision of dementia definitions (Dubois, et al., 2007; AAICADD, 2010; Galluzzi, et al., 2010) including volume loss evidenced by MRI, specific pattern on functional neuroimaging by PET and abnormal cerebral spinal fluid biomarkers.

At present, from a neuropsychological point of view, dementia includes the cortical damage of more than one cognitive domain (e.g. language, apraxia) usually memory. In particular, episodic memory impairment is pathognomonic of Alzheimer’s disease (AD), the most common type of progressive dementia. Epidemiology of degenerative disease in European elderly (> 65 years) shows that AD is 54%, Lewy-body dementia (DLB) is 20%, vascular dementia 16% and other 10%. Fronto-temporal dementia (FTLD) onset is often before 65 years old and is 12% of the other disease before 65 years old (Rossor, 2009).

There is a consensus that AD alterations in the brain develop slowly (10 – 20 years) before AD end stage, while cognitive deficits may start to appear 3-10 before the final stage (AAICAD, 2010; Duff & Grabowski, 2008, Palmer et al., 2008). Particularly, cerebral changes seem to be due to an accumulation of amyloid - Aβ-42 and tau and phospho tau (see figure 1.4) that subsequently caused neuritic plaques and tangles in medial temporal lobe (MTL). Finally AD shows a reduction of glucose metabolism in tempo-parietal cortex detected with SPECT or PET and wide range of structure are impaired (e.g. volume reduction in MTL).

Figure 1.4 Cerebral changes in AD



A,B,C: evolution of amyloid plaques in neocortex: from a lower power magnification (A) to a diffusion (C).
D, E, F: Tau immunohistochemistry leads to neurofibrillary tangles which assumes different shapes.

(*Image retrieved by Howard, Rossor & Shorvon, 2009 p.259)*

The first cognitive symptoms in AD are represented by a difficulty in learning and retention of new information well known as episodic memory, and hippocampus is one of the main structure involved. Over time, cerebral degeneration affects other brain regions causing a severe evolution (aphasia, apraxia, agnosia and executive dysfunction) while, primary motor and sensory cortices are less damaged than other cerebral structures (AAICAD; Albert, 2008).

Many attempts have been made to better understand the transitional phase between normal functions and AD. The epidemiological Canadian Study of Health and Aging (Graham et al., 1997) identified a condition that was not dementia but in which some cognitive functions resulted impaired in standardized tests. This condition has been called CIND (cognitive impairment no dementia). It was 16.8% of Canadian sample and of this percentage, 5.3% had memory deficits. CIND matched to the first definition of Mild Cognitive Impairment (MCI). This term first appeared in 1982 in association with stage 3 of Global Deterioration Scale (Reisberg, Ferris, de Leon & Crook, 1982). Actually, the revised criteria of MCI (Frank & Petersen, 2008; Winbland, et al., 2004) are similar to CIND, clinicians and researchers usually use MCI (Albert, 2008) to identify this phase.

The consensus clinical criteria for MCI are the following:

- The patient is neither normal nor demented.
- There is evidence of cognitive deterioration indicated by subjective report of decline by self and or informant in conjunction with objective cognitive deficits or objectively measured cognitive decline over time.
- Activities of daily living are preserved and complex instrumental functions are either intact or minimally impaired.

As it can be noted, MCI is a clinical entity referred to a cognitive impairment which is abnormal but insufficient for a diagnosis of dementia;

complaints are referred to cognitive domains (in the first version only memory was considered), both indicated by patients or caregiver and subsequently emergent in testing evaluation. As general guideline, performance between 1.0 SD and 2.0 SD (standard deviation) below to the mean of any cognitive measure is considered an objective deficit. It's very important that progressive deterioration is regard to the prior patient's baseline and, finally, cognitive deficits do not interfere in every day life.

Since the first definition, the construct of MCI has been revised, and different subtypes have been detected (Petersen & Morrison, 2005). Clinicians have to wonder if memory can fall into cognitive deficit. If the answer is "yes it can", MCI is called Amnestic-MCI (a-MCI), after that it can be divided into single (deficits are only in memory) or multiple domain (deficits are found in more domains). If memory is not involved, MCI is Nonamnestic (non-a-MCI). Even in this case there is a separation in single and multiple domain. It is interesting to note that, when clinicians detect MCI subtypes, guidelines suggest to determine the etiology of the syndrome for better understanding and possibly predicting the evolution of this condition (see table 1.2).

Tab. 1.2 MCI subtypes and possible etiology

		Etiology			
		Degenerative	Vascular	Psychiatric	Medical conditions
Amnestic MCI	Single domain	AD		Depr	
	Multiple domain	AD	VaD	Depr	
Non amnestic MCI	Single domain	FTD			
	Multiple domain	DLB	VaD		

AD = Alzheimer's disease; FTD = frontotemporal dementia; DLB = dementia with Lewy bodies, VaD = vascular dementia; Depr = depression.

This table highlights MCI as an evolution status; in fact, some patients who have been originally diagnosed MCI can convert to different pathologies. Some remain stable and others come back to a normal status. This framework rises many considerations. The first one: why do some patients convert to other pathologies and some other do not? Second, if a-MCI (single and multiple type) changes in AD, will it represent an incipient AD or, just, a risk factor? Research is trying to answer these questions. It's well established that MCI is a frequently occurring syndrome in the elderly; a European longitudinal study shows an incidence rate per 1000 person years between 11.4 for a-MCI and 33.8 for other cognitive impairments. It is interesting to note what the data reveals: the impairments are greater than dementia prevalence (Caracciolo, et al., 2008).

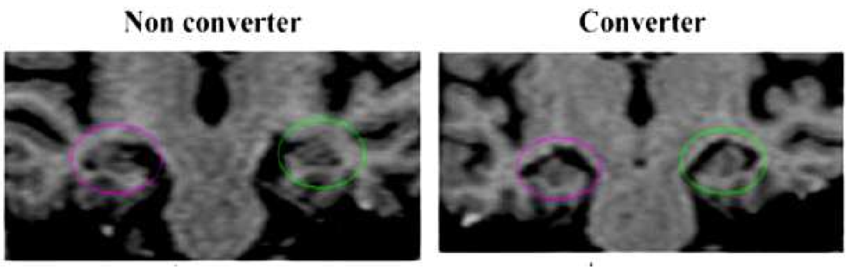
A recent meta-analysis (Mitchell & Shiri–Feshki, 2009) reveals the annual conversion in clinical setting (using Petersen's criteria) are the following:

- MCI converts to dementia 9.6%
- MCI coverts to AD 8.1%
- MCI converts to VaD 1.9%

Researchers conclude that most MCI will not convert to dementia even after 10 years of follow up. This fact could mean that MCI is not a disease per se, but a risk factor for AD.

Neuroimaging and neuropsychological attempt have been made to better understanding MCI converters to AD, finding in change's hippocampus volume (see fig. 1.5) a good marker.

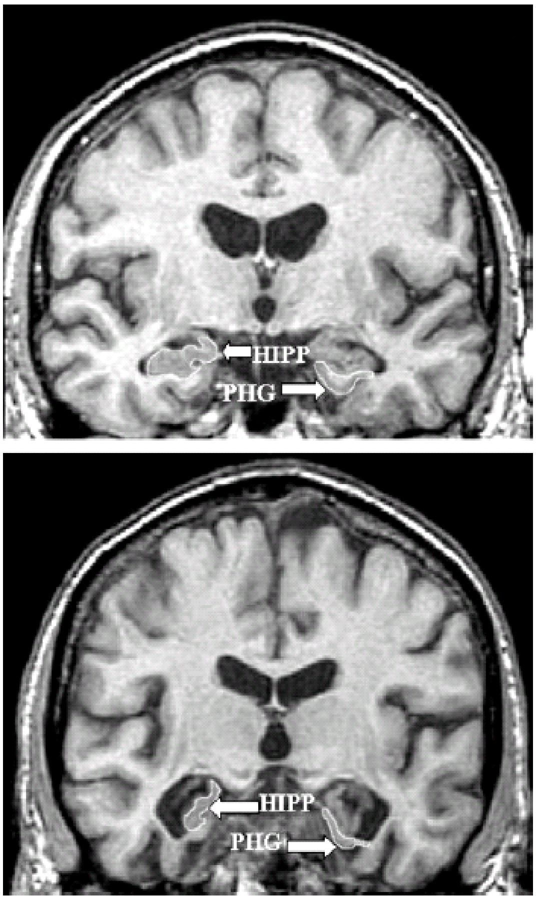
Figure 1.5 Hippocampal volume in MCI



(Image retrieved by Galluzzi et al., 2010, p.2)

A recent neuroimaging research suggests not only a reduction in the brain volume, but also a significant bilateral decrease in the hippocampus, entorhinal cortex and right amygdala in patients with AD, MCI and SMI (Subjective Memory Impairment) (Striepens et al., 2010). These results are consistent with studies reported in literature (Apostolova et al., 2008; Mosconi et al., 2005). Increase of CA1 and subicular atrophy are observed in cognitive normal subjects who will develop a-MCI, while progressive atrophy until CA2 – 3 observed in a-MCI patients leads to a conversion in AD (see fig. 1.6). Galluzzi et al. (2010) found that the medial temporal (MT) atrophy and abnormal CFS (level of beta amyloid in cerebrospinal fluid) are the most important predictors of the conversion from MCI to AD.

Figure 1.6 Cerebral structures in normal subject and MCI converter



HIPP = Hippocampus; PHG = parahippocampal gyrus

Upper image refers to a 70 years old male healthy subject.

Lower image refers to 67 years old male MCI converter

(Image retrieved by Devenand et al., 2007, p.68)

From a neuropsychological point of view, topographic disorientation seems to occur in a-MCI and AD (Bird et al., 2009; Hort et al., 2007). DeIpoly et al. (2007) and Cushman & Stein (2008) studies are proving that navigational deficits increase in MCI and AD while they do not in healthy normal subjects. Similar results have been observed for visual spatial short–term memory (Alescio – Lautier et al., 2007) that is involved in TD. If the early occurrence of TD among the clinical manifestations of MCI and onset AD are confirmed by further studies, it will be important to evaluate topographical orientation abilities in the neuropsychological assessment of aging.

CHAPTER 2

TOPOGRAPHIC DISORIENTATION: A FORERUNNER OF DEGENERATION?

2.1. Cognitive functions and orientation skills

The ability to interact efficiently in environments and to form a cognitive map is a prerequisite for the survival. This ability is called topographic orientation (Roche, Mangaoang, Commins & O'Mara, 2005). Many cerebral structures and cognitive functions (see table 2.1) are required to achieve an efficient navigation ability (Iaria, Bogod, Fox & Barton, 2009).

Tab 2.1 Cognitive functions involved in orientation

Cerebral regions	Cognitive functions
Orbito – prefrontal cortex	Attention , working memory, decision making
Parietal cortex - Retrosplenial cortex	Spatial perception - Update tracking the subject's movements – route learning
Hippocampal formation	Learning - retrieving spatial information (spatial memory), object location, binding
Subcortical structures (caudate nucleus)	Procedural memory along familiar environments

Spatial memory (the ability to remember the spatial characteristics of environment) has an important role in navigation **(**Kessels & Postma, 2006). As table 2.1 shows, it refers to several sub–processes which are correlated to different neural networks: route learning (posterior parietal cortex), spatial working memory (prefrontal cortex) and object location memory (hippocampal formation). Spatial memory can be divided into explicit and implicit: while in former the information about environments are consciously coded and retrieved, in the latter the stimuli are unconsciously processed. Normal aging seems to affect only explicit spatial memory (Caldwell & Masson, 2001).

Several hypotheses have been proposed to explain deficits in spatial memory. In the past, the context–deficit hypothesis was widely popular (Mayes, 1988) and it suggested that spatial memory impairment was caused by a difficulty in the contextual features coding. Nowadays, the binding–deficit hypothesis (Van Asselen, 2005) highlights that memory deficits could be a consequence of a difficulty in joining together the multiple features that compose a piece of target information. It's clear that these assumptions are not opposite, rather, they complete each other.

2.2 Hippocampus'role in egocentric and allocentric perspective

As in the first chapter has been illustrated, the medial temporal lobe is employed in long-term memory, and it is involved in spatial memory, in binding and object–location. Some recent neuroimaging evidences (Doeller, King & Burgess, 2008; Hartley et al., 2007; Hirshorn et al., 2011) show the role of hippocampal formation in topographic orientation (Aguirre & D'Esposito, 1999; Han, Pai & Hong, 2011; Iaria & Barton, 2010; Manning, 2010). In particular, hippocampus is activated by acoustic, olfactory, visual and vestibular inputs: all of them provide elements in order to create a spatial experience; such information is then converted into cognitive representations from an egocentric and allocentric point of view.

Egocentric (route) representations specify fixed sequences of salient landmarks (e.g. building, road sign), describing a starting point, a goal and a direction of movement, whereas allocentric (survey) representations allow preserving Euclidean relationship between landmarks in the environment (Aguirre & D'Esposito, 1999; Han Han, Pai & Hong, 2011; Panagiotaki & Bertoz, 2006). In human development these components emerge in different periods. By the age of 6-9 months, children are able to find their bearings in environment only using egocentric strategies. At 11 months they start to use information pertaining to landmarks and landmark array; finally the relation place strategies required for cognitive mapping start to develop at around 7 or 8 years and complete their development by 10 years (Lehnung et al., 2003).

In adulthood, to encode new spatial information, either allocentric or egocentric, the hippocampal area is recruited and information is stored in long–term memory; the right hippocampus is mainly active for allocentric pattern (see table 2.2) while bilateral parahippocampus formation is responsible for retrieving egocentric pattern (Han, Pai & Hong, 2011). A recent research (Ciaramelli, Rosenbaum, Solcz, Levine & Moscovitch, 2010) underlines the role played by the posterior parietal cortex in supporting egocentric representation of environments learned in the past. An interesting observation is referred to patients with parietal cortex damages who reported poorer feelings of familiarity and re-experiencing about navigation than control subjects.

Tab. 2.2 Different areas involved in egocentric and allocentric perspective

	Egocentric	Allocentric
Encoding	Hippocampal areas	Hippocampal areas
Retrieval	Bilateral parahippocampus areas Bilateral entorhinal and parahippocampal cortex	Right Hippocampus areas

Iachini, Ruggero, and Ruotolo (2009) investigated egocentric and allocentric strategies in a healthy elderly sample. The study found an age-related selective impact over egocentric processes starting from the 70s. Researchers argued that a decline before 70s in allocentric process could be pathological and it could represent the early symptoms of a neurodegenerative disorder.

The convergence of route and survey information forms a composite mental representation, defined “cognitive map” or “spatial map” (Roche et al., 2005). Neuroimaging studies (e.g. Iaria et al., 2007) have established that anterior hippocampus is involved during the formation of the map, while the posterior hippocampus is responsible for using it; moreover, the retrosplenial cortex is active during each phase as a sort of supervisor, useful for updating individual’s location when the frame changes.

2.3 Topographic disorientation in elderly people

TD is an individual's inability to orient himself-herself in the environment (De Renzi, 1982). This failure could be in learning new routes and orienting oneself within familiar surroundings (Guariglia, et al., 2004; Rusconi, Morganti & Paladino, 2008).

Traditionally, TD is well known as an isolated disorder caused by a focal brain injury resulting in two main deficits (Landis, Cummings, Benson & Palmer 1986): topographical agnosia and topographical amnesia. The first one is characterized by difficulty in identifying environmental landmarks. It usually occurs after brain lesions in the mesial part of the occipital–temporal region (lingual and fusiform gyri). In the second one (topographical amnesia), patients identify landmarks but they are not able to find a way because of the difficulty in keeping in mind the spatial relationship of environment.

Aguirre and, D'Esposito (1999) developed a taxonomy highlightening neural processes and the many ways in which mental navigation and landmark are related:

- *Egocentric disorientation* is usually associated to right posterior parietal cortex lesions (bilateral or unilateral); patients are able to recognize landmarks but they cannot represent the location of landmarks in respect to the their self;
- *Heading disorientation* is a selective impairment in the direction to go from the landmarks, even if they are recognized correctly. Heading disorientation is due to retrosplenial cortex-posterior lesions;

- *Landmark agnosia* is the inability to recognize salient environmental landmarks; it is subsequent to medial temporal–occipital cortex lesions (bilateral or right);
- *Anterograde topographical disorientation* is due to parahippocampal areas; it does not allow to form new cognitive maps of environments.

Topographic disorientation (TD) has been usually studied in adults with acquired brain damage (Aguirre & D'Espisto, 1999; Carelli et al., 2011; Ciaramelli et al., 2011; Rusconi et al., 2008) congenital malformations, genetic syndromes (Iaria et al., 2005) and retarded intrauterine development. More recently, some studies (Iaria & Barton, 20101) have investigated TD in adulthood also as a result of the selective impairment in the formation of mental representations of the environment. A prominent field of research is TD at the onset of degenerative illness like AD.

Medial temporal regions are damaged both in TD, MCI and AD. This fact could explain the onset of TD in these neurodegenerative disorders. Furthermore, some recent neuroimaging investigations have detected hippocampal and entorhinal atrophy in MCI who later convert to AD (Alescio – Lautier at al., 2007; Devenand et al., 2010), and a loss of grey matter in medial temporal regions (Kantarci et al., 2008) in MCI with TD at the onset. These results are consistent with the observation of deIpoli et al., (2007) about elderly, showing a reduction in the volume of posterior right hippocampus in "loosing elderly" .

2.4 Assessment tools for TD evaluation

Several instruments are usually used in neuropsychological assessment for TD. They can be divided as follows:

1. Paper and pencil tests: *Mental Rotation Test* is useful for measuring the ability to modify mental representations of geometric forms by implementing a rotation of the same, as to recognize the previously presented target in a series of alternatives (Grossi, 1991). Wisc-R Maze subtest (Wechsler, 1976) is another example of navigation paper and pencil test.

- Ecological methods (e.g. deIpolyi et al., 2007, Rankin, et al., 2007; Hort et al., 2007; Iaria, et al., 2009; Rusconi, et al., 2008). In these studies, subjects were asked to follow the experimenter into real environments, like hospital halls and corridors or city streets. Subjects had done the same path seen previously by the experimenter and they had to make a map of the route, recall landmarks, and other performances were required. This orientation assessment is very useful for studying deeper a single case, and it helps to understand the characteristics of the environment used for familiarization. However it does not allow to have normative data and it is time consuming;
- Virtual reality (VR) technology (e.g. Carelli et al., 2011; Cushman & Stein, 2007; Doeller et al., 2008, Hort et al., 2007, Iaria et al., 2007); in VR a real environment is reproduced and subjects were asked to move in. *Arena Maze Test* (Moffat & Resnick, 2002; Hort et al., 2007) or other software as *Quake3*, *ID software* (Hort et al., 2007), *Epic games* (Doeller, et al., 2008), *Game Studio A6* (Iaria, et al., 2007) are performed to evaluate TD. VR offers realness and

experimental control, providing a high dynamic and interactive representation of a complex environments. However there are not data about Italian pathological elderly people. What is more, its using may be controversial, because pathological subjects could make navigational errors caused by difficult in the use of technology.

- *Reading Maps and Road Map test* (De Renzi, 1982). In the first test, patients were given a road map of a trajectory about a way tracked in the floor, covered with some colored circles. Subject has to walk throw the circle following the trajectory on the map. In the second test, patients received a road map with a way marked route. Patient had to imagine himself walking along this route. At every crossroad, he had to decide if turning on right or left.
- Battery of tests for navigational disorders. Iaria et al. (2005) performed a battery included three different categories of tasks. The first category assesses specific domains like visual–spatial perception, visual spatial memory and visual spatial imagery. The second and third categories of tests assess specific navigational abilities involving an experimental and an ecological environment. This battery has been employed in healthy subjects and patients with brain injury.
- Navigational questions (e.g. Lim, Iaria & Moon, 2010). TD is evaluated by asking the patients or their caregivers if the subject hesitates about finding ways in an environment, if he has some difficulty in heading towards a specific desitination or in going back home. By using only questions, however, it may have not sufficient data to study deeper the involved cognitive functions.

All of the presented instruments can have some advantages and limitations too. One of the limits could be the difficulty in putting together both ecological tools and standardized assessments and not being able to share data interpretation, which is an important challenge for clinical and research fields. Literature reports the difficulty in making ecological and valid evaluations which involve the control of external variables and make a laboratory setting similar to the real world (Cavallini & Vecchi, 2006). Last but not least, in order to obtain reliable data, the instruments for pathological Italian elderly people need to be adequately developed.

CHAPTER 3

CLINICAL RESEARCH

3.1 Aims

Since TD has been found in MCI converter to AD and not many instruments are available in Italian elderly, this research attempts to create a new ecological instrument (the Plastic City) to be used in clinical practice. Preliminary results collected in a sample of healthy elderly are going to be presented. The hypotheses of the study support that:

1. Females would show more navigational mistakes than the males.
2. The oldest people in the sample would show more navigational mistakes than the youngest.
3. According to literature (deIpolyi et al., 2007), TD is not caused by deficit in recognition landmarks, rather it is due to deficit in visual–spatial memory abilities.
4. Inspired by a previous study (Alescio-Lautier et al., 2007), a bidimensional visual-spatial test has been also created to be compared with other navigational visual–spatial tasks in order to find significant correlations between experimental tasks (bidimensional and tridimensional) and neuropsychological standardized instruments.

Finally, cognitive reserve has been evaluated to study its possible implication in navigational abilities.

3.2 Method

3.2.1 Sample

38 healthy volunteer participants have been enrolled, 18 males and 20 females. After a complete description of the study to the subjects, informed written consent was obtained for the elaboration of personal data, in accordance with Law 675/1996 (model 2003). Nobody received money for participating in research. All subjects had no history of neurologic, psychiatric and movement illness. They underwent a screening evaluation of cognitive functions: MODA (Milan Overall Dementia Assessment) (Brazzelli, et al, 1994), GDS (Global Deterioration Scale) (Reisberg et al., 1982) and CDR (Clinical Dementia Rating) (Hughes, Berg, Danziger, Coben & Martin, 1982) were employed. Subjects who obtained MODA score < 89 (MODA's cut-off for normal performance), GDS score > 2 and CDR score > 0.5 were excluded.

3.2.2 Assessment

In order to evaluate subjects' spatial abilities and general cognitive functions, a comprehensive neuropsychological battery was administered. These tests are described in the next paragraphs, together with the experimental Plastic City and Bidimensional stimuli.

3.2.2.1 Screening evaluation

Milan Overal Dementia Assessment (MODA) (Brazzelli et al., 1994) is a useful Italian screening test for cognitive impairment. It is a rating scale divided into three sections: orientation (spatial, temporal, personal and familiar), autonomy (e.g. walking;

incontinence) and neuropsychology assessment (reversal learning, attentional test, verbal intelligence, short story, semantic fluency, token test, digital agnosia, constructional apraxia, and street's completion test). Scores lower than 85.5 are considered pathological, scores between 85.5 and 89.0 are considered borderline, scores higher than 89.0 are normal.

Global Deterioration Scale (Reisberg et al., 1982) and Clinical Dementia Rating Scale (Hughes et al., 1982) are international instruments; clinicians judge the gravity of a degeneration considering the impairment of cognitive functions. GDS scores lower 2 and CDR correspond to normal score.

3.2.2.2 Standard neuropsychological tests

After screening test, a comprehensive neuropsychological assessment was employed to evaluate cognitive functions.

Progressive Raven's Matrices (PM 47) were administered for intelligence level (Measso et al., 1993), short Token test (MODA), Phonemic and Semantic Fluencies (Novelli et al., 1986) for verbal abilities evaluation. Verbal memory was assessed by Digit Span forward and backward (Orsini et al., 1987), Short Story Recall (included in MODA), Short Story Recall (Novelli et al., 1986) and Bisyllabic Words Repetition (Spinnler & Tognoni, 1987) while visuo-spatial memory was evaluated by means of Corsi Span (Spinnler & Tognoni, 1987) and Rey's Complex Figure Recall (immediate and delayed) (Carlesimo et al., 2007). Attention and executive functions were evaluated by means of the Trial Making Test (divided attention) (Giovagnoli et al., 1996) and attentive matrices (selective attention) (Spinnler & Tognoni, 1987).

Spatial ability evaluation was composed by the Rey's Complex Figure Copy (Carlesimo et al., 2007) and the Elithorn's Perceptual Maze test (Spinnler & Tognoni, 1987) for visual-spatial planning evaluation. Visual-perceptual abilities were assessed by means of Street's Completion test (MODA), while Pictures Copy (MODA) was employed for visuo-constructional skills. Besides, Manikin's test (Ratcliff, 1979) was administered in order to evaluate right-left orientation ability. The presence of unilateral spatial neglect was assessed by means of the line cancellation test included into the Behavioural Inattention test (BIT) (Wilson, Cockburn & Halligan, 1987).

Finally, cognitive reserve was measured by a recent questionnaire (CRIq) (Nucci et al., 2011) which is composed by CRI School, CRI Work, CRI Free-Time and CRI total sections, each of which provides a subscore.

3.2.2.3 Experimental tasks

a) Navigation into the Plastic City Test

An ideal city made up of 14 Lego's pieces (4 – 12 cm about), 12 road signs, one toy car and one lay-figure was built. All landmarks were removable and they were supported on a thick sheet (100 X 80 cm) on which are printed 18 road and 4 squares (see figure 3.1, 3.2, 3.3, 3.4). The disposition of streets and routes name were inspired by a "navigation test" (Pazzaglia, Poli & De Beni, 2004).

Fig. 3.1 The Plastic City (global vision)

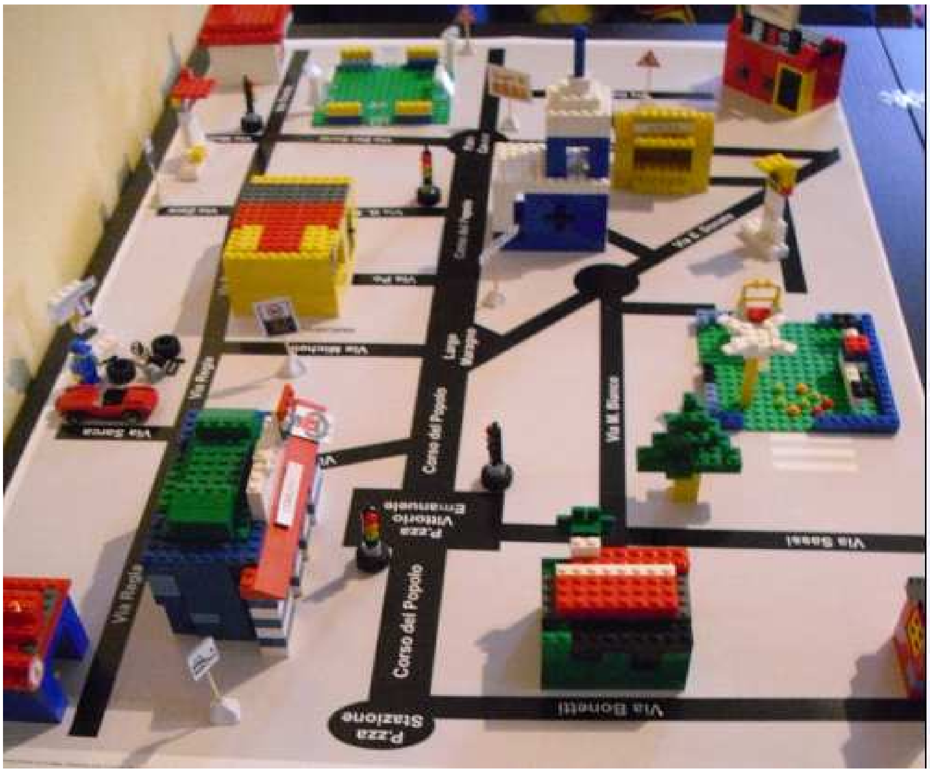


Figure 3.2 The Plastic City (a detail)

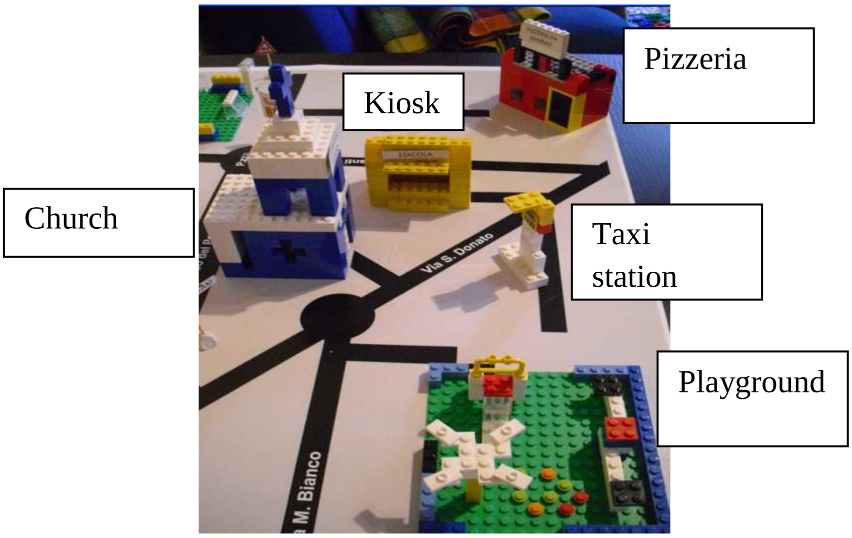


Figure 3.3 The Plastic City (a detail)

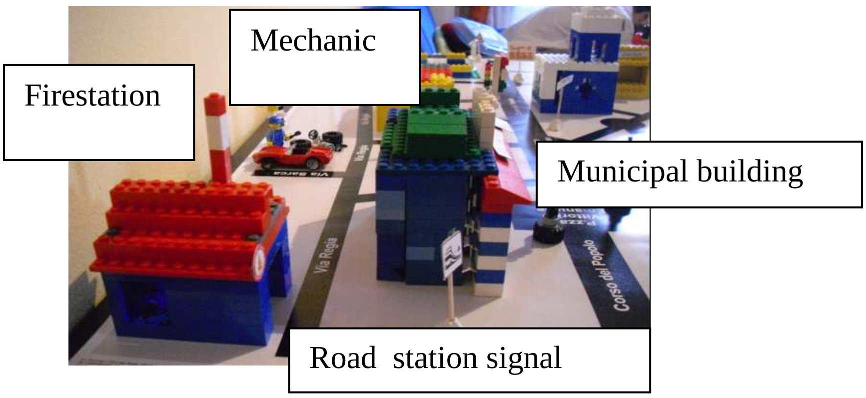
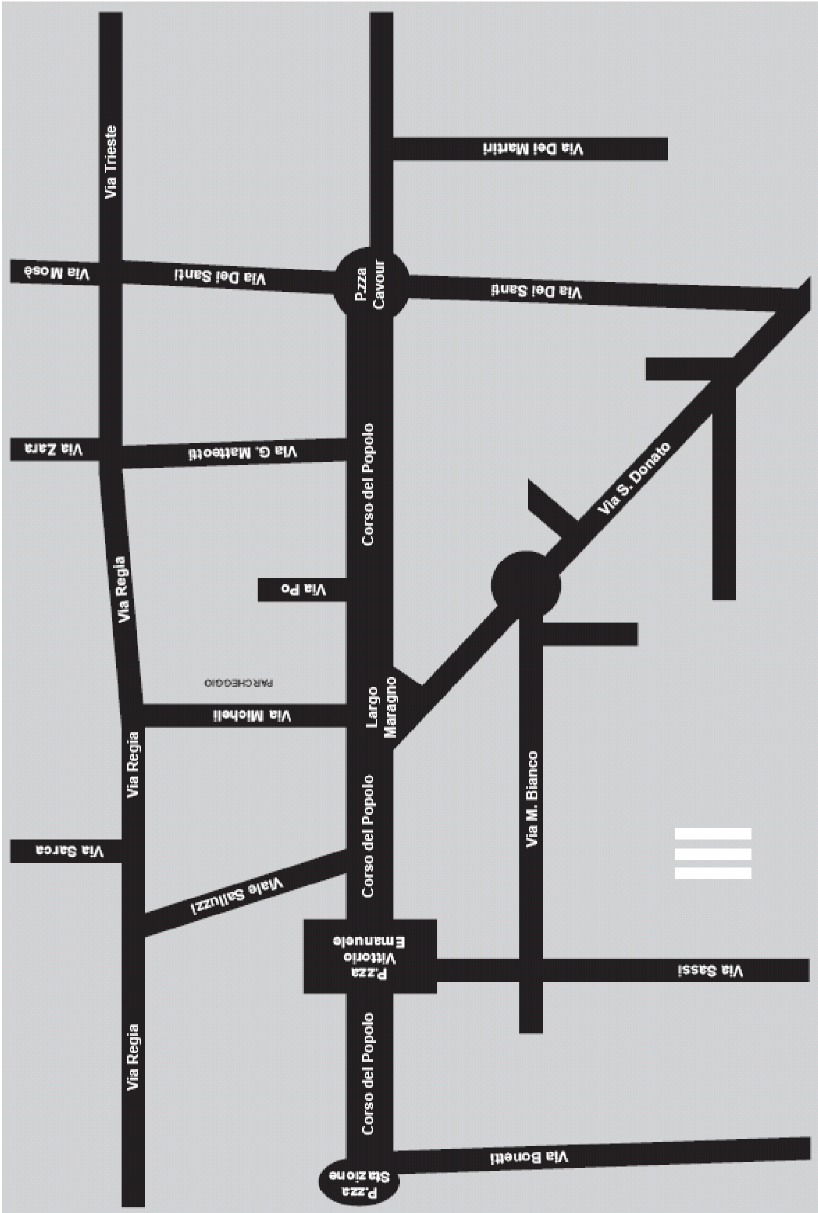


Figure 3.4 Roads of the Plastic City



Tasks were inspired by previous studies in VR and ecological environments (Cushman & Stein, 2008; deIpolyi et al., 2007) and partially modified. They consisted of the following eleven subtests:

1) Route Learning Forward test (I): after the route demonstration performed by the examiner, subjects were required to repeat the same path, with the possibility of modifying route errors. The examiner had to take note about time and errors and he could bring him/her back to the last correct place. If the subjects had lost at the beginning of the path, the examiner would show the route again. Only one chance was allowed.
2) Route Learning Backward test: after completing the Route Learning Forward test, subjects were asked to make the path in the reverse direction, by crossing the same landmarks. Data were collected as in the previous task without the possibility to see the path again.
3) Landmark Recall: subjects were given one minute to recall buildings, road signs, traffic lights, name of streets and any other landmark they have met during the previous path. The examiner registered all named landmarks (both in route F1 – B1 and outside the path).
4) City Landmark Replacement: the examiner removed two buildings, a poster advertisement, one road sign (bus stop) and one traffic light; then, participants had to replace those elements in the Plastic City correctly.
5) Map Drawing: participants were turn back the Plastic City, and without having the possibility to watch it. It was asked to draw a map of it. The

following evaluation was performed: 2 scores if the landmark was correctly placed; 1 score, for the adjoining position; 0.5 score when the landmark was put in the wrong place; 0.25 score if the participants were able to name the landmark, but they would not replace it, or if they were not able to name it exactly (e.g., “road signs” instead of “work in progress”).

6) Landmark Recognition: subjects saw ten photographs; five of them were taken from the city, while the remaining five were modified (a false landmark had been introduced or a landmark had been moved from its real position). Subjects had to say if the photo was true or false.
7) Map Replacement: the same photographs of previous subtest were shown again and subjects had to replace each landmark on a blank map in the correct position. If participants placed, at least, two correct landmarks (and recognized the untrue in the false photos), the answer was considered correct.
8) Recall Replacement on Map: a city map without the name of the streets and landmarks had been shown to participants. They had to say which landmark corresponded to six points indicated on the map.
9) Route Planning: after showing for 45 seconds a map with the name of the streets (without any other landmarks), the examiner removed it and participants had to say which way to go from a place to another (e.g. school to pharmacy). He took note about time and scored 0.5 for each street correctly named, 1 for correct directions (e.g. right, left, go straight on) and 0.5 for mentioned landmarks. For each mistake, scores were removed (-1 for

directions, -0.5 for landmarks and streets). The examiner took note about time.

10) Short Route Planning: while watching the plastic city, subjects had to say which was the shortest way to go from sport stadium to bakery. Data were collected as in the previous subtest. The examiner took note about time.

11) Route Learning Forward (II): this task was identical to the first subtest but with a different path.

The table below (3.1) summarizes subtests and scoring.

Tab. 3.1 Navigation subtests and scoring

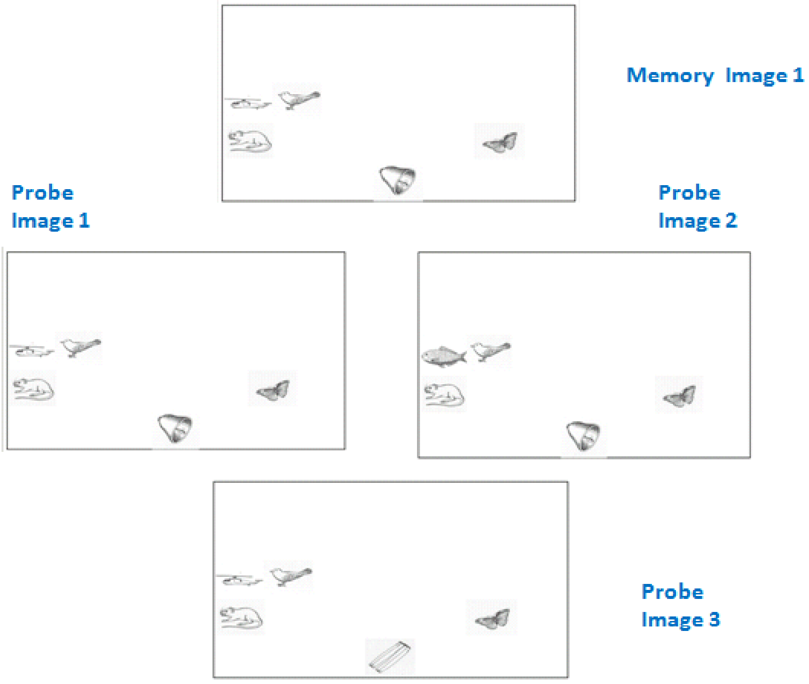
	Subtests	Scoring	
1	Route Learning forward test (1)	Number of errors	Time
2	Route Learning back test (1)	Number of errors	Time
3	Landmark recall (route, other, tot)	Number of landmarks	60 sec
4	City landmark replacement (5)	Number of landmark correctly replaced	
5	Map drawing	(2 ; 1; 0.5; 0.25)	
6	Landmark photo recognition (5V – 5F)	Number of photos correctly judged	
7	Photo map replacement (10)	Number of photos correctly replaced	
8	Recall replacement on map (6)	Number of identified elements	Time
9	Route planning (map)	0.5 route 1 right, left, straight on	Time
10	Short route planning	0.5 route 1 right, left, straight on	Time
11	Route Learning forward test (2)	Number of errors	Time

Appendix A shows the research protocol and some experimental navigation tests.

b) Bidimensional Stimuli Test

Stimuli consisted of black and white line-drawing images representing concrete objects of daily living. The image was randomly located in a 5×7 grid on a paper sheet. Images had no salient distinguishing features. 40 images have been used with 10 trials. Each trial was composed of a memory image (MI) and three probe images (PIs). The MI contained 5 images. The images of the MI were presented at random locations within the background. The PIs always contained the same number of images as the MI. The subjects' task was to detect whether images were changed or not (visual short-term memory, VSTM) as regards their spatial location. Among the three PIs, there was always one PI in which no change occurred (no-change) and two PIs in which visual change have occurred (change). The subjects were invited to answer "Yes" if any change have occurred, "No" if some change have occurred. The position of the no-change-PI between the three PIs was balanced. This means that in some cases the PI without change could be presented as first, in other cases as second and in other as third probe image. The trial was scored as correct when the subject gave the right answer for all three probe images. So the score of each patients could vary between 0 and 10. Figure 3.5 shows a trial.

Fig. 3.5 Example of Bidimensional Stimuli



3.2.3 Procedure

Two sessions were scheduled for each participant: in the first session, the informed consent was obtained and the screening test was administered; in the other session, the neuropsychological evaluation, the navigation testing, Bidimensional stimuli test and CRI questionnaire were conducted. The overall experimental procedure took about three hours for each subject.

3.2.4 Statistical analysis

Results from navigational tasks, Bidimensional stimuli were correlated to neuropsychological battery (Pearson product-moment correlation, $p < .05$).

After verifying that the sample had a normal distribution (Kolmogorov-Smirnov one sample *p*>.05), one-way ANOVA was employed in order to find significant differences between male and female, "young" elderly" and "old elderly" (mean age was used to divide sample). Finally, a new variable has been created (mean of total mistakes in route F1, B1, F2) and subjects with higher scores and lower scores than mean have been compared. The statistical software SPSS 15.0 was used to analyze the data.

3.3 Results

As table 3.2 shows, sample mean age is 67.05 (*SD* = 8.06) and mean education level of participants is 8.84 (*SD* = 4.29). Sample is quite balanced for sex (males 47.36%; females 52.63%); all subjects are right-handed and the most of them is retired (78.94%). Table 3.3 illustrates subjects' performances on neuropsychological standard test.

Tab. 3.2 Socio-Demographic Characteristics of Subjects

	M (SD)
Age	67.05 (8.06)
Education level	8.84 (4.29)
Hadness (%)	
Right	100
Left	
Gender (%)	
Males	47.36
Females	52.63
Marital status (%)	
Married	89.47
Widowed	10.52
Occupation (%)	
Retired	78.94
Employee	5.26
Housewife	15.78

M = mean, SD = Standard deviation

Tab. 3.3 Performances on neuropsychological tests

	M	SD	Min	Max
Cdr	0.13	0.22	0.00	0.50
Gds	1.18	0.39	1.00	2.00
Moda	92.25	2.45	89.00	96.90
Elithorn	11.13	3.81	1.75	16.25
Raven PM (47)	28.46	5.00	16.00	36.00
Bisyllabic	3.74	0.83	2.55	6.75
Corsi	4.82	0.93	2.50	6.75
Forward_Span	5.26	0.98	3.50	7.50
Backward Span	3.50	0.95	2.00	6.00
Short MODA	5.06	1.84	0.00	7.40
Rey Copy	31.50	5.67	11.40	38.90
Rey Immediately	16.42	6.61	3.40	29.00
Rey Delayed	15.91	5.01	6.70	27.60
Pesenti Story	15.55	3.18	9.50	21.00
Street MODA	2.45	0.69	1.00	3.00
Token MODA	4.92	0.36	3.00	5.00
Phonemic Fluency	33.13	10.30	14.00	58.00
Semantic Fluency	42.68	6.73	28.00	56.00
TMT A	36.66	40.21	3.00	203.00
TMT B	86.76	66.94	23.00	312.00
TMT BA	53.00	51.61	41.00	218.00
Matrices	51.70	6.32	33.25	60.00
Manikin Test	23.39	5.80	16.00	32.00
Barrage Lines	35.97	0.16	35.00	36.00
Copy MODA	2.83	0.37	1.50	3.00

M = mean, SD = Standard deviation

With regard to navigational subtests in the Plastic City (see table 3.4), every participant saw the first way once, and errors decreased in the three paths: Route F1 (*M* = 1.55, *SD* = 1.37), Route B1 (*M* = 1.03, *SD* = 1.42), Route F2 (*M* = 0.76, *SD* = 0.79), along with time Route F1 (*M* = 48.37, *SD* = 21.72), time Route B1(*M* = 39.29, *SD* = 24.26), time Route F2 (*M* = 29.87, *SD* = 20.32).

Tab. 3.4 Mean and standard deviation of experimental navigational subtests

		M	SD	Min	Max
Subtest1	Route_F1	1.55	1.37	0.00	7.00
	Time F1	48.37	21.72	14.00	105.00
	Number_Vision	1.00	0	1.00	1.00
Subtest 2	Route B1	1.03	1.42	0.00	6.00
	Time B1	39.29	24.26	11.00	120.00
Subtest 3	Route Recall	5.82	2.06	2.00	10.00
	Other Recall	1.82	1.50	0.00	5.00
	Tot Recall	7.63	2.87	2.00	13.00
Subtest 4	City Landmark	2.70	1.17	0.50	5.00
Subtest 5	Map Drawing	18.87	9.16	2.50	41.00
Subtest 6	Landmark Photo Recognition	6.58	1.81	3.00	10.00
Subtest 7	Map Replacement	3.26	2.41	0.00	10.00
Subtest 8	Recall Replacement On Map	2.50	1.13	0.00	5.00
Subtest 9	Route Planning	1.83	1.31	1.50	4.50
	Time Route Planning	34.00	17.31	10.00	85.00
Subtest 10	Short Route Planning	2.46	1.03	0.50	4.50
	Time Short Route Planning	26.16	13.50	10.00	60.00
Subtest 11	Route Forward 2	0.76	0.79	0.00	3.00
	Time Route Forward 2	29.87	20.32	8.00	90.00

M = mean, SD = Standard deviation

Even if participants had seen the all the plastic city (allocentric perspective), they were able to remember more met landmarks (M = 5.82, SD = 2.06) in the first path (F1 and B1) than those not met (M = 1.82, SD = 1.50).

Subjects show more difficulty to recall and replace landmarks in a blank map (subtest 8): anybody was able to put back all 6 landmarks (*M* = 2.50, *min* = 0 *max* 5,); on the contrary, they performed better in replacing 5 landmarks on plastic city (subtest 4: *M* = 2.70, *min* 0.5, *max* 5). Besides, photo replacement test was more difficult (*M* = 3.26, *SD* = 2.41) than the recognition (*M* = 6.58, *SD* = 1.81): subjects were always not able to return correctly on map the photos they had recognized before as true and false. In Map Drawing (*M* = 18.87, *SD* = 9.16) anybody draw the name of streets excepts in a few cases (Corso del Popolo). Finally, subjects performed better in driving directions, both in performance and in time, when they were watching the city (subtest 10) rather than they had to use a mental map (subtest 9).

As regard Bidimensional Stimuli task and cognitive reserve index, results are shown in table 3.5 and table 3.6.

Tab. 3.5 Mean and Standard deviation of experimental Bidimensional stimuli test.

	M	SD	Min	Max
Bidimensional Stimuli	6.05	2.25	1.00	10.00

M = mean, SD = Standard deviation

Tab. 3.6 CRI index

	M	SD	Min	Max
CRI school	96.21	15.69	67.00	149.00
CRI work	97.89	17.12	66.00	133.00
CRI freetime	95.45	19.54	58.00	142.00
CRI tot	95.32	18.60	61.00	140.00

M = mean, SD = Standard deviation

In order to verify correlation between navigational tests and neuropsychological tasks, Pearson's correlation ($p < .05$) was used to compare spatial and memory neuropsychological test with experimental ones. As expected, Elithorn's test was correlated to route F1 *r* (-.66), $p < .05$, route B1 *r* (-.62), $p < .05$, route planning *r* (.44), $p < .05$ and route recall *r* (.32), $p < .05$.

An interesting observation concerns Corsi span that resulted to be not associated to visual–spatial navigation test while it was only correlated with time for short route planning *r* (-0.46), p< .05.

As it could be seen in table 3.7, Trail Making Test was one of the neuropsychological testing that most correlated to experimental ones. In particular, TMTB and TMT B-A were negatively correlated to route recall *r* (-.43), $p < .05$; *r* (-.45), $p < .05$ (respectively), total recall *r* (-.42), $p < .05$; *r* (-.39), $p < .05$ (respectively) and short route planning *r* (-.55), $p < .05$ (TMTA), *r* (-.45), $p < .05$ (TMTB), *r* (-.33), $p < .05$ (TMTB-A). Finally, executive functions were positive involved in route F1 *r* (.40), $p < .05$ (TMTA), *r* (.54), $p < .05$ (TMTB), *r* (.44), $p < .05$ (TMTB-A) and in route B1 *r* (.48), $p < .05$ (TMTA); *r* (.57), $p < .05$ (TMTB); *r* (.44), $p < .05$ (TMTB-A).

Tab 3.7 Significant correlations between navigational subtests and executive functions

	TMTA	TMTB	TMTB-A
Route F1	.40*	.54*	.44*
Time F1	.53*	.26	.15
Route B1	. 48*	.57*	.44*
Time B1	.63*	.45*	.37*
Route recall	-.25	- .43*	- .45*
Tot recall	-.32	- .42*	- .39*
City landmark	-.41*	- .51*	- .44*
Map drawing	-.45*	- .38*	- .21
Map replacement	-.42*	- .38*	- .27*
Recall replacement on map	-.30	- .55*	- .52*
Route planning	-.35*	- .31*	- .29
Short route planning	-.55*	- .45*	- .33*

* Pearson's correlation, p<.05

Manikin test showed association with route F1 r (-.37), p< .05, route B1 r (-.58), p< .05, route recall r (.50), p< .05, total recall r (.52), p< .05, map drawing r (.33), p< .05 . An interesting result concerns short story (MODA) that was correlated with route F1 r (-.58), p< .05, route B1 r (.-48), p< .05, route F2 r (.-30), p< .05, route recall r (.44), p< .05, city landmark r (.52), p< .05, recall replacement on map r (.38), p< .05.

With regard to navigational subtest, Map Drawing showed many correlations. First, it was found an association with age r (-.41), p< .05; second, correlations emerged between Map Drawing and some neuropsychological test like Rey's copy r (.40), p< .05 and TMTA r (-.46), p< .05. See table 3.8 for other significant correlations with neuropsychological test.

Tab. 3.8 Significant correlations between Map drawing and neuropsychological assessment

	Map Drawing
MODA	0.34
Rey copy	0.40
TMTA	-0.46
TMTB	-0.39
Manikin	0.33

Pearson's correlation, $p<.05$

Map drawing is also associated with some navigational sub test involved in visual-spatial skills like city landmark *r* (.51), *p*< .05, map replacement *r* (.63), *p*< .05, recall replacement on map *r* (.49), *p*< .05, and Bidimensional stimuli *r* (.40), *p*< .05.

Moreover map drawing correlated negatively to several executions time (see table 3.9) as Time F1 *r* (-.44), *p*< .05, Time B1 *r* (.51), *p*< .05, Time route planning *r* (-.51), *p*< .05 and time F2 *r* (-.40), *p*< .05.

Tab. 3.9 Significant correlations between Map drawing and experimental subtests

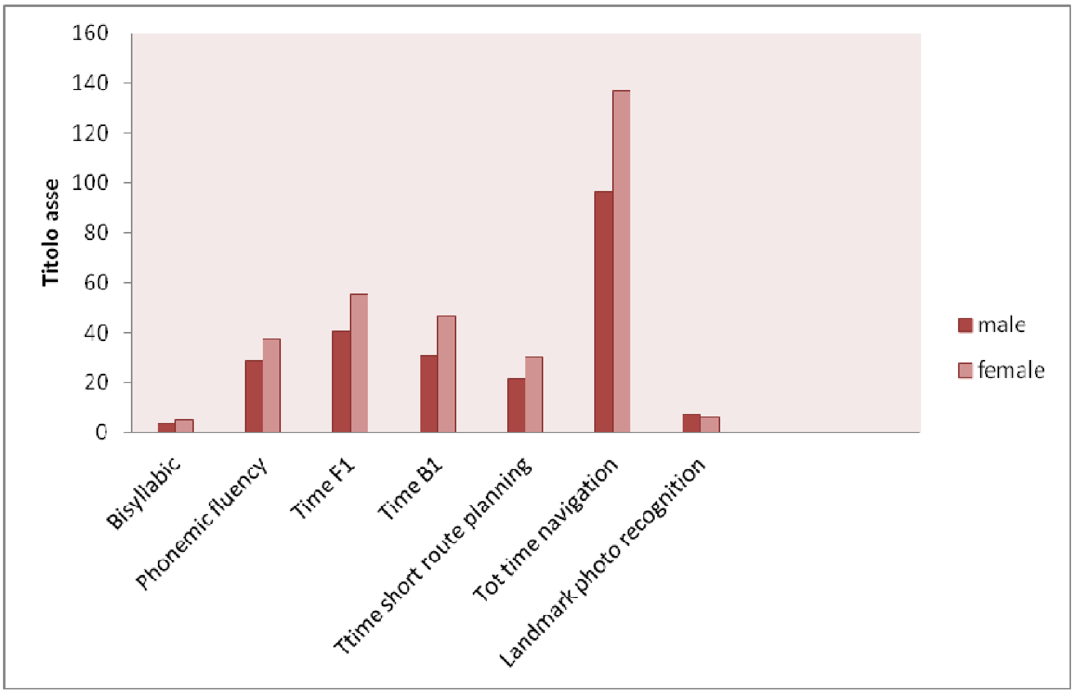
	Map Drawing
TimeF1	-0,44*
Route B1	-0,32*
Time B1	-0,51*
Route recall	0,37*
Other recall	0,37*
Total recall	0,46*
City landmark	0,51*
Map replacement	0,63*
Recall replacement on map	0,49*
Time route planning	-0,51*
Time F2	-0,40*
Bidimensional stimuli	0,40*

Pearson's correlation, $p<.05$

After verifying that the sample had a normal distribution (Kolmogorov-Smirnov one sample $p>.05$), one-way ANOVA was used to compare gender, to compare age, and mean of mistakes in the three paths.

Some interesting differences have been found between males and females (see figure 3.6): the latter scored significantly higher in bisyllabic words repetition $F(1,36) = 8.01$, $p = .01$, in phonemic fluency $F(1,36) = 8.5$, $p = .01$ than the former performed better in landmark photo recognition $F(1,36) = 6.8$, $p = .01$ and in some times of executions in the Plastic City: time F1 $F(1,36) = 4.8$, $p = .03$, Time B1 $F(1,36) = 4.8$, $p = .03$, Time short route planning $F(1,36) = 3.9$, $p = .05$ and Total time navigation (F1 +B1 + F2) $F(1,36) = 5.2$, $p = .03$. Figure 3.6 illustrates these data.

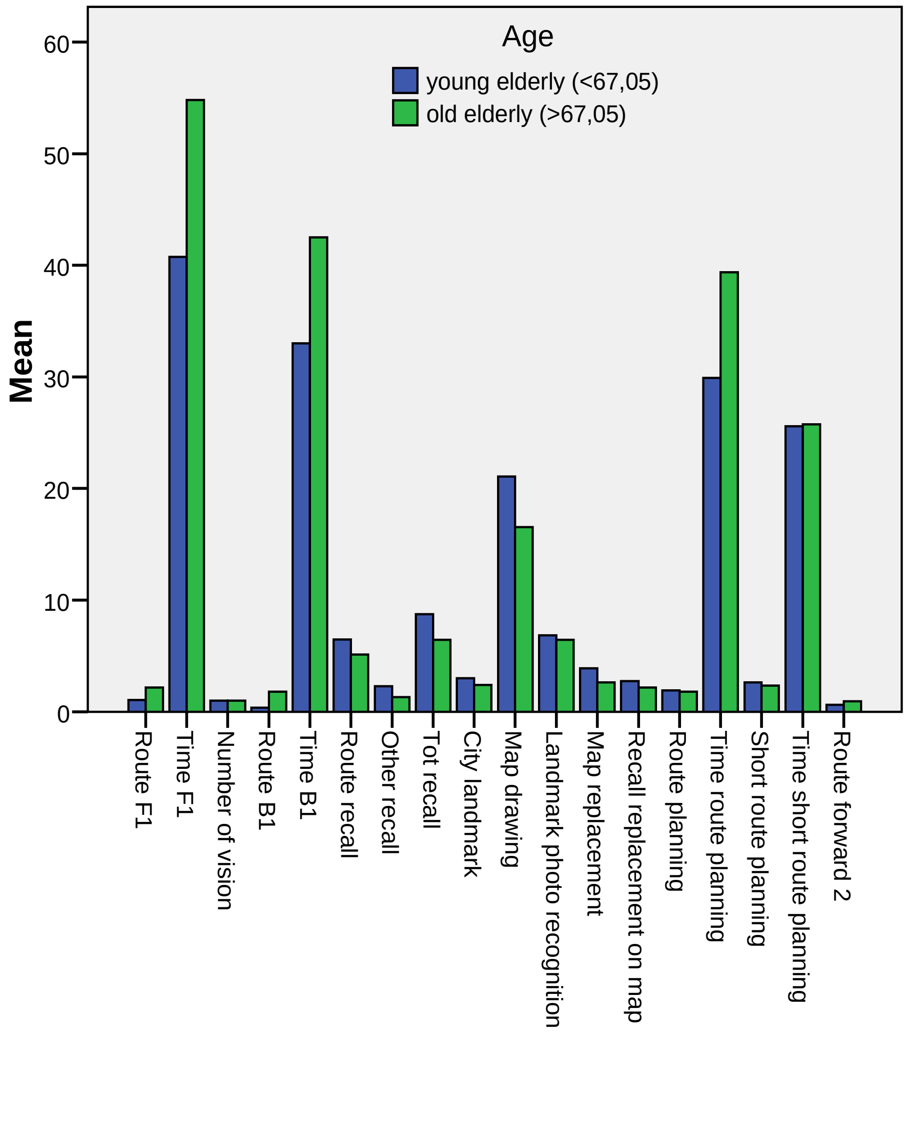
Figure 3.6 Males and females significant differences



In order to find differences about age, sample was divided with regard to mean age (67.05) and two groups were obtained: "young elderly" (M < 67.05) and "old elderly" (M > 67.05).

Among the neuropsychological tasks, ANOVA showed that only Manikin test $F(1,36) = 5.94$, $p = .02$, and short story's MODA $F(1,36) = 4.0$, $p = .05$ were discriminatory between the two groups: "young elderly" had higher scores. On the contrary, there were many differences in navigational subtests. In particular, "young elderly" showed significant better results in the first part of navigational test: Route F1, $F(1,36) = 7.51$, $p = .001$; time F1, $F(1,36) = 6.63$, $p = .01$; route B1, $F(1,36) = 12.7$, $p = .001$; route recall, $F(1,36) = 5.3$, $p = .03$; other recall, $F(1,36) = 5.09$, $p = .03$; total recall, $F(1,36) = 8.82$, $p = .001$; and total mistakes in three paths $F(1,36) = 11.24$, $p = .001$ (see figure 3.7).

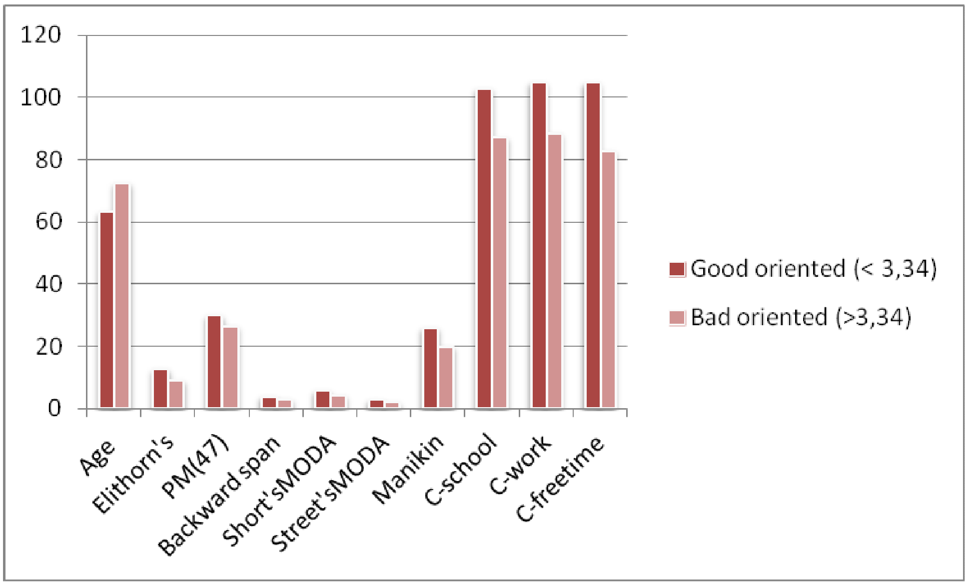
Figure 3.7 Mean of young elderly and old elderly in the Plastic City



With regard to cognitive reserve index, we amazed not have found significant differences between old and young elderly neither in CRI school, nor in work, nor in free time nor in CRI total. The same happened for Bidimensional stimuli: young and old elderly did not differ in this task.

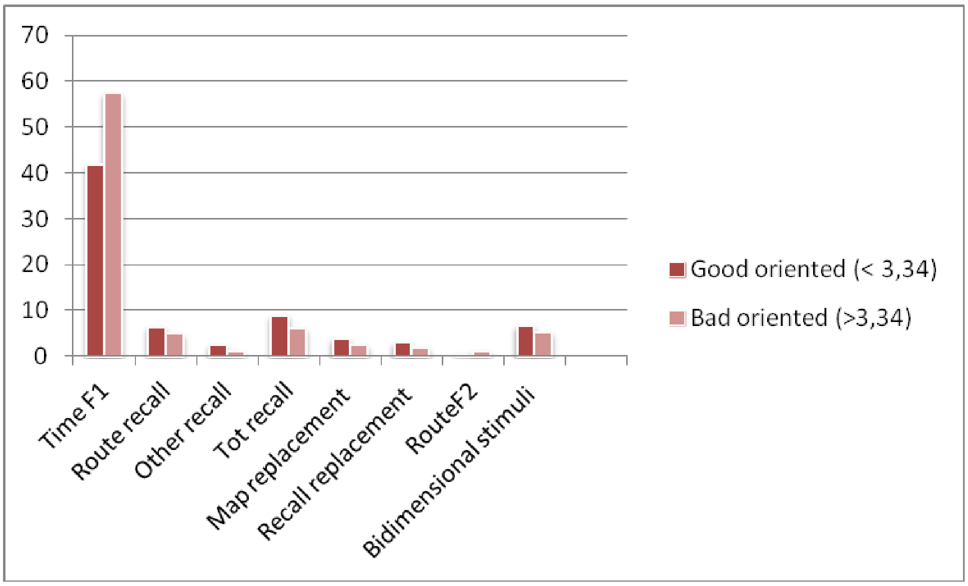
Mean of mistakes during the three paths (F1, B1; F2) was used to have a global index about orientation navigation mistakes and it resulted to be 3.34 (SD = 2.98). Subjects have been divided according to high and low mean mistakes (M = 3.34). ANOVA revealed that the youngest participants were more oriented than the oldest ones, $F(1,36) = 17.36$, $p = .00$. Moreover, “bad oriented subjects" showed a worse performance also in Elithorn’s test, $F(1,36) = 10.50$, $p = .00$; PM (47) $F(1,36) = 4.67$, $p = .04$; Backward digit span $F(1,36) = 9.35$, $p = .00$; Short story’s MODA $F(1,36) = 8.09$, $p = .00$; Street’s MODA $F(1,36) = 11.08$, $p = .00$; Manikin test $F(1,36) = 13.00$, $p = .00$; CRI school $F(1,36) = 12.02$, $p = .00$, CRI free time $F(1,36) = 16.59$, $p = .00$; CRI work $F(1,36) = 10.80$, $p = .00$ (figure 3.8).

Figure 3.8 Significant differences between “good and bad oriented subjects” in neuropsychological assessment



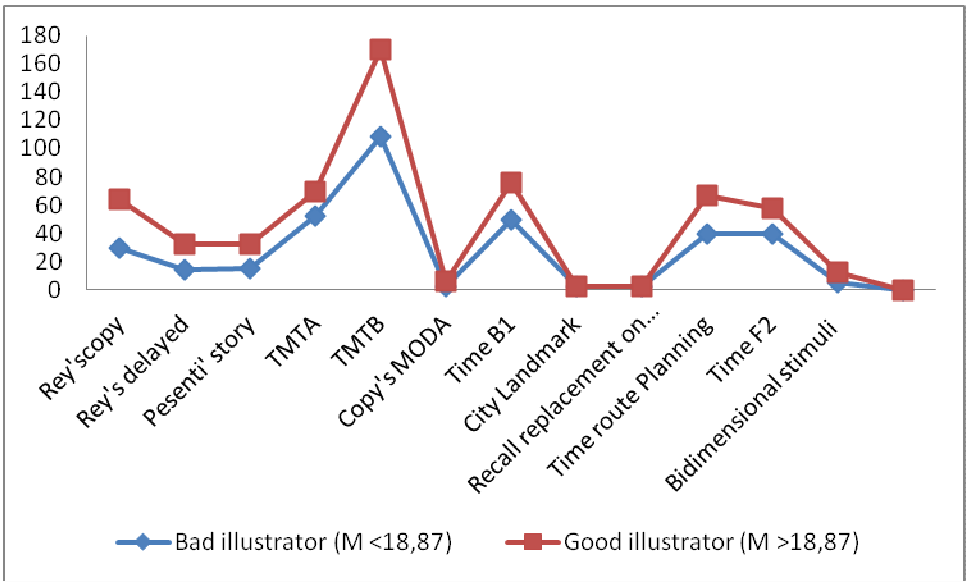
Differences between groups have been also detected in experimental tests. Subjects that make navigational mistakes higher than the mean (3.34) performed worse in Time F1 $F(1,36) = 5.22$, $p = .03$; Route Recall $F(1,36) = 5.63$, $p = .02$; Other Recall $F(1,36) = 10.14$, $p = .00$; Total Recall $F(1,36) = 12.66$, $p = .00$; Map Replacement $F(1,36) = 4.05$, $p = .05$, Recall Replacement on Map $F(1,36) = 10.59$, $p = .00$, Route F2 $F(1,36) = 4.37$, $p = .04$ and Bidimensional stimuli $F(1,36) = 4.45$, $p = .04$ (see figure 3.9).

Figure 3.9 Significant differences between "good and bad oriented subjects" in experimental tests



Since map drawing involves egocentric and allocentric perspective and it requires several visual-spatial abilities, the sample was separated between subjects with low and high scores in map drawing ($M = 18.87$, $SD = 9.16$). Demographic indexes (sex, age and education level) did not differ in the groups, while many neuropsychological tasks did (see figure 3.10).

Figure 3.10 Significant differences between "bad and good illustrator"



In particular, subjects who performed Map Drawing at higher level of mean had good scores in Rey's copy $F(1,36) = 10.12$, $p = .00$ and Rey's delayed, $F(1,36) = 5.20$, $p = .02$; Pesenti' story $F(1,36) = 3.87$, $p = .05$; TMTA $F(1,36) = 7.85$, $p = .00$; TMT B $F(1,36) = 4.90$, $p = .03$ and Copy's MODA $F(1,36) = 4.91$, $p = .03$. In experimental tasks, "good illustrator" performed better than "bad illustrator" in Time B1 $F(1,36) = 10.13$, $p = .00$; City landmark $F(1,36) = 10.13$, $p = .00$; Recall Replacement on Map $F(1,36) = 6.95$, $p = .01$; Time Route Planning $F(1,36) = 4.87$, $p = .03$; Time F2 $F(1,36) = 15.69$, $p = .00$ and Bidimensional stimuli $F(1,36) = 7.15$, $p = .01$.

With regard to Bidimensional stimuli test, no significant differences occurred neither in gender (males and females) nor in age (old elderly and young elderly). On the contrary, total navigation mistakes and map drawing have detected differences in Bidimensional stimuli. In particular, "good oriented subjects" have shown good performances in Bidimensional stimuli too and a similar trend has observed for "good illustrator". Finally, Bidimensional stimuli have shown significant correlations with working memory *r* (.40), *p*< .05 (backward digit span) and episodic memory *r* (.36), *p*< .05 (Pesenti's story). This experimental test has also many associations with education and cognitive reserve as it can be seen below (table 3.10).

Tab. 3.10 Bidimensional stimuli task correlations

	Bidimensional Stimuli
Education	.42*
Backward span	.40*
Pesenti's story	.36*
CRI school	.40*
CRI work	.36*
CRI free time	.32*
CRI tot	.44*
Route F2	-.39*

* Pearson's correlation, *p*<.05

Cognitive reserve index shows interesting results too. First of all, no clear differences were observed between "young elderly" and "old elderly" in CRI school, CRI work, CRI free time and CRI total. The same was observed for gender and Map drawing. On the contrary, all the CRI indexes, except for CRI total, were dissimilar between participants that made navigational mistakes lower and higher than mean (3.34). It could mean that these CRI (school, free time and work) may buffer disorientation.

In this regard, significant correlations were found with CRI and Route F1, B1 and F2, as it can be seen in table 3.11.

Tab. 3.11 Significant correlations with CRI indexes and navigational subtests

	CRI school	CRI work	CRI freetime	CRI tot
Route F1	- 0.42*	- 0.47*	- 0.44*	- 0.55*
Route B1	- 0.32*	- 0.49*	- 0.48*	- 0.54*
Route recall	0.29	0.59*	0.49*	- 0.37
Landmark photo recognition	0.39*	0.35*	- 0.32*	- 0.43*
Recall replacement on map	0.37*	0.39*	- 0.46*	- 0.25
Route Planning	0.20	0.40*	- 0.35*	- 0.10
Route F2	- 0.23	- 0.40*	0.38*	0.22

* Pearson's correlation, p<.05

CHAPTER 4

DISCUSSION AND CONCLUSION

4.1. Discussion

This study shows preliminary results of a new and ecological instrument, the Plastic City, for evaluating orientation in elderly people. Considering the importance of visual-spatial memory in navigation, we have also created a bidimensional task to be compared with some navigational subtests. The hypotheses of the study have supported that:

1. Females would show more navigational mistakes than males.
2. The oldest people in the sample would show more navigational mistakes than the youngest.
3. According to literature (deIpolyi et al., 2007), orientation impairment is not caused by deficit in recognition landmarks, rather it is due to deficit in visual–spatial memory abilities.
4. Inspired by a previous study (Alescio-Lautier et al., 2007), a bidimensional visual-spatial test has been created to be compared with other navigational visual–spatial tasks in order to find significant correlations between experimental tasks (bidimensional and tridimensional) and neuropsychological standardized instruments.

Finally, cognitive reserve has been evaluated to find its implication in navigational abilities.

On a descriptive level, a decrease of errors along three paths (route F1, B1, F2) was observed in the Plastic City; this fact implies the presence of a learning-effect. As it can be expected, subjects showed a worst performance in visual-spatial tasks in which a mental map was required (Map Replacement and Recall Replacement on Map) than in tasks in which the vision of the Plastic City was available (City Landmark Replacement).

The fourth hypothesis has been confirmed by the significant correlations between experimental tests and some neuropsychological standard tests. In particular, episodic memory (short’s story MODA), spatial planning (Elithorn’s Perceptual Maze test) and executive functions (TMT) have been involved in learning route subtests (Route F1, B1, F2) and in remembering landmarks previously met (Route Recall). Moreover, spatial intelligence-planning is required to plan a way route in the map, while executive functions are involved in planning a new route observing the Plastic City; executive functions have also engaged in landmark replacement by a map and in the Plastic City. Bidimensional stimuli are associated significantly with education level, CDR, CRI (school, free time, work and total), working memory, episodic memory and Recall Replacement on Map.

The hypothesis about gender differences was not confirmed (first hypothesis). However, we unexpectedly found interesting data in literature: even if elderly women performed better in test involving verbal components while men performed better in test involving visual-spatial skills, old male and old female did not have many differences in navigation skills (Proust-Lima et al., 2008). Salthouse (2010) found similar rates of age–related decline in navigation across gender. Bell, Willson, Wilman, Dave, and Silverstone (2005) exploring the effect of gender on regional brain activity in healthy subjects with fMRI during a motor task and three cognitive tasks (one of them was a spatial attentional task), found differential patterns of activation in males and females, even though performance in these tasks were the same. Finally, according to Cushman & Stein (2008) in our sample we have not found an effect of age on photo recognition tasks, while males performed better than women in the same task and they had superior performances than women in several executions time in which memory and planning were required (time F1, time B1 and time short route planning).

The results deal with aging and navigation performances are very interesting (hypothesis 2). In fact, in the neuropsychological standard battery, the two age groups have shown different performances only in Manikin test and short story's MODA whereas navigational subtests have pointed out several differences between "young elderly" and "old elderly". Two main considerations could arise from these results. First, the Plastic City has been useful in bringing out age differences in navigation cognitive performances: it seems to be a sensitive and adequate tools also for a clinical setting test. Then, better performances have been observed in young elderly, in particular in the first part of navigation test (route F1, time F1, route B1, route recall, other recall, total recall): this suggests better learning abilities in young elderly both in accuracy and in execution times.

Moreover, several cognitive functions have been involved in subjects who made navigation mistakes lower than mean (M = 3.34; SD = 2.98). In neuropsychological standard assessment, intelligence, spatial planning, working memory, episodic memory and orientation right-left prove to be a cognitive skill employed in learning of new environments. Finally, cognitive reserve (school, free time and work) has also engaged in navigation mistakes, suggesting that is a possible buffer for TD. With regard to experimental subtests, it has been found that “bad oriented subjects” were also less rapid in execution times (time F1) and, as confirmed by previous studies (Cushman & Stein, 2008; deIpoly et al., 2007), they have not remembered many met landmarks and they have shown bad performances in replacing landmarks into a map (Map Replacement and Recall replacement on Map) and in Bidimensional stimuli.

This leads to confirm the third hypothesis. In order to perform Map Replacement, Recall replacement on Map and Bidimensional stimuli, visual-spatial skills are required, and it is noteworthy that “bad oriented” people have shown bad scores in all of these tasks in which visual-spatial memory is important. According to literature (ibidem), these data represent a further demonstration that visual-spatial abilities are quite involved in orientation. Besides, it is interesting that Corsi’s test performance was not different in “bad and in good oriented subjects”, and it was not correlated to other navigation and visual-spatial subtests. The reasons deserve to be understood by increasing the healthy sample and comparing it with pathological subjects. At present, these preliminary results suggest that Corsi’s test is not sensitive to detect of visual-spatial skills in orientation abilities; one explanation may be that our navigational Plastic City and Bidimensional stimuli are more ecological than it.

In order to better clarify the described results, we compared subjects according to their ability in drawing a map of the Plastic City without seeing it (M = 18.87, SD = 9.16). This task is very useful because it allows to see egocentric and allocentric perspective and to study visual-spatial skills. We have found that the two groups were not different with regard to demographic indexes, while they have shown different performances in visual-constructional skills (Rey’s Complex figure copy; copy’s

MODA), memory (Rey's Complex figure delayed; Pesenti'story), and executive functions (TMT). With regard to experimental tasks, all the subtests that involved visual-spatial abilities were engaged in performing a good map of the city (City Landmark, Recall Replacement on Map and Bidimensional Stimuli).

These results are consistent with a recent study (Iaria & Barton, 2010) that suggested that spatial impairments were neither a product of a generalized decay (in our sample MODA, CDR or GDS did not discriminate navigation mistakes) nor a result of some deficits in landmark recognition. Instead, spatial impairment could be considered a selective deficit, and in our sample this selective deficit involves visual-spatial skills and spatial planning above all.

With regard to Bidimensional stimuli, it was found that neither age nor gender were dissimilar in this task. On the contrary, bidimensional visuo-spatial abilities were different in navigation mistakes (M = 3.34) and in map drawing (M = 18.87); moreover Bidimensional task has significant correlations with working memory and cognitive reserve. The latter was different in people with higher and lower mean of navigation mistakes, then cognitive reserve shows many correlations with subtest about learning new paths.

4.2 Conclusion

This study has proposed a new instrument to evaluate navigation abilities in Italian healthy elderly people.

Many correlations among the Plastic city, Bidimensional stimuli and neuropsychological standard assessment have been detected. According to recent literature (Salthouse, 2010), in elderly, navigation skills are not influenced by gender, while age and visual-spatial abilities seem to have an important role, as well as, cognitive reserve. The latter has not been studied yet in orientation and our results suggest that it has an important role on navigation that should be investigated deeper in future research.

These preliminary results encourage us to enhance the healthy sample and to consider its application in MCI and AD patients.

The Plastic City has many limitations too: some subtests need to be improved and time of administration must be shorter. Then the Plastic City has to be re-tested to verify its reliability and to be applied in clinical setting.

This challenging work also raises many questions. For instance, since we have not found age differences in the neuropsychological tests, what can happen with pathological subjects? What will be different performances in the Plastic City between normal and pathological subjects? In particular, if we found a correlation between episodic memory and navigational orientation as it seems to be, this association could explain and predict the MCI conversion in AD? Surely, a longitudinal study with neuroimaging can be a prominent field of investigation.

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APPENDIX A: THE PLASTIC CITY.

INSTRUCTIONS

Consegna preliminare al soggetto prima di iniziare il compito:

Questo plastico rappresenta una città. Come vede ci sono case, strade ed edifici vari (indicarli e nominarli tutti). Cerchi di ricordare il più possibile tutto ciò che è presente nel plastico e la posizione di ciascun elemento (nominare e indicare gli edifici e i cartelli, accertandosi che il soggetto li abbia compresi tutti).
In questa città è appena arrivato un turista che, dopo aver letto la guida, ha deciso visitare la città.
Ora io muoverò la pedina (usare una penna o qualunque cosa che sia ben visibile e che funga da pedina) mostrandole il percorso del turista.
Lei deve prestare molta attenzione alle strade ai luoghi, ai cartelli che il turista incontra per raggiungere la sua meta, poiché dopo le chiederò di fare alcune cose, tra cui di intraprendere lo stesso percorso.

SUBTEST

1.Route Learning forward test (1) 

L' E. fa vedere bene la pedina, la posiziona al punto di partenza chiedendo al paziente di rifare il percorso mostrato in precedenza. Ad ogni incrocio il paziente dovrà dire ad alta voce: dritto, dx o sx. Viene corretto se sbaglia il percorso (ma non lo si riporta al punto di partenza!).
Se il paziente parte male da subito (va in via Bonetti o in via Sassi), viene riportato all'inizio e gli si fa rivedere il percorso un'altra volta. Si dà solo una possibilità.
→Valutare il numero di correzioni fatte dall'esaminatore (errori commessi dal pz)
→ tempo totale

Descrizione del percorso

Si parte dalla stazione, si attraversa piazza Vittorio Emanuele e si prosegue per corso del Popolo, si attraversa Largo Maragno fino ad arrivare a piazza Cavour e superarla. Girare a destra in via dei Martiri e arrivare fino alla pizzeria "da Mimmo". Tornare indietro, girare a sinistra in Piazza Cavour, attraversarla e riprendere corso del Popolo fino a Largo Maragno. Lì girare a sinistra in via S. Donato. Alla rotonda, prendere la prima uscita a destra e imboccare la prima via che ci si trova di fronte. Andare al parco e prendere l'uscita che porta alla stazione dei taxi. Lì prendere la via che si ha di fronte ed arrivare all'edicola.
(vedere piantina Route F1)

Foglio di registrazione

Percorso in avanti 1			
Visione del percorso	1 volta	2 volte	
		Luoghi in cui è stato corretto	
Numero di **correzioni** dell'esaminatore	1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.		Annotazioni
	Totale		
Tempo:			

2.Route Learning back test 

La pedina viene posta al punto di arrivo. Si chiederà al paziente di rifare il percorso precedente al contrario

Ad ogni incrocio il paziente dovrà dire ad alta voce: dritto, dx o sx. . Viene corretto se sbaglia il percorso (ma non lo si riporta al punto di partenza!). Se sbaglia sin dall'inizio (gira in via dei Santi), lo si corregge senza far rivedere il percorso.

→Valutare il numero di correzioni fatte dall'esaminatore (errori commessi dal pz)

→tempo totale

Foglio di registrazione

Percorso indietro 1			
		Luoghi in cui è stato corretto	
Numero di **correzioni** dell'esaminatore	1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.		Annotazioni
	Totale		
Tempo:			

3.Free recall Landmark 

In 1 minuto il soggetto deve nominare il maggior numero di Landmark (oggetti e edifici) che ha incontrato nel percorso. Possono essere riferiti anche Landmarks non incontrati ma presenti nel plastico. Invitare il soggetto a riferire principalmente quelli del percorso.

Foglio di registrazione

Parole che devono dire:		***Landmark non incontrati nel percorso ma riferiti (visione allocentrica)***	*Annotazioni*
1. Cartello stazione (o stazione)			
2. Semaforo (deve dirne almeno 1)			
3. Farmacia			
4. Albero			
5. Comune			
6. Cartello velocità			
7. Cartello stazione taxi			
8. Nomi vie			
9. Parcheggio			
10. Posta			
11. Chiesa			
12. Pizzeria			
13. Edicola			
14. Pubblicità biscotti			
15. Giardinetto bimbi			
16. Cartello lavori in corso			
17. Stazione taxi			
	Totale		

4.Ricollocamento dei Landmark sul plastico

Il soggetto viene fatto voltare di spalle, in modo da non vedere il plastico e vengono rimossi 5 landmarks. Il soggetto deve riposizionarli correttamente sul plastico.

Foglio di registrazione

Landmark da rimuovere	*Landmark correttamente riposti* *1*	*Landmark riposti nella "zona" corretta ma non precisa* *0.5*	*Landmark riposti con aiuto* *0*
Panettiere antico mulino			
scuola			
semaforo (corso del popolo) visto di fronte			
cartello blu fermata bus			
Pubblicità biscotti			
	Tot: /5		

5.Map drawing:
Il soggetto deve disegnare su un foglio bianco la mappa della città (senza vedere il palstico).

Valutazione:
2: presenza e correttezza spaziale dell'elemento
1: presenza e posizione nelle zone adiacenti
0,5: se l'elemento è presente (quindi a prescindere dalla posizione)
0,25: l'elemento è stato nominato ma il soggetto non sa dove metterlo oppure lo segna sulla mappa definendolo con un termine generico (es: cartello. Ma non sa specificare quale)

6.Landmark recognition & ricollocamento su mappa :
Mostrare 5 foto bidimensionali che rappresentano alcuni dei Landmarks (serie A) incontrati e 5 foto di landmarks non incontrati (serie B). In ciascuna foto saranno presenti 3 o 4 edifici/cartelli

Per ciascuna foto il soggetto deve effettuare un riconoscimento dei Landmark. Esso è ritenuto valido se il soggetto risponde correttamente ad entrambe le domande:

1) Tutti gli elementi mostrati sono presenti nel plastico?
2) Se sì, tali elementi hanno la stessa posizione spaziale nel plastico?

E' quindi importante sottolineare al soggetto di non considerare ciascun edificio/ segnale singolarmente, ma l'elemento insieme agli altri. Ribadire la consegna più volte e mostrare i due esempi di prova.

Foglio di registrazione

	Riconoscimento*corretto
A3	
A2	
B5	
A4	
B4	
A5	
B3	
B2	
B1	
A1	
	/10
	Tot

Landmark presenti (A):
Riconosce che tutti i Landmark presenti nella foto sono stati incontrati proprio in quel punto del percorso? (assegnare 1 punto)

Landmark assenti (B):
Riconosce che all'interno della foto ce n'è qualcuno che non ha mai visto prima? (assegnare 1 punto)

Dopo aver fatto vedere ciascuna delle 10 foto e chiesto il riconoscimento, il soggetto deve mettere una X sulla mappa (senza riferimenti) in cui indica in quale punto del percorso ha incontrato gli elementi (del punto 2).
In questa prova verranno rimostrate tutte le foto per verificare se durante il ricollocamento (aiutato dalla visione della mappa) il soggetto si "rende conto" di aver commesso un errore di riconoscimento nella prova precedente.
Il ricollocamento è considerato corretto (sia nelle prove A sia B) se almeno 2 elementi della foto sono riposti correttamente e se almeno un elemento sbagliato (contrassegnato con Z, nelle prove B) non viene collocato in nessun punto. Per elemento sbagliato si intende l' elemento assente nel plastico.

	Ricollocamento* corretto su mappa
A3	1 2
A2	1 2
B5	1 2 Z
A4	1 2
B4	1 2 Z
A5	1 2
B3	1 2 Z
B2	1 2 Z
B1	1 2 Z
A1	1 2
	Tot

<u>*Landmark presenti (A)*</u>*:*
Colloca correttamente almeno 2 elementi nella mappa (assegnare 1 punto)? Li colloca in parti errate della mappa? (0).

<u>*Landmark assenti (B):*</u>
Colloca correttamente almeno 2 elementi nella mappa e non ricolloca il distrattore Z (assegnare 1 punto).

7.Rievocazione e ricollocamento sulla mappa 

Ricollocamento in una mappa (fornita dall’ E.) di alcuni Landmark del plastico.
Fornire la mappa (senza i nomi delle vie) con disegnato il percorso fatto al punto 1. Nella mappa sono indicati con una X 6 punti. Entro un minuto il soggetto dire quale Landmark si trovano in ciascun punto segnato dalla X.

Foglio di registrazione

Landmark	*Rievocazione corretta*	*Annotazioni*
1 cartello velocità 80		
2 semaforo		
3 scuola		
4 pizzeria da Mimmo		
5 albero		
6 chiesa		
	Totale /6	

8.PIANIFICAZIONE DI UN PERCORSO SU MAPPA 

Fornire la mappa della città (con i nomi delle vie) e lasciarla osservare per 45 secondi. E. nomina i vari edifici e Landmarks per aiutare il pz a formarsi una rappresentazione mentale della mappa.
Successivamente, E toglie la mappa e il soggetto deve riferire verbalmente quale percorso deve fare per andare dalla scuola alla farmacia

Tempo impiegato:
Percorso intrapreso (trascrivere la verbalizzazione del paziente):

Valutazione:
Andare dritti in via Trieste **0.5** GIRARE A SX **1** in via dei Santi **0.5**
In piazza Cavour **0.5** andare a DX **1**
Prendere corso del Popolo **0.5** andare sempre dritto **1**
Superare Largo Maragno **0.5** andare sempre dritto **1**
In piazza V. Emanuele **0.5** girare a SX **1**

Se nomina e posiziona correttamente dei landmarks: 0.5 (es: passo davanti alla chiesa che è sulla sx)

5 + 3 = 8 DA QUESTO TOGLIERE GLI ERRORI (0.5 PER VIE) (1 DX E SX)

9. PIANIFICAZIONE DI UN BREVE PERCORSO OSSERVANDO LA CITTA’ 

Osservando il plastico il paziente deve dire qual è il percorso più breve per andare dallo stadio al fornaio

Tempo impiegato:
Percorso intrapreso (trascrivere la verbalizzazione del paziente):

Valutazione
<u>Dallo stadio GIRARE A SX</u> **1** In <u>via piazza Cavour</u> **0.5**
Prendere <u>corso del Popolo</u> **0.5** <u>andare sempre dritto</u> **1**
Superare <u>Largo Maragno</u> **0.5**
Arrivare in piazza <u>V. Emanuele</u> **0.5** <u>girare a sx</u> **1**
<u>In via Sassi</u> (possono dire anche Bonetti) c'è panettiere **0.5**

3+ 2.5 = 5. 5 TOGLIERE GLI ERRORI (0.5 PER VIE) (1 DX E SX) (1 se percorso non è qs ma un altro più lungo)
Non togliere punti se dicono percorso: Trieste, Regia, Saluzzi, piazza V. Emanuele e via Sassi

10 Route learning test forward (2) 

Partire dalla fine di piazza Cavour, proseguire fino alla terza via sulla destra (via Po) e andare in Posta. Tornare indietro, girare a destra in via Largo Maragno e girare alla prima via sulla sinistra (via S. Donato), girare alla prima via sulla destra (via Monte Bianco), proseguire diritto fino alla farmacia.
Se sbaglia, non si fa rivedere una seconda volta.

<u>Foglio di registrazione</u>

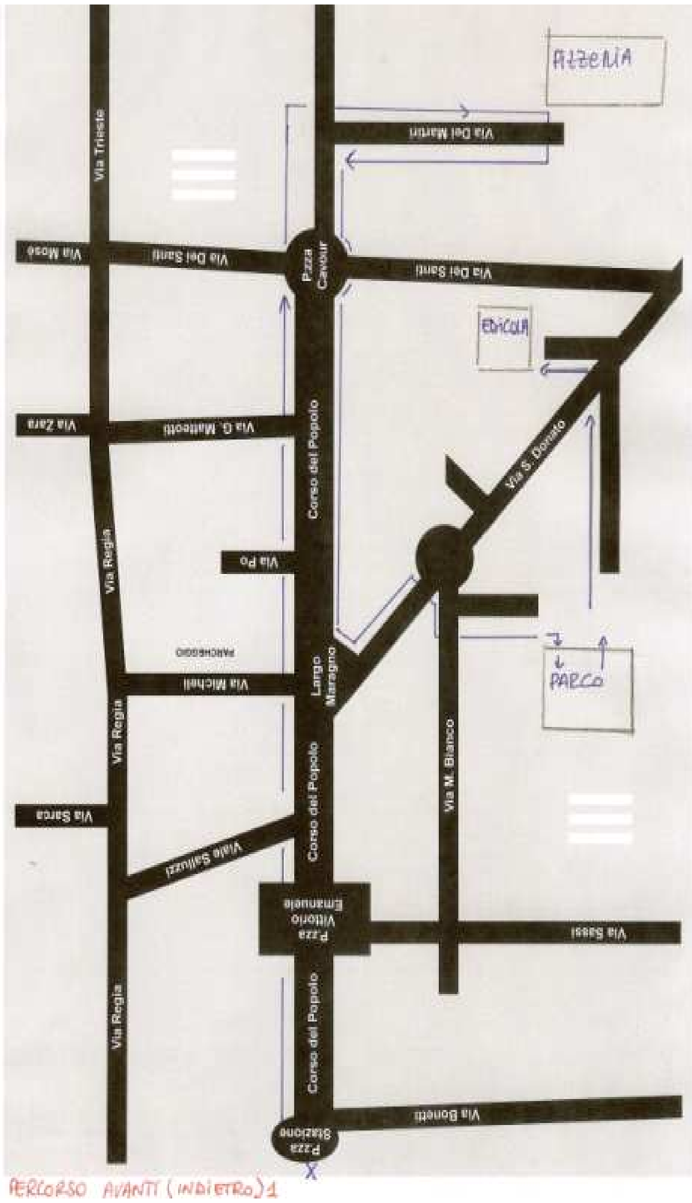
Percorso in avanti 2			
		Luoghi in cui è stato corretto	
Numero di **correzioni** dell'esaminatore	1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.		Annotazioni
	Totale		
Tempo:			

APPENDIX B: THE PLASTIC CITY.

INSTRUMENTS FOR ADMINISTRATION

ROUTE F1

ROUTE B1



ROUTE F2

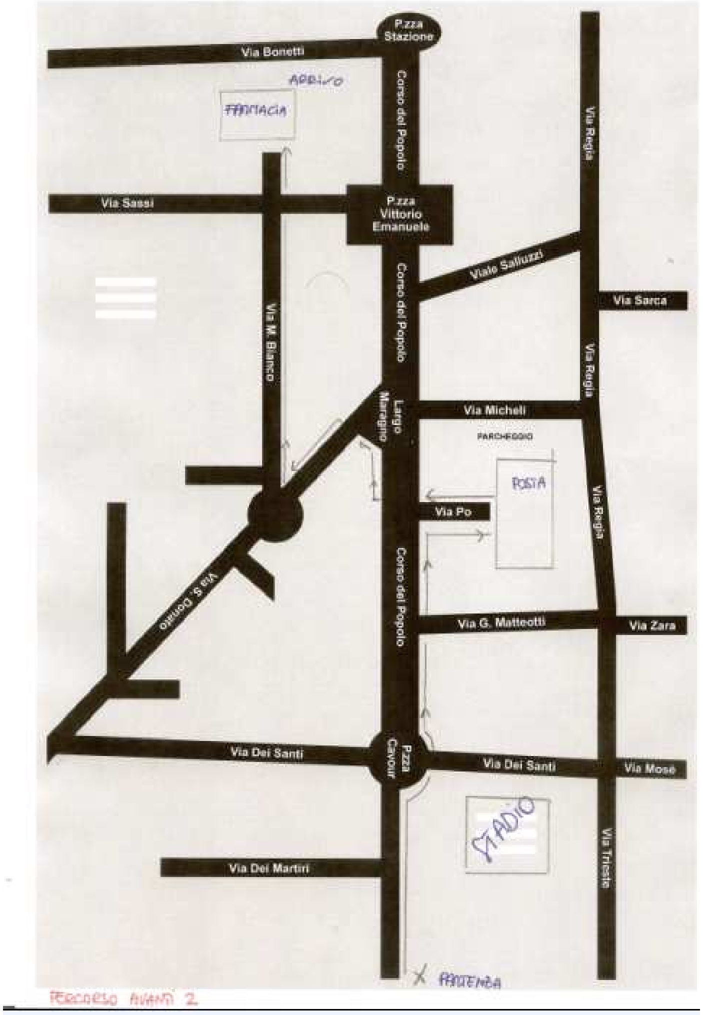

P.zza Stazione
Via Bonetti
ARRIVO
FARMACIA
Corso del Popolo
Via Regia
Via Sassi
P.zza Vittorio Emanuele
Viale Salluzzi
Via Sarca
Via M. Bianco
Largo Maragno
Via Micheli
PARCHEGGIO
POSTA
Via Po
Via S. Donato
Via G. Matteotti
Via Zara
Via Dei Santi
Pzza Cavour
Via Mosè
STADIO
Via Trieste
Via Dei Martiri
PARTENZA
PERCORSO AVANTI 2

PHOTO RECOGNITION

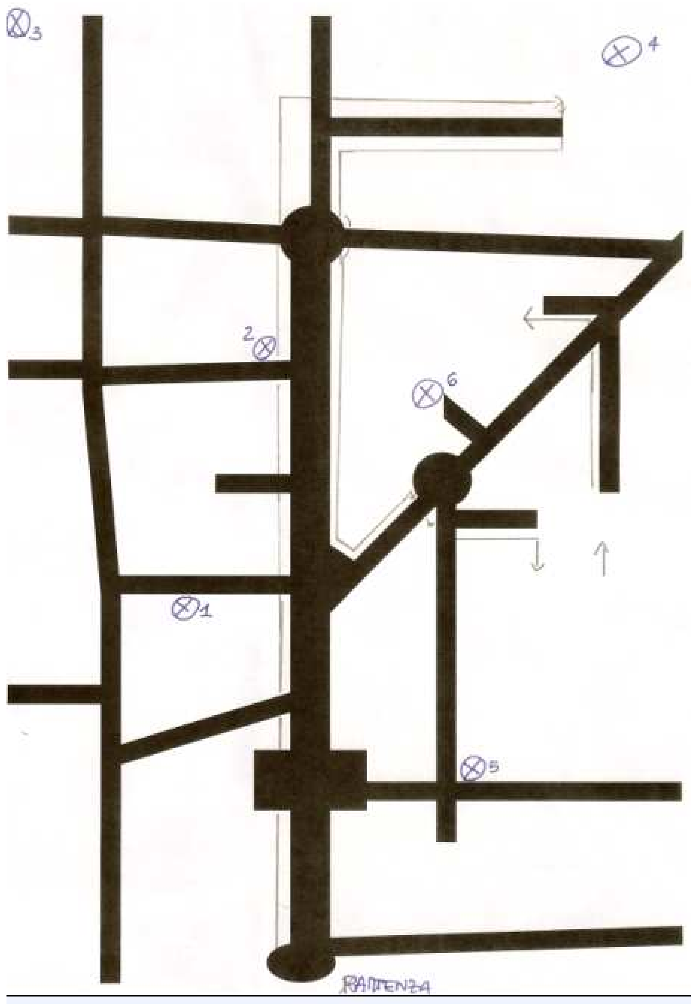
LA FOTO è VERA O FALSA?

PHOTO REPLACEMENT

DOVE COLLOCHI GLI ELEMENTI DELLA FOTO PRECEDENTE ?

RECALL REPLACEMENT ON MAP

QUALI ELEMENTI VANNO AL POSTO DELLE X?



APPENDIX C:

BIDIMENSIONAL STIMULI

CONSEGNA PRELIMINARE AL SOGGETTO

Le farò ora vedere alcuni fogli. Su ogni foglio ci sono alcune immagini disposte in un certo modo. Le chiederò di guardare con attenzione il foglio e cercare di memorizzare le immagini che vede e la posizione in cui si trova. Di seguito le farò vedere altri fogli e lei mi dovrà dire, per ognuno, se è identico a quello che le ho chiesto di memorizzare (rispondendo "Sì") o se qualcosa cambia (rispondendo "No")

TEST

L'esaminatore fa vedere al soggetto la prima Memory Image per **5 secondi** e lo invita a memorizzare le immagini presenti e la loro posizione. Presenta dunque la prima Probe Image e chiede al soggetto di rispondere "Sì" se è identica alla Memory Image oppure "No" se non è identica. La Probe Image non viene rimossa finchè il soggetto non fornisce una risposta. Quando il soggetto fornisce una risposta si presenta la seconda e una volta fornita la risposta per la seconda, si presenta la terza.

Ad ogni memory images ripetere, se necessario, la consegna.

→ Per ogni trial si valuta superata la prova se il soggetto fornisce tutte e tre le risposte corrette per le PI.

FOGLIO DI REGISTRAZIONE

	Risposte corrette			Risposte Fornite			Trial Superato
MI1	N	S	N				
MI2	S	N	N				
MI3	N	S	N				
MI4	N	N	S				
MI5	N	N	S				
MI6	S	N	N				
MI7	S	N	N				
MI8	N	S	N				
MI9	N	N	S				
MI10	N	S	N				

APPENDIX D:

CRIq

COGNITIVE RESERVE INDEX

M. Nucci, D. Mapelli & S. Mondini

Istruzioni: In caso di alterazione cognitiva o comportamentale, anche solo sospetta, il questionario è da somministrare ai *familiari* o a *chi si prende cura del paziente*, indicandolo al fondo del questionario nella apposita casella.

Cognome: .... Nome: ....

Data di nascita: ....../....../...... Luogo di nascita: .... Età: ....

Luogo di residenza: .... Nazionalità: italiana ☐ altro ☐ ....

Stato civile: celibe/nubile ☐ coniugato ☐ divorziato ☐ vedovo ☐

CRI - SCUOLA

Istruzioni: Contare gli anni di scuola superati più 0.5 per gli anni in cui si è stati respinti. Per ogni corso di formazione frequentato contare 0.5 ogni 6 mesi.

	Anni
1. Anni di scolarità (compresa eventuale specializzazione)	.....
2. Corsi (0.5 ogni 6 mesi)	.....

CRI - LAVORO

Istruzioni: Indicare gli anni lavorativi approssimati per eccesso, utilizzando una scala di 5 anni in 5 anni (0 - 5 - 10 - 15 - 20 ecc; ad esempio, se una persona ha lavorato per 17 anni, indicare 20). I cinque livelli sono suddivisi per il grado di impegno cognitivo richiesto e di responsabilità personale assunta. Riportare ogni professione esercitata, anche se svolta in contemporanea con altre.

	Anni
1. Operaio non specializzato, lavoro in campagna, giardiniere, cameriere, autista, meccanico, idraulico, operatore call center, elettricista ecc.	.....
2. Artigiano o operaio specializzato, impiegato semplice, cuoco, commesso, sarto, infermiere, militare, parrucchiere, rappresentante ecc.	.....
3. Commerciante, impiegato di concetto, religioso, agente di commercio, agente immobiliare, maestra d'asilo, musicista ecc.	.....
4. Dirigente di piccola azienda, libero professionista qualificato, insegnante, imprenditore, medico, avvocato, psicologo, ingegnere ecc.	.....
5. Dirigente di grande azienda, impiego di alta responsabilità, politico, docente universitario, magistrato, chirurgo, ricercatore, ecc.	.....

Età d'interruzione di ogni attività professionale: .....

CRI - TEMPO LIBERO

Istruzioni:

- Tutte le voci vanno riferite ad attività svolte con *regolarità* durante la vita adulta (dai 18 anni in seguito).
- Sono *escluse* tutte le attività che comportino un reddito (in tal caso rifarsi alla sezione IRC - Lavoro).
- Rispondere secondo le frequenze stimate durante il periodo di riferimento (settimanale, mensile, annuale).
- Se le frequenze sono molto cambiate negli anni, rispondere secondo quella più alta. Ad esempio se una persona ha guidato per circa 30 anni tutti i giorni, ma negli ultimi 15 anni ha guidato solo una due volte alla settimana, allora si risponderà «Spesso - Sempre».
- Nella colonna «Anni» riportare *per quanti anni* l'attività è stata esercitata, approssimando per eccesso e utilizzando una scala di 5 anni in 5 anni (5 – 10 – 15 – 20 ecc.). Ad esempio se una persona ha letto regolarmente un quotidiano per circa 27 anni si riporterà 30 nella colonna degli anni di attività, anche se non legge più da anni.
- La cella indicata con «a» è da segnare se la risposta riguarda un'attività ancora *attuale* e regolarmente esercitata.

1. ATTIVITÀ CON FREQUENZA SETTIMANALE

	minore o uguale a 2 volte a settimana	maggiore o uguale a 3 volte a settimana	Anni
1. Lettura di giornali e settimanali	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
2. Attività domestiche (cucinare, lavare, stirare ecc.)	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
3. Guida (escluse biciclette)	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
4. Attività di tempo libero (sport di ogni genere, caccia, ballo, carte, bocce, enigmistica ecc.)	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
5. Uso di nuove tecnologie (macchine digitali, computer, Internet ecc.)	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]

2. ATTIVITÀ CON FREQUENZA MENSILE

	minore o uguale a 2 volte al mese	maggiore o uguale a 3 volte al mese	Anni
1. Attività sociali (cene con amici, circoli, pro loco, dopolavoro ecc.)	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
2. Cinema o teatro	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
3. Cura dell'orto, giardinaggio, tinta alle pareti, lavori di idraulica, maglia, ricamo ecc.	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
4. Provvedere ai nipoti/ai genitori anziani	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
5. Attività di volontariato	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
6. Attività artistiche (suonare uno strumento, dipingere, scrivere ecc.)	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]

3. ATTIVITÀ CON FREQUENZA ANNUALE

	minore o uguale a 2 volte all'anno	maggiore o uguale a 3 volte all'anno	Anni
1. Mostre, concerti, conferenze	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
2. Viaggi di più giorni	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
3. Lettura di libri	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]

4. ATTIVITÀ CON FREQUENZA FISSA

Istruzioni: Nella «Cura dei figli» non vanno riportati gli anni di accudimento, la cella indicata con «a» è da segnare solo quando almeno uno dei figli è minorenne.

			Anni
1. Cura dei figli	☐ No	☐ Sì (numero ......)	[a]
2. Cura di animali domestici	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]
3. Gestione del conto corrente in banca	☐ Mai/Di rado	☐ Spesso/Sempre	..... [a]

Questionario somministrato: all'interessato ☐ all'accompagnatore ☐

Data: ...../...../......

Nome dell'operatore: ....

Risultato

CRI-Scuola ....

CRI-Lavoro ....

CRI-TempoLibero ....

CRI ....

APPENDIX E

STATISTICAL ANALYSIS

Kolmogorov-Smirnov test

	Age	Education	Cdr	Gds	MODA	Elithorn	Raven
Numerosità	38	38	38	38	38	38	38
Parametri normali(a,b)	67,05263158	8,842105263	0,131578947	1,184210526	92,24737	11,125	28,46053
	8,063757318	4,290317923	0,223129175	0,392859452	2,445264	3,807776	5,001867
Differenze più estreme	0,094868684	0,209484728	0,459145716	0,496217759	0,10499	0,118485	0,0949
	0,089341842	0,209484728	0,459145716	0,496217759	0,10499	0,089163	0,053995
	-0,094868684	-0,132620535	-0,277696389	-0,319571714	-0,100133	-0,118485	-0,0949
Z di Kolmogorov-Smirnov	0,584809843	1,291350591	2,830364282	3,058891705	0,647199	0,730391	0,585002
Sig. Asint. a 2 code	0,88	0,07	0,00	0,00	0,80	0,66	0,88

a La distribuzione del test è normale > 0.05

b Calcolo dei dati

c La distribuzione non dispone di varianza per questa variabile. Impossibile eseguire il test di Kolmogorov-Smirnov per un campione

Kolmogorov-Smirnov test

	Bisyllabic	Corsi	Forward span	Backward span	Short MODA	Rey immediately	Rey delayed
Numerosità	38	38	38	38	38	38	38
Parametri normali(a,b)	3,744737	4,815789	5,263158	3,5	5,055263	16,41842	15,90789
	0,833244	0,934844	0,975974	0,951528	1,838874	6,611041	5,006503
Differenze più estreme	0,166868	0,130915	0,158912	0,305635	0,186561	0,090218	0,091791
	0,166868	0,105927	0,158912	0,305635	0,11881	0,085658	0,091791
	-0,118446	-0,130915	-0,085544	-0,220681	-0,186561	-0,090218	-0,05225
Z di Kolmogorov-Smirnov	1,028642	0,807015	0,979596	1,884061	1,150037	0,556139	0,565837
Sig. Asint. a 2 code	0,24	0,53	0,29	0,00	0,14	0,92	0,91

Kolmogorov-Smirnov test

	Pesenti'story	Street MODA	Token MODA	Fonemic fluency	Semantic fluency	TMT A	TMT B
Numerosità	38	38	38	38	38	38	37
Parametri normali(a,b)	15,54658	2,447368	4,921053	33,13158	42,68421	36,65789	86,75676
	3,180177	0,685659	0,358795	10,30395	6,726733	40,21179	66,94251
Differenze più estreme	0,125211	0,342506	0,534446	0,112531	0,123985	0,201292	0,120765
	0,064693	0,210125	0,412922	0,066815	0,075472	0,200498	0,120765
	-0,125211	-0,342506	-0,534446	-0,112531	-0,123985	-0,201292	-0,098745
Z di Kolmogorov-Smirnov	0,771855	2,11135	3,294548	0,693685	0,764294	1,240847	0,734587
Sig. Asint. a 2 code	0,59	0,24	038	0,72	0,60	0,09	0,65

Kolmogorov-Smirnov test

	TMT BA	Matrixes	Manikin test	Barrage lines	Copy MODA	CRI school	CRI work
Numerosità	37	38	38	38	38	38	38
Parametri normali(a,b)	53	51,70132	23,39474	35,97368	2,828947	96,21053	97,89474
	51,61341	6,323172	5,800929	0,162221	0,372651	15,69499	17,12401
Differenze più estreme	0,164116	0,138603	0,19223	0,538118	0,466362	0,182682	0,113248
	0,164116	0,094688	0,19223	0,435566	0,323112	0,182682	0,113248
	-0,112283	-0,138603	-0,154789	-0,53812	-0,466362	-0,147345	-0,08584
Z di Kolmogorov-Smirnov	0,998278	0,854407	1,184984	3,317185	2,874848	1,126127	0,698106
Sig. Asint. a 2 code	0,27	0,46	0,12	0,00	0,00	0,16	0,71

Kolmogorov-Smirnov test

	CRI freetime	CRI tot	Route F1	Time F1	Route B1	Time B1	Route recall
Numerosità	38	38	38	38	38	38	38
Parametri normali(a,b)	95,44737	95,31579	1,552632	48,36842	1,026316	39,28947	5,815789
	19,53749	18,60268	1,369501	21,71862	1,423487	24,25752	2,064569
Differenze più estreme	0,102475	0,118046	0,18775	0,114258	0,317173	0,156102	0,122346
	0,102475	0,118046	0,18775	0,114258	0,317173	0,156102	0,122346
	-0,06206	-0,088648	-0,128456	-0,071664	-0,235459	-0,121764	-0,114496
Z di Kolmogorov-Smirnov	0,631697	0,727685	1,157369	0,704333	1,955185	0,962279	0,754194
Sig. Asint. a 2 code	0,82	0,66	0,14	0,70	0,46	0,31	0,62

Kolmogorov-Smirnov test

	Route Planning	Time Route Planning	Short Route planning	Time Short Route Planning	Route Forward 2	Time Route Forward 2	Bidimensional Stimuli
Numerosità	38	37	38	38	38	38	38
Parametri normali(a,b)	1,828947	34	2,460526	26,15789	0,763158	29,86842	6,052632
	1,311469	17,30928	1,02918	13,4958	0,786171	20,32462	2,253494
Differenze più estreme	0,104518	0,136367	0,143058	0,116281	0,255211	0,155312	0,140896
	0,080684	0,136367	0,116281	0,116281	0,255211	0,155312	0,140896
	-0,104518	-0,085495	-0,143058	-0,115604	-0,197339	-0,140973	-0,109684
Z di Kolmogorov-Smirnov	0,644291	0,829486	0,881866	0,716807	1,573223	0,957408	0,868539
Sig. Asint. a 2 code	0,80	0,50	0,42	0,68	0,31	0,32	0,44

Kolmogorov-Smirnov test

	Other Recall	Tot Recall	City Landmark	Map Drawing	Landmark Photo Recognition	Map Replacement	Recall Replacement on Map
Numerosità	38	38	38	38	38	38	38
Parametri normali(a,b)	1,815789	7,631579	2,697368	18,86842	6,578947	3,263158	2,5
	1,504143	2,870362	1,165608	9,156805	1,810354	2,412627	1,133042
Differenze più estreme	0,206215	0,111141	0,122882	0,169827	0,125439	0,116869	0,197923
	0,206215	0,081311	0,119913	0,169827	0,125439	0,116869	0,171607
	-0,113679	-0,111141	-0,122882	-0,128893	-0,11997	-0,088102	-0,197923
Z di Kolmogorov-Smirnov	1,271196	0,685116	0,757495	1,046883	0,773259	0,720428	1,220077
Sig. Asint. a 2 code	0,08	0,74	0,61	0,22	0,59	0,68	0,10

One - way Anova – Gender

	MALE		FEMALE		F(1,36)	*p*
Measure	M	SD	M	SD		
Bisyllabic words repetition	3,38	0,51	4,08	0,93	8,01	0,01
Fonemic fluency	28,44	10,65	37,35	8,11	8,51	0,01
Time F1	40,56	19,01	55,40	22,03	4,89	0,03
Time B1	31,00	22,17	46,75	24,13	4,89	0,03
Landmark Photos Recognition	7,33	1,78	5,90	1,59	6,88	0,01
Time Short Route Planning	21,72	11,50	30,15	14,17	3,99	0,05
Total Time Orientation	96,33	44,61	136,60	61,09	5,28	0,03

$p<.05$

One - way Anova – Age

	YOUNGER (< 67,05)		OLDER (>67,05)		F(1,36)	*p*
Measure	M	SD	M	SD		
Short story MODA	5,57	1,00	4,42	2,40	4,00	0,05
Manikin Test	25,33	5,10	21,00	5,85	5,94	0,02
Route F1	1,05	0,97	2,18	1,55	7,51	0,01
Time F1	40,76	16,50	57,76	24,10	6,63	0,01
Route B1	0,38	0,74	1,82	1,67	12,70	0,00
Route Recall	6,48	2,02	5,00	1,87	5,37	0,03
Other Recall	2,29	1,71	1,24	0,97	5,09	0,03
Tot Eecall	8,76	2,62	6,24	2,59	8,82	0,01
Total errors orientation	2,05	1,69	4,94	3,49	11,24	0,00

$p<.05$

One - way Anova – Navigation Errors

	Error <3.34		Error>3.34		F(1,36)	*p*
Measure	M	SD	M	SD		
Age	63,18	6,10	72,38	7,49	17,36	0,00
Elithorn	12,65	3,13	9,03	3,74	10,50	0,00
Raven	29,89	4,57	26,50	5,04	4,67	0,04
Backward Span	3,86	0,99	3,00	0,63	9,35	0,00
Short story MODA	5,72	1,07	4,14	2,28	8,09	0,01
Street MODA	2,73	0,46	2,06	0,77	11,08	0,00
Manikin Test	25,91	4,70	19,94	5,48	13,00	0,00
CRI school	102,82	16,97	87,13	7,24	12,02	0,00
CRI work	104,82	16,82	88,38	12,66	10,80	0,00
CRI freetime	104,68	16,46	82,75	16,28	16,59	0,00
Time F1	41,86	18,60	57,31	23,06	5,22	0,03
Route Recall	6,45	1,87	4,94	2,05	5,63	0,02
other_recall	2,41	1,62	1,00	0,82	10,14	0,00
Tot Recall	8,86	2,42	5,94	2,62	12,66	0,00
Map Replacement	3,91	2,79	2,38	1,41	4,05	0,05
Recall Replacement on Map	2,95	0,84	1,88	1,20	10,59	0,00
Route F2	0,55	0,67	1,06	0,85	4,37	0,04
Bidimensional Stimuli	6,68	2,01	5,19	2,34	4,45	0,04

$p<.05$

One - way Anova – Map Drawing

	Map <18,87		Map >18,87		F(1,36)	*p*
Measure	M	SD	M	SD		
Rey Copy	29,14	6,57	34,42	2,05	10,12	0,00
Rey Delayed	14,33	5,09	17,86	4,27	5,20	0,03
Pesenti' Story	14,67	3,57	16,63	2,28	3,87	0,06
TMT A	51,76	46,98	18,00	17,64	7,85	0,01
TMT B	108,10	70,25	61,65	54,62	4,90	0,03
Copy MODA	2,71	0,46	2,97	0,12	4,91	0,03
Time B1	49,38	26,87	26,82	12,62	10,13	0,00
City Landmark	2,21	1,10	3,29	0,97	10,03	0,00
Recall Replacement on map	2,10	1,18	3,00	0,87	6,95	0,01
Time Route Planning	39,50	18,35	27,53	13,85	4,87	0,03
Time Route F2	39,81	21,50	17,59	9,34	15,69	0,00
Bidimensional Stimuli	5,24	2,00	7,06	2,19	7,15	0,01
Total time orientation	144,29	60,60	84,47	28,55	13,99	0,00

$p<.05$