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# The impact of age and familiarity with the environment on representing categorical and coordinate spatial relations



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**Abstract**

Retrieving spatial information is a crucial ability in everyday life and is affected by age-related changes. Previous research showed that this change is mediated by familiarity with the environment. The aim of the present research is to extend and deepen the role of aging in spatial mental representations of environments with different levels of familiarity, disentangling coordinate and categorical spatial relations, in a series of landmark location tasks. The study was conducted under the following hypotheses: (a) the advantage of younger on older adults is expected only in less familiar environments, (b) the advantage of categorical on coordinate spatial relation performance is expected mainly in less familiar environments, and finally, (c) the interaction between age, familiarity and spatial relations might draw different trajectories in coordinate and categorical spatial relations as effect of age and familiarity themselves. Results showed that: (a) the difference in performance between young and elderly is confined to the lesser familiar environments, (b) the expected reduction of the difference between coordinate and categorical accuracy due to increasing familiarity with the environment was confirmed, while (c) the interaction between age and level of familiarity did not differentiate significantly coordinate and categorical spatial relations.



**Keywords**

Categorical and Coordinate Spatial Relations, Sketch Map, Familiar Environments, Individual Differences, Aging

## Introduction

Aging modifies brain and cognitive processes. State-of-the-art-knowledge regarding age-related decline emphasises that old age is associated with functional decline in several very basic aspect of cognition such as executive functions, attention, verbal and visual explicit memory, working memory, processing speed and also spatial cognition. With increasing age an ensemble of basic representations and mechanisms supporting visuospatial perception, mental imagery and rotation, spatial memory, and processing metric properties, are compromised (e.g., Burgess, 2008; Iachini, Iavarone, Senese, Ruotolo, & Ruggiero, 2009; Moffat, 2009; Park & Schwarz, 2000; Klencklen, Desprès, & Dufour, 2012; Serino, Morganti, Di Stefano, & Riva, 2015; Caffò et al., 2018; Lopez, Caffò, Spano, & Bosco, 2019a; Sapkota, van der Linde, & Pardhan, 2020). First, the ability to manage egocentric and allocentric spatial representation (to locate objects in relation and independently to bodily space, respectively) decreases (for a review, Colombo et al., 2017). Second, categorical and coordinate processing is compromised. Categorical and coordinate spatial relations are considered *mainstays* for the construction of accurate and precise spatial mental representation of the environment (e.g., Lopez et al., 2020b). Few studies investigated the differential vulnerability to aging of categorical and coordinate spatial relations. Hoyer and Rybash (1992) found an overall age-related decrement in computing visual–spatial relations. Parkin and colleagues (1995) showed that older adults were impaired in performing tasks that required remembering spatial relations between objects. Bruyer, Scailquin and Coibion (1997) reported a peculiar decrease in performing coordinate spatial judgements with aging, and Meadmore, Dror and Bucks (2009) found that the elderly were less accurate than young adults on both categorical and coordinate processing. These impairments compromise elderly people's spatial orientation and navigation, and in more severe manifestations, may be involved in spatial/topographical disorientation processes (e.g., Piccardi et al., 2018; Piccardi, Palmiero, Bocchi, Boccia, & Guariglia, 2019). Topographical disorientation in turn compromises and interferes with social and occupational functioning, experiencing a range of behavioural symptoms such as poor understanding of safety risks, poor decision-making ability, inability to plan complex or sequential spatial activities and wandering (e.g., Chertkow, Feldman, Jacova, & Massoud, 2013; Song, Lim, & Hong, 2008), whose consequences undermine the ability to conduct lives safely and self-sufficiently.

All the studies above mentioned, however, used only visual-spatial tasks based on newly learned spatial information. It is noteworthy that recent spatial information is more incline to be compromised, because the learning processes suffer from the damage in parahippocampal cortex and in parietal and occipital lobes, due to the effect of aging (e.g., Boccia, Nemmi, & Guariglia, 2014).

The ability to mentally represent space seems to withstand the effect of aging, deteriorating more slowly, if spatial information refers to familiar environment. At high levels of familiarity with the environment, the consolidation of memory traces related to topographical information is strong, making the memory traces less prone to be impaired by the effect of aging (e.g., Moscovitch, Nadel, Winocur, Gilboa, & Rosenbaum, 2006). Several research have shown how familiarity with environment enhanced in the elderly the accuracy in wayfinding, distance estimation, route and map placement tasks (e.g., Foley & Cohen, 1984; Kirasic, Allen, & Siegel, 1984; Kirasic, Allen, & Haggerty, 1992; Prestopnik & Roskos-Ewoldsen, 2000; Campbell, Hepner, & Miller, 2014; Muffato, Meneghetti, Doria, & De Beni., 2019; Caffò et al., 2020). Focusing the attention on spatial mental representations, recently, Lopez and colleagues (2018, 2019a, 2019b) have shown that elderly participants seemed to preserve their ability in two landmark location tasks, testing them on their hometown area. The authors suggested that the experience with the environment increased the level of familiarity which, in turns, led to construct suitable egocentric and allocentric spatial mental representations. Nonetheless, such studies did not differentiate the information contained in these representations according to the type of supposed *categorical* (i.e., position right/left; above/below) and *coordinate* (i.e., distances between objects) spatial relations, between landmarks and between the landmarks and the observer (e.g., Kosslyn, 1987; Hellige & Michimata, 1989; Bullens & Postma, 2008; de Goede & Postma, 2015). However, the same authors carried out a study investigating the effect of familiarity on categorical and coordinate spatial relation in young participants (Lopez et al., 2020b). The authors showed how familiarity - as effect of different levels of knowledge with different geographical areas - played a role in improving the accuracy of distance evaluation, and how the differences in depicting coordinate and categorical information – usually favouring the latter - decreased as a function of familiarity in groups of young adults.

In light of that said so far, it might be noteworthy to evaluate whether the changes associated with aging, and partially mediated by familiarity with the environment, can provide useful information on mental representation in the perspective of categorical and coordinate spatial relations for spatial information with different degrees of familiarity. This information is missing in literature and would be useful because, according to Kosslyn (1994), if humans could not encode categorical and coordinate spatial information they would not be able to recognize the role of landmarks in guiding actions involved in both navigation and grasping. Moreover, information about the way the space is encoded could have an important role in neuropsychological rehabilitation for people with progressive disorders such as topographical disorientation. Individually designed intervention based on spared spatial skills could support autonomy in everyday functioning and well-being, rather than to enhance performance to cognitive test (e.g., Clare, 2007).

The present study aimed to verify if there were differences: a) between young and elderly participants in categorical and coordinate spatial relations; b) in the depiction of positions and distances of landmarks in a series of landmark location tasks with which the participants had high, medium, and low familiarity (i.e., one's own Hometown, one's own Country, and Northern Europe area, respectively). The hypothesis was that familiarity with the environment can be considered a protective factor for spatial mental representations in terms of categorical and coordinate spatial relations. The advantage of categorical on coordinate spatial relation performance was expected mainly in less familiar environments. At higher levels of familiarity should correspond less differences between categorical and coordinate spatial relations; and c) to test the interaction between age, familiarity, and spatial relations. It is expected that coordinates and categories may show different trajectories in relation to the age of the participants and the degree of familiarity with the environments considered. Since older people benefitted of environmental exposure for longer than young people, they could show a *paradoxical* effect which makes them particularly competent in estimating distances compared to young people, withdrawing the disadvantage in performance compared to young people, but only for very familiar environments, such as one's own hometown.

## Methods

### *Participants*

A power analysis was carried out using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) to estimate the sample size, with the following parameters: a p level of 0.05; a cautious low effect size (0.10); and a power of 0.80. Results indicated that a sample size of 96 participants was adequate to warrant an 80% chance of correctly rejecting the null hypothesis.

One hundred healthy participants (50 women) took part in the study. All participants were from a small town in a rural area in the south-east of Italy, in which participants were recruited as a part of a larger research project on the epidemiology of mild cognitive impairment in a south Italian population. Fifty young participants (i.e., ranging between 19-30 years old, age mean±sd 23.86 ± 4.56; level of education in years mean±sd 16.38 ± 2.66), 50 healthy Elderly people (i.e., ranging between 65-85 years old, age mean±sd 73.16 ± 6.48; level of education in years mean±sd 9.44 ± 4.44), were enrolled in the study. Descriptive statistics are reported in Table 1. All participants, blind to the hypothesis of the study, signed a consensus form. The Ethical Committee of the Institution approved the study protocol, and the whole study was performed following the Helsinki Declaration and its later amendments.

*Insert Table 1 here*

*Materials and procedure*

All participants were from Turi, a small town of 13,000 inhabitants over an area of approximately 71 $km^2$ and have been living there since birth. Both young and elderly participants were volunteers recruited by a proxy informant, generally an undergraduate or graduate student, and by word of mouth. The elderly had to be in a good general state of physical and psychological health. All participants were enrolled between February 2018 and July 2018. Nobody rejected the invitation of the proxy to participate in the study. In order to exclude elderly people with a history of suspected uncompensated systemic/traumatic/psychiatric disease or with severe vision/hearing loss that could have affected cognition, a general anamnesis was carried out and assessed by supervised trainees in psychogeriatric assessment. Moreover, global cognitive function was assessed through the Montreal Cognitive Assessment test (MoCA, Nasreddine et al., 2005; Krishnan et al., 2017; Bosco, Caffò, Spano, & Lopez, 2020). The inclusion cut-off was a MoCA score above 17, which was shown to be the optimal cut-off for discriminating healthy participants from participants with probable cognitive impairment in an Italian elderly sample from the same geographical area (Bosco et al., 2017). Finally, the Activities of Daily Living and Instrumental Activities of Daily Living (ADL, Katz, 1983; IADL, Lawton & Brody, 1969) were administered and assessed for any possible occurrence of functional decline usually associated with dementia (inclusion cut-off higher than 4 for ADL and higher than 4 for males and 6 for females for IADL), the 15-item version of the Geriatric Depression Scale (GDS, Brink, Yesavage & Lum, 1982; inclusion cut-off less than 4), in order to exclude depressive symptoms, and the Subjective Memory Complaints Questionnaire (SMCQ, Youn et al., 2009) to exclude robust complaints regarding memory loss (inclusion cut-off less than 5) were administered. No one was excluded from the sample. Some thresholds for the sample size were reached early, such as the number of female young participants. The remaining portion of the sample was expressly recruited. Data from potential participants who did not fulfil the requirements were not recorded. At the end of the enrolment procedure, the final sample was composed of 50 elderly participants and 50 young participants.

In order to test their knowledge of hometown, all participants were assigned a score based on the frequency they visited the landmarks employed in the task, using a scale from 1 (never) to 7 (always). Moreover, they were rated on their geographical knowledge of their own country (i.e., Italy) and of a target Northern Europe area, according to four items: their use of Google Maps, Paper Maps, Weather Forecast, on a scale from 1 (never) to 7 (always), and the Study of Geography at school according to their proficiency at school.

Participants completed three landmark location tasks – a simplified sketch map task - regarding: their hometown (three memorable landmarks within the city of Turi), their own country (three Italian cities: Genoa, Cagliari and Naples) and an area of the Northern Europe (three European cities: Paris, London, Amsterdam). The three geographical areas were expected to be highly, middle, and low familiar to the participants, respectively. The *Hometown Area* (see figure 1a) was composed of three very familiar landmarks: a very renowned and antique pharmacy, the Local Justice Building and the monumental Palace in Marchesale Square. The target area was approximately 15 $Km^2$. The stated scale was 1cm = 15 m. Participants had mainly learnt about this area through direct and frequent experiences of navigation. The *Country Area* (see Figure 1b) considered three landmarks: Genoa, Naples and Cagliari. The target area was approximately of 128600 $Km^2$. The stated scale was 1cm = 42 km. *Northern Europe Area* (see Figure 1c) was composed of three landmarks: Paris, London, and Amsterdam. The target area of the country investigated was approximately of 63012 $Km^2$. The stated scale was 1cm = 30 km. Participants had learnt about the latter two areas mainly through intentional map study or through unintentional/incidental learning such as when one looks at the map planning a travel or being interested in the weather forecast, following a television broadcast.

*Insert figure 1 here*

These tasks were based on pinpointing the three triplets of landmarks in a “sketching area”, namely, a north facing empty box, oriented in portrait format, measuring 11.3x12 cm (e.g., De Goede & Postma, 2015, see Figure 2a). Participants were requested to keep in mind metric (i.e., relative distances) as well as categorical (“A is North/South and East/West of B”) spatial relations between landmarks. Participants were asked to follow the instructions: “Think of the spatial relationships between the landmarks. In the box below, draw three crosses, corresponding to the landmarks, and label them. Please, use the full sketching area. Please, be careful to respect the distances between landmarks and their correct positions relative to each other” (see Figure 2b for an example of a sketch map drawn by a participant). In order to avoid the pitfalls of standard repeated measures designs, tasks were administered in a randomized order. The entire procedure was made clear to the participants beforehand. Participants were assessed individually in a well-lit and quiet room without disturbances. Data were collected in one session. The whole assessment lasted approximately 45 minutes.

*Insert figure 2 here*

Scoring

The landmarks were chosen after an evaluation of their memorability, using a rating scale, and for the discriminability of their positions and distances from each other. In order to compute the scores for the categorical and coordinate locations, we used the three landmarks pinpointed in the sketch box. For each pair of landmarks, we obtained categorical locations (see Figure 3a), separately comparing positions on the x (B is to the right of C) and y (B is above C) axes. We obtained coordinate locations (see Figure 3b) separately comparing distances on the x (the distance between landmarks B and C is greater than the distance between landmarks A and C) and y (the distance between landmarks B and C is lesser than the distance between landmarks A and C) axes. For each correct depiction of categorical and coordinate spatial relation one point was assigned for a maximum of six points - three comparisons along each axis, respectively - (Lopez et al., 2020a).

*Insert figure 3 here*

A measure of the intrinsic difficulty of the three target areas was provided to increase the comparability between them. For each target area two difficulty scores were obtained one for categorical, and one for coordinate relations (for more details, Lopez and colleagues 2020b). They were used to proceed to statistically control and neutralise the unfavourable effect of the different, intrinsic and unavoidable difficulties of the target areas, through the *y adjusted* multiple regressions (Kirk, 1982; Lison, Robotti, & Título, 1982; Sardone, Bosco, Scalisi, & Longoni, 1995; Athey et al., 2017). This method has the advantage, unlike the most common analysis of covariance, of considering individual differences when computing the level of association between X and Y variables. Preliminarily, task difficulty scores were transformed into their logarithm (Benoit, 2011, p. 2). Then, the observed performance (Y) and task difficulty (X) were considered separately for each participant, computing the regression of X on Y, with the following formula:

$$Y_{adj} = Y + b(x_i - \bar{x})$$

where b is the regression coefficient, $x_i$ is the score of the participant and $\bar{x}$ is the mean score.



**Results**

Preliminary analysis of neuropsychological and geographical knowledge tests was performed, as reported in Table 1. Moreover, significant differences ($p<0.05$) between the levels of self-reported level of familiarity with the three target areas emerged (Hometown: 4.8 ±0.3; Country: 3.7 ±1.5; Northern Europe: 3.5 ±1.6).

From now on, when we refer to participants' performance, we will refer to the corrected score using the *Y adjusted* method. In order to accomplish the purposes of the study, a mixed factor ANCOVA was also performed, with Group (two levels: Y, young; E, elderly) and Gender as between-subject variables. Repeated measure variables included Target Area (three levels: Hometown, Country, and Northern Europe) and Spatial Relation (two levels: categorical and coordinate spatial relations), controlling for education level of the participants.

The results were as follows: the main effect of Group ($F(1, 95) = 6.20$, $p<0.01$; $\eta_p^2 = 0.10$; means and sds: Y 4.50±0.078; E 4.05 ±0.08), the main effect of Target Area ($F(2, 95) = 6.01$, $p<0.01$; $\eta_p^2 = 0.06$; means and sds: Hometown: 4.9±0.09; Country: 4.18±0.07, and Northern Europe: 3.68±0.10), the main effect of Gender ($F(1, 95) = 5.26$, $p<0.01$; $\eta_p^2 = 0.06$; means and sds: Male: 4.40±0.07; Female: 4.10±0.07) and the main effect of Spatial Relation ($F(1, 95) = 10.00$, $p<0.01$; $\eta_p^2 = 0.10$; means and sds: Category: 4.50±0.07; Coordinate: 4.03±0.05) proved to be significant. The post-hoc analysis (Tukey's Test) regarding the variable Target area showed a significant effect for all the three comparisons ($p<0.05$). Moreover, the interaction Group x Target Area ($F(2, 95) = 4.42$, $p<0.01$; $\eta_p^2 = 0.04$) proved to be significant. From the inspection of the graph (see Figure 4) the young and the elderly had a comparable performance on hometown area, while a higher advantage in favour of young participants on country area and even more on Northern Europe area occurred.

*Insert here figure 4*

Finally, the interaction Target Area x Spatial Relation ($F(2, 95) = 4.10$, $p<0.01$; $\eta_p^2 = 0.04$) was also significant. From the inspection of the graph (see Figure 5) an advantage emerged for coordinates over categorical judgements in hometown area (categorical - coordinate score = -0,15) and for category over coordinate judgements both in the country area (categorical - coordinate score = 0.3), and particularly in the Northern Europe area (categorical - coordinate score = 0.9). No other main or interaction effects were significant, included the level of education as a covariate.

*Insert here figure 5*

**Discussion**

The present study compared the performance of young and elderly participants on three landmark location tasks characterized by different levels of familiarity for the participants. Acquiring information about the spatial mental representations of participants by interpreting their sketch maps appears to be a viable way to study how categorical and coordinate processes are involved in encoding spatial relations (Lopez et al., 2020a).

Firstly, the young and the elderly differed with respect to schooling and to the proficiency on geography at school. Coherently with previous research, the young were better than the elderly in geography (e.g., Lopez et al., 2020b). Conversely, the level of familiarity with the target areas was comparable across groups, as evidenced from self-reported scores.

Nonetheless, the younger globally outperformed the elderly in performing the landmark location tasks focused on their own country and especially on Northern Europe area, showing to better represent allocentric information, notwithstanding elderly self-reported an equal level of familiarity (e.g., Roser & Ortiz-Ospina, 2017). Two considerations are necessary to unravel this result. The first concerns the actual knowledge of the area of Northern Europe by young and old. Indeed, although it is very popular for all people, it is likely that the young participants in our study had a more direct and frequent knowledge of those areas that perhaps the older ones lacked. Secondly, it cannot be excluded that the elderly overestimated their own level of familiarity, as an effect of metacognitive difficulties due to aging (e.g., Hertzog, 2002), distorting self-estimations of their actual spatial abilities (Taillade, N'Kaoua, & Sauzéon, 2016). Beyond the main effect of age group, the first-order interaction between age group and target area, specified that the difference in performance between young and elderly is confined to the lesser familiar target areas, namely the participants' own country and even more the Northern Europe area. These results confirmed that the spatial mental representations of elderly people are comparable to that of young people in very familiar environments, like the hometown, confirming that the protective factor of the semantization of information can be extended to the spatial cognition domain (Moscovich et al., 2006).

From the inspection of difference in performance between spatial relations, irrespective to the age group, participants were more accurate in depicting categorical than coordinate relations. This effect is in line with the largest part of previous studies (Bruyer et al., 1997; Trojano et al., 2002; Klencklen et al., 2012; Lopez et al., 2020b). This previous research employed tasks requiring learning sessions of new material, inspired by Hellige and Michimata (1989) and Koenig, Reiss, and Kosslyn (1990) experiments, in which stimuli consisted of a small dot presented above or below a horizontal line or of computerized task with dot and boxes. They were not based on remote spatial knowledge, disadvantaging older people with early manifestations of difficulties in retaining newly learned materials. Moreover, the self-reported frequency as well as geographical knowledge of target areas seemed to influence the performance on categorical and coordinate spatial relations. First, the expected reduction of the difference between coordinate and categorical accuracy as effect of the supposed familiarity with the environment was confirmed in the present study, as well as the presence of a slight advantage for coordinate over categorical spatial relations in the hometown area (Lopez et al., 2020b). The participants' knowledge of their hometown was based on spatial information acquired mainly through frequent experiences of navigation, relying on egocentric reference frame that refers to *self-to-object relations*. The active navigation of the environment which assumes movements and the activation of the internal device estimating time spent in motor behaviour (e.g., Santoro et al., 2017), could contribute in explaining a more accurate estimation of distances (e.g., Martens, Ellard, & Almeida, 2013; Murata, 1999; Servos, 2000; Waller, Loomis, Golledge, & Beall, 2000). These egocentric representations are constantly updated, because of their implication in online processing of navigation and direct perception of spatial information (e.g., Kelly, Avraamides, & Loomis, 2007; Mou & McNamara, 2002; Waller & Hodgson, 2006). Moreover, using path integration and sensed motion, humans can update their actual position and orientation relative to a starting position. To do this they have to employ their ability to track movement throughout space (Durgin et al., 2005; Rieser, Pick, Ashmead, & Garing, 1995). Thus, visuo-spatial information acquired and stored in memory are integrated into motoric actions through the dorsal stream, (from the primary visual area to posterior parietal cortex; e.g., Snyder, Batista, & Andersen, 1997). More specifically, the somatosensory system stores proprioceptive information which is then integrated with vestibular information to compute distances (e.g., Barlow et al., 1964; Hatzipanayioti, Galati, & Avraamides, 2016). Thus, it is plausible to infer that the regular experience with the hometown, protects from getting lost and disorientation (e.g., Golledge, 2002), also via the improvement of coordinate relation processing.

On the contrary, an advantage of categorical information emerged in the case of one's own country and Northern Europe area. This kind of information are organized around allocentric reference frames (e.g., Hatzipanayioti, et al., 2016). Since, it is more likely that there are not regular updates of this kind of spatial information. These long-term spatial mental representations provide an example of the so called *offline spatial reasoning*, namely enduring representations not updated with the observer's movement (Avraamides & Kelly, 2008).The ventral stream, which covers from the primary visual area to the inferior parietal cortex, is involved in processing and retaining the enduring characteristics of objects such as their positions. Consequently, it is reasonable to assert that intentional map study enriched mostly categorical processing (for a review, Norman, 2002; Rock, 1983), when present.

Regarding gender differences, men outperformed women. This result is in line with previous findings in which men were found to be more accurate in managing metric information, when facing an object location memory task, and in manipulating allocentric spatial memory (e.g., Postma, Jager, Kessels, Koppeschaar, & van Honk, 2004; Picucci, Caffò, & Bosco, 2009; Lopez et al., 2020b). This difference could reflect gender difference in hippocampal functions, and men's larger activation in the right hippocampus (e.g., Persson et al., 2013). This male advantage was maintained into advanced age, (e.g., Maitland et al., 2000; Parsons et al., 2007; Klencklen et al., 2012), and it was not attributable to a larger number of men than women in the younger group that could increase the expected aging effect, as happens in some studies, but rather to the kind of task (for a Meta-Analysis see, Techentin, Voyer & Voyer, 2014).

Finally, the present study did not support an initial hypothesis of different trajectories between young and elderly participants in categorical and coordinate estimations as effect of different levels of familiarity with spatial information. It is known that this kind of research enters the field of ecological and environmental psychology. The study of remote spatial information inevitable comes up against the impossibility of controlling, by the experimenter, all the intervening variables in the relations between age and spatial representation, and familiarity (e.g., Lockton, 2012). One might suppose, properly, by reference very familiar environment (i.e., hometown), that the elderly could have even had a better performance compared to the young, possessing, on average, more experience. This paradoxical effect, also possible for spatial information based on map study (the elderly individual habits, such as to see the weather forecast, or the level of education might help them to refresh that memories), might not be emerged because of the influence of other factors such as the frequency, the kind and the attitudes towards the explorations, the self-confidence to be a good explorer, and cognitive functioning. Further research should consider the contribution of these intervening variables, in order to try to understand the relationship between the number of opportunities of experience with the environment, and the knowledge with it. Unfortunately to study cognition in an ecological way, pays the cost of poor control, gaining, on the contrary, in knowledge regarding cognitive functioning in the real life.



**Conclusion**

To the best of our knowledge, this is the first attempt to investigate the effect of familiarity on categorical and coordinate spatial relations across age groups, employing a simplified version of the sketch map task. Further investigations could deepen whether the increase in the number of elements to arrange in the sketched area, may reveal a moderation of age on the relationship between familiarity with the environment and the encoding of categorical and coordinated spatial information. Furthermore, remote overlearned spatial information might be used in improving our knowledge of *situated cognition* regarding target areas characterized by both daily (e.g., the usual workplace, shopping mall, home neighbour) and recurrent (e.g., a holiday resort, an occasional work or leisure place) environment explorations. Finally, it would also be appropriate to consider groups of older people characterized by different level of cognitive functioning and with neurocognitive disorders, in order to develop a more general framework regarding the encoding and mental representation of distances and positions along the life span.

The present study refers to a kind of situated spatial cognition intrinsically associated with the social and cultural contexts in which it occurs (Cobb, 2001), and because it, researchers can not be disregard that both mind and environment should be considered together to understand behaviours (e.g., Simon, 1990).

In conclusion, the present study provides new evidences on fundamental aspects of spatial mental representation and spatial cognition in aging. The role of familiarity with geographical areas and its impact on the representation of categorical and coordinate relations is an emerging and interesting topic which deserves further investigation for its practical implication in the rollout of compensatory and restorative approaches (e.g., Caffò et al., 2014a, 2014b), in enhancing efficient spatial behaviours, such as, way-finding and reducing wandering and topographical disorientation in people with neurocognitive disorders (Lancioni et al. 2011; 2013).

**Authors' contributions** AL and AB contributed to the conception, data analysis and drafting the manuscript, AOC to discuss the results and revising the manuscript.

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**Conflict of interest statement** The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Ethical standard** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (Commissione Etica Locale- nr. 3660-CEL03/17) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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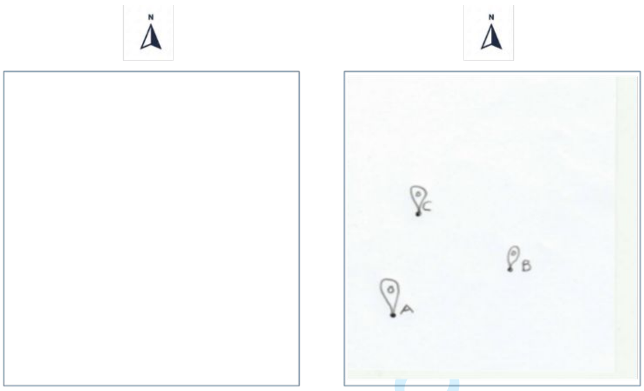
Table 1. Means ± standard deviations for interval variables. Significance values obtained through t test -χ2 for frequencies – on demographical variables, study of geography and familiarity levels with the target areas as effect of group

| | YOUNG | ELDERLY | Test |
|---|---|---|---|
| Gender, F/M | 25/25 | 25/25 | *n.s.* |
| Age, years | 23.86 ± 4.56 | 73.16 ± 6.48 | $p<0.001$ |
| Education, years | 16.38 ± 2.66 | 9.44 ± 4.44 | $p<0.001$ |
| Montreal Cognitive Assessment | - | 22.20 ± 2.82 | |
| Subjective Memory Complaints Questionnaire | - | 2.6 ± 1.45 | |
| Act.s of Daily Living | - | 5.88 ± 0.38 | |
| Instr. Act.s of Daily Living | - | 6.02 ± 1.84 | |
| Geriatric Depression Scale | - | 2.76 ± 2.50 | |
| *PROFICIENCY ON GEOGRAPHY AT SCHOOL* | | | |
| Turi | - | - | |
| Italy | 4.80 ± 1.45 | 4.30 ± 1.78 | $p<0.01$ |
| Northern Europe | 4.82 ± 1.29 | 4.40 ± 2.26 | $p<0.01$ |
| *LEVEL OF FAMILIARITY WITH MAPS* | | | |
| Turi | 4.20 ± 0.37 | 4.25 ± 0.38 | *n.s.* |
| Italy | 3.89 ± 1.60 | 3.67 ± 1.42 | *n.s.* |
| Northern Europe | 3.64 ± 1.05 | 3.50 ± 1.80 | *n.s.* |

Figure 1. Target Geographical areas and distances between landmarks: a) Hometown; b) Country; c) Northern Europe. Illustrations free downloaded from Google Maps

Figure 2: a) Empty box to draw provided to participants; b) An example of sketch map drawn by a participant




a b

Figure 3. a) Graphical analysis method for categorical relations; b) Exemplification of the graphical analysis method for coordinate relations between landmark distances, on x and y axis

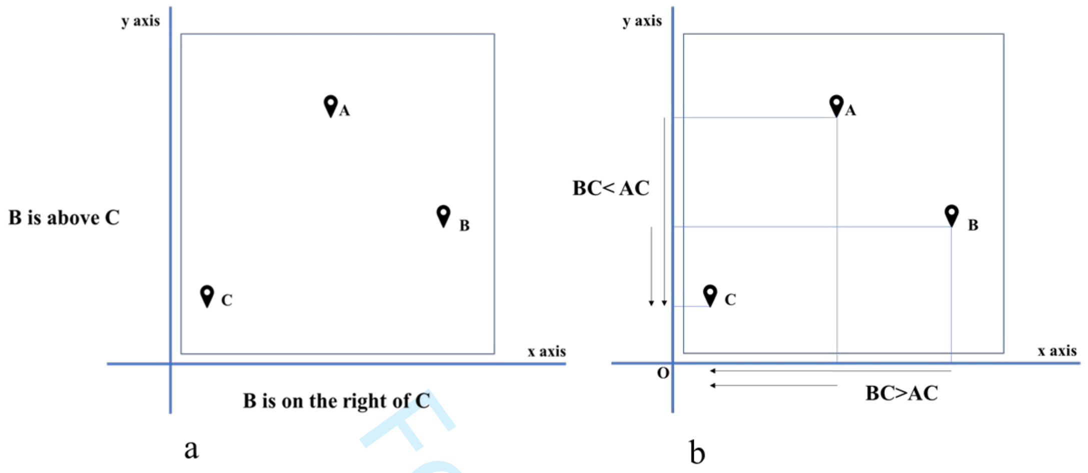


Figure 4. Mean proportions of correct responses and 95% Confidence Intervals for the young (dark grey bars) and the elderly (light grey bars), on Hometown, Country and Northern Europe Geographical Area.

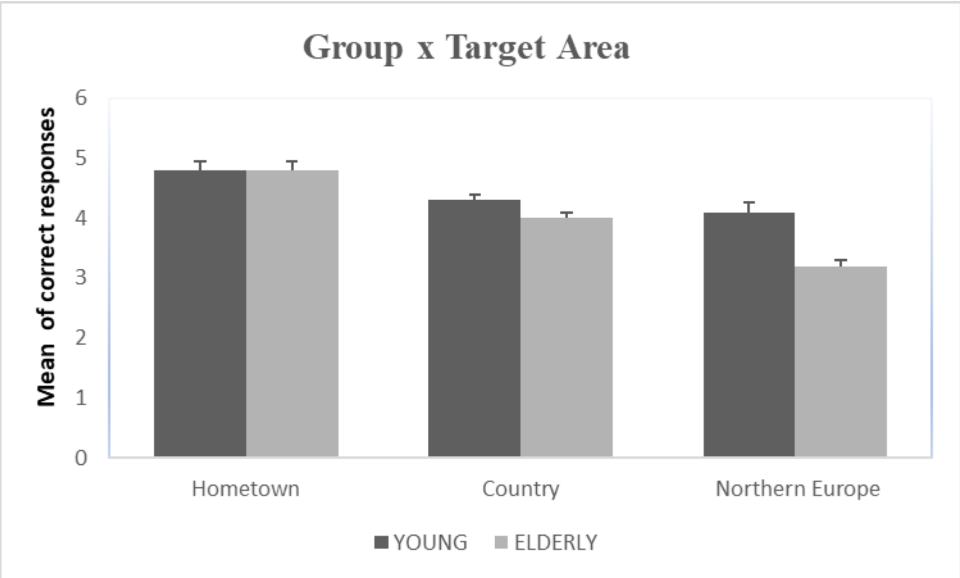


Figure 5. Mean proportions of correct responses and 95% Confidence Intervals for categorical (dark grey bars) and coordinate (light grey bars) spatial relations, on Hometown, Country and Northern Europe Geographical Area.