Age-related differences in pointing accuracy in familiar and unfamiliar environments

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Keywords (separated by '-')	Familiar environment - Pointing task - Spatial abilities - Age-related differences
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SHORT REPORT

Age-related differences in pointing accuracy in familiar and unfamiliar environments

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Abstract This study aimed to investigate age-related differences in spatial mental representations of familiar and unfamiliar places. Nineteen young adults (aged 18–23) and 19 older adults (aged 60–74), all living in the same Italian town, completed a set of visuospatial measures and then pointed in the direction of familiar landmarks in their town and in the direction of landmarks in an unknown environment studied on a map. Results showed that older adults were less accurate in the visuospatial tasks and in pointing at landmarks in an unfamiliar environment, but performed as well as the young adults when pointing to familiar places. Pointing performance correlated with visuospatial tests accuracy in both familiar and unfamiliar environments, while only pointing in an unknown environment correlated with visuospatial working memory (VSWM). The spatial representation of well-known places seems to be well preserved in older adults (just as well as in young adults), while it declines for unfamiliar environments. Spatial abilities sustain the mental representations of both familiar and unfamiliar environments, while the support of VSWM resources is only needed for the latter.

Keywords Familiar environment · Pointing task · Spatial abilities · Age-related differences

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Introduction

The cognitive map (introduced by Tolman 1948) is a mental representation of the environment that, among other functions, enables people to reach destinations successfully and remember locations. The ability to acquire environmental knowledge is essential to every human being, and for older adults it is fundamental to their independent living.

Most studies on environment learning in older adults have focused on the acquisition of new environments (for a review see Klencklen et al. 2012). Studies have shown an age-related decline in the ability to learn new environments using various inputs, such as spatial descriptions (e.g., Meneghetti et al. 2014a, b), navigation (e.g., Wilkniss et al. 1997), and maps (e.g., Borella et al. 2014). A method commonly used to test environment representation is the pointing task, which involves asking participants to judge directions of landmarks from new imaginary positions (Shelton and McNamara 2001), and this has proved particularly resource consuming for older adults (e.g., Borella et al. 2014).

Little is known, on the other hand, about how mental representations of well-known places, such as one's home town or familiar places, are influenced by aging. Kirasic (1991) asked young and older women to complete a wayfinding task in two supermarkets, one familiar and one unfamiliar, and found that the older women only performed as well as the younger women in the familiar environment. Kirasic (1989) had previously found no differences between young, middle-aged and elderly people's ability to indicate the directions of landmarks in their home town. Rosenbaum et al. (2012) recently tested young and old people who had once lived in Toronto for at least 10 years, but had rarely returned in recent years. The results showed that older adults performed just as well as (or even better than) the younger adults in a series of spatial tasks, such as

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judging directions. After learning a new environment, on the other hand, the same older adults performed less well in spatial tasks than the younger ones. Furthermore, Meneghetti et al. (2013) showed that older people's mental representation of their home town (tested by judgment of directions) remained as accurate as in younger people, despite the former's worse performance in visuospatial working memory (VSWM) and spatial tests.

Analyzing the role of spatial skills can be a useful way to see whether they are differently involved in environment representation of young and older adults in familiar and unfamiliar places. Studies concerning unfamiliar places have shown that older adults rely more on their visuospatial skills than young adults (e.g., Meneghetti et al. 2011). As for familiar environments, Campbell et al. (2014) recently found that age had no impact on memory for familiar places (using route and landmark recall, for instance). They concluded that experience, rather than different underlying cognitive abilities, is important in navigating familiar environments. The only exception concerned performance in a direction judging task associated with spatial span and mental rotation tasks. Meneghetti et al. (2014a, b) also showed that the ability to orient oneself (by indicating the cardinal points) starting from one's own home is influenced by age, but this influence is mediated by an individual's spatial abilities, spatial preferences, and WM.

Given that only a few studies have compared the spatial representation of unfamiliar and familiar environments, and the contribution of visuospatial abilities, the aim of the present study was to investigate age-related differences in a task that involved managing information from different viewpoints (i.e., a pointing task) of both familiar places (the participants' home town) and unfamiliar places (learned from a map), considering at the same time the role of visuospatial competences.

Methods

Participants

The study involved 38 participants: 19 young adults (9 females, aged 18–23) and 19 young–old adults (9 females, aged 60–74). All participants were volunteers living in the same town (Vittorio Veneto, in the northeast of Italy). The older participants were all healthy and living independently, and they met our inclusion criterion requiring a score of more than 27 in the mini-mental state examination (Folstein et al. 1975).

The young adults had more schooling than the older adults [$F(1, 37) = 14.77$, $\eta^2 = .01$, $p < .001$]—a difference due to the cohort effect (see ISTAT 2011)—and the two groups had similar scores for vocabulary (Wechsler 1981; $p = .61$; see Table 1).

Table 1 Means (*M*) and standard deviations (SD) of demographic variables, familiarity with home town landmarks and spatial test performance by age group

	Young adults		Young–old adults	
	M	SD	*M*	SD
Age	20.11	1.55	66.75	4.32
Education	13.90	1.52	10.26	3.83
Vocabulary	44.95	10.73	43.37	8.01
Familiarity with home town landmarks (from 1 to 6)	5.42	.63	5.71	.45
VSWM (max. 29)	23.26	3.18	17.84	4.39
sMRT (max 10)	4.63	2.54	2.95	1.90
sOPT (max. 180°)	41.26	28.59	64.87	15.84

VSWM visuospatial working memory (Jigsaw Puzzle Test), *sMRT* short Mental Rotations Test, *sOPT* short Object Perspective Test

Materials

Spatial tests

Jigsaw Puzzle Test (*JPT*, *De Beni et al.* 2008) The task (which is considered a measure of VSWM) involves solving 27 puzzles by mentally recomposing the picture and indicating where the corresponding pieces (from 2 to 10) should go on an answer sheet, without actually moving pieces. The final score is the sum of the scores obtained in the three most complex correctly solved puzzles.

Short Mental Rotations Test (*sMRT*, *De Beni et al.* 2014) This involves identifying two of four 3D abstract objects that match a target object in a rotated position (ten items; time limit 5 min). The total score is the sum of the correct answers.

Short Object Perspective Test (*sOPT*, *De Beni et al.* 2014) This task entails imagining standing at one object in a configuration, facing another, and pointing in the direction of a third. The answer is given by drawing an arrow from the center toward the perimeter of a circle drawn on a piece of paper (six items; time limit 5 min). The total score is the mean of the absolute degrees of error.

Unfamiliar environment: botanical garden

Map A map of the Botanical Garden in Padua was prepared in A4 format. It included 14 landmarks (e.g., the ticket office, the shrubbery, the freshwater plant pool) and 5 structural landmarks (i.e., four doors named as the cardinal points and a point where two paths crossed).

Pointing task Twelve misaligned pointing items were prepared and participants were asked to imagine pointing in the direction of a given landmark in the Botanical Garden while standing at another landmark and facing

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Table 2 Means (*M*) and standard deviations (SD) of pointing performance (degrees of error from 0° to 180°) by age group and for total sample

Type of environment	Young adults		Young–old adults		Total	
	M	SD	*M*	SD	*M*	SD
Familiar	39.14	14.17	42.69	11.55	40.92	12.86
Unfamiliar	48.89	15.47	66.96	21.11	57.93	18.29
Total	44.02	14.82	54.83	16.33		

toward a third (e.g., "Imagine being at the ticket office, looking at where the paths cross, and pointing to the shrubbery"). The answer was given by drawing an arrow from the center toward the perimeter of a circle.

Familiar environment: Vittorio Veneto town

Sketch map A map with the essential features of the city (e.g., the main road through the town, going from south to north) was prepared.

Pointing task Twelve misaligned pointing items were prepared that again involved imagining adopting different viewpoints and answering using a circle (as for familiar environment).

To score performance in the pointing tasks, we calculated the minimum absolute angle of the difference between the direction of the participant's answer and the right direction. Then, the mean vectors for unfamiliar and familiar places were computed (see Borella et al. 2014).

Procedure

Participants were tested individually at two sessions lasting 45 min each, conducted in a quiet room at a recreation center in the Vittorio Veneto town center. Participants were always seated facing north. In the first session they completed a socio-demographic questionnaire, the Vocabulary test, the JPT, the sMRT and the sOPT (in a balanced order). During the second session, participants were asked to rate on a 7-point Likert scale their familiarity with 14 landmarks in Vittorio Veneto and, after looking at the sketch map of the town for 30 s, they performed the pointing task for the familiar environment. Then they studied the map of the Botanical Garden for a maximum of 5 min, before performing the pointing task for an unfamiliar environment.

Results

Preliminary analysis

Univariate ANOVAs revealed that older adults had a worse performance than their younger counterparts in all the spatial tests: the JPT, $F(1, 37) = 19.03$, $\eta_p^2 = .35$, $p < .001$; the MRT, $F(1, 37) = 5.35$, $\eta_p^2 = .13$, $p = .03$; and the OPT, $F(1, 37) = 4.06$, $\eta_p^2 = .10$, $p = .05$ (see Table 1).

Young and older adults did not differ in terms of their familiarity with Vittorio Veneto landmarks [$F(1, 37) = 2.64$, $\eta^2 = .07$, $p = .11$; see Table 1].

Pointing task

The 2 (age: young vs. young–old adults) × 2 (type of environment: unfamiliar vs. familiar) ANOVA showed a significant main effect of age, $F(1, 36) = 7.12$, $\eta_p^2 = .17$, $p = .01$, young participants showing fewer degrees of error (i.e., being more accurate) than their older counterparts. The main effect of Type of environment was also significant, $F(1, 36) = 27.81$, $\eta_p^2 = .44$, $p < .001$, with smaller degrees of error for the familiar than for the unfamiliar environments. The age × type of environment interaction was significant, $F(1, 36) = 5.07$, $\eta_p^2 = .12$, $p = .03$. Post hoc comparisons (using Bonferroni's correction, only $p < .01$ was significant) showed that young adults performed better than young–old adults in the unfamiliar environment ($p < .01$), but the two groups had similar degrees of error for the familiar environment ($p = .40$) (Tables 2, 3). AQ3

Correlations between spatial tests and pointing tasks

Correlations between age, spatial tests (JPT, sMRT and sOPT), and pointing performance (in familiar and unfamiliar environments) showed that: age correlated with all the spatial tests and pointing in an unfamiliar environment, but no significant correlation emerged between age and pointing in a familiar environment. The spatial tests (sMRT and sOPT) correlated with pointing performance in both familiar and unfamiliar environments; the JPT (assessing VSWM) only correlated with pointing in an unfamiliar environment.

Discussion and conclusion

Mental maps of an individual's home town and of a new environment were investigated in young and young–old participants, analyzing their ability to manage information

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Table 3 Correlations between age, spatial tests and pointing tasks in unfamiliar and familiar environments

	1	2	3	4	5	6
1. Age	1					
2. VSWM	−.61**	1				
3. sMRT	−.38**	.59**	1			
4. sOPT	.34*	−.39**	−.38*	1		
5. Unfamiliar environment—pointing	.44**	−.30*	−.32*	.17	1	
6. Familiar environment—pointing	.13	−.11	−.30*	.32*	.27*	1

$N = 38$

VSWM visuospatial working memory (Jigsaw Puzzle Test); *sMRT* short Mental Rotations Test, *sOPT* short Object Perspective Test

* $p < .05$; ** $p < .01$

from different viewpoints (using a pointing task), and how this ability related to their spatial abilities.

Our results showed that older adults were less accurate than young adults in pointing at landmarks in an unfamiliar environment (as in Borella et al. 2014), while they performed as well as young adults when pointing to familiar places (as in Meneghetti et al. 2013). This confirms that mental representations of familiar environments (such as one's home town) are well preserved with aging (Rosenbaum et al. 2012): Experience of one's own home town enables the formation of a more flexible representation in which older adults preserve the ability to adopt new imaginary viewpoints. It should be noted (and this might be a limitation of the present study) that our results could be influenced by participants tiring in the second part of the test, since they completed the pointing task relating to a familiar environment first, and then to an unfamiliar one, in a fixed order. Another possible limitation of our study could concern an influence of the older adult participants' more limited schooling (though they had all completed their compulsory education) on their worse pointing performance in unfamiliar places. Further studies should take these variables more carefully into account, and replicate the formation of flexible representations of familiar (but not unfamiliar) environments in older adults.

Concerning the relationship with spatial skills, our results newly show that spatial abilities modulate mental representations of familiar and unfamiliar environments. Pointing in both types of environment were related with spatial (rotation) abilities, but only pointing in an unfamiliar environment was related to VSWM. Spatial abilities thus sustain the mental representation of both familiar (Campbell et al. 2014; Meneghetti et al. 2011) and unfamiliar environments, and VSWM resources also play a part in supporting the formation of a mental representation of a new environment.

In conclusion, older adults have difficulty in forming a mental representation of a new environment, while this is not the case for familiar environments. Both types of representation are supported by spatial (rotation) abilities, while only the representation of an unfamiliar environment is sustained by VSWM resources too.

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