Age-Related Differences in Viewer-Rotation Tasks: Is Mental Manipulation the Key Factor?

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Using a viewer-centered frame of reference (VCFR) paradigm, we examined whether the necessity to mentally manipulate the frame of reference can explain why older adults were found to be impaired on a variety of spatial memory tasks. Twenty-four younger participants (18–35 years of age) and 24 older participants (65–78 years of age) performed a pointing task under four conditions in which a physical or imagined rotation was induced. In three conditions (updating, imagining, and ignoring), the frame of reference was shifted after encoding, which required a mental manipulation at the time of retrieval. In a control condition, the VCFR was held constant. Overall results show that the necessity to mentally manipulate the VCFR accentuates age-related differences. The presence of mental manipulation should therefore be considered when one is interpreting age-related differences found in spatial memory tasks.

Key Words: Mental manipulation—Spatial memory—Viewer-rotation task.

In order to function adequately in everyday life, one must remember the spatial location of surrounding objects. The inherent complexity of our environment and the fact that we constantly change location requires the mental manipulation of stored spatial representations. Imagine that you exit a department store by using your entry point, eager to find your car. Because you looked over your shoulder to see where your vehicle was parked before you entered the store, you are likely to locate your vehicle on the basis of your original frame of reference (FR), as both entry and exit point overlap perfectly. Conversely, leaving the department store by using one of the alternate exits would force you to mentally update your original FR in order to find your car. We hypothesize that this distinction between manipulating a spatial FR or not might explain the inconsistent findings pertaining to the performance of older adults on spatial memory and imagery tasks.

Spatial memory tasks (e.g., recognition of object arrays, free recall of the spatial location of objects, navigation, and perspective-taking tasks) require participants to encode and retrieve the spatial position of objects on the basis of a specific spatial FR. Several theoretical models (e.g., Gallistel, 1989; O’Keefe & Nadel, 1978; Paillard, 1991; Tolman, 1948) stipulate that spatial information is encoded on the basis of at least two reference frames (i.e., egocentric–viewer-centered FR and allocentric–object-centered FR). In egocentric encoding or viewer-centered (VCFR) encoding (Fiset, Gagnon, & Beaulieu, 2000; O’Keefe & Nadel; Wraga, Creem, & Profitt, 2000), the spatial coordinates of an object are encoded according to the viewer’s body axes (up–down, front–back, and left–right). In contrast, in both the allocentric FR and the object-centered FR (OCFR), the spatial coordinates of a specific object rest upon its relationship with surrounding objects or landmarks (O’Keefe & Nadel; Shelton & McNamara, 1997). The allocentric and OCFR frames of reference are not totally equivalent because the latter also considers an object as a spatial entity, which implies that the components of an object are encoded relative to each other (Wraga et al.). Despite this minimal difference between the VCFR–OCFR and the egocentric–allocentric frames of reference, in this article we use the VCFR–OCFR nomenclature, given that it has been widely used in human spatial cognition (Amorim & Stucchi, 1997; Committier et al., 2004; Farah, Brunn, Wong, Wallace, & Carpenter, 1990).

Various studies have reported that spatial memory is impaired in older adults (Cooney & Arbuckle, 1997; Craik & Salthouse, 1992; Naveh-Benjamin, 1987; Spencer & Raz, 1996; Perlmutter, Metzger, Nezworski, & Miller, 1981; Uttl & Graf, 1993; Zelinski & Light, 1988; for a review, see Park et al., 2002). However, others have concluded that spatial memory can be resilient to aging (Desrocher & Smith, 1998; Parkin, Walter, & Hunkin, 1995; Pouliot & Gagnon, 2005). A closer look at these diverse findings led us to believe that this discrepancy could be accounted for by the necessity to mentally manipulate the FR in some spatial memory tasks. We argue that the performance of older adults is influenced by the congruence (match) or incongruence (mismatch) between the encoded and retrieved FRs. Accordingly, a mismatch situation would automatically necessitate some sort of mental manipulation of the stored FR. For instance, age-related differences are typical of the OCFR literature because OCFR memory tasks require that participants generate or manipulate the studied FR. For example, Desrocher and Smith asked participants to either recall the location of an object on a board relative to their body position or recall the location of pairs of objects relative to one another. They found that, in the latter condition, older participants recalled fewer spatial locations than did the younger participants. Although Desrocher and Smith interpreted the older adults’ performance based on a dissociation between the VCFR and the OCFR, it is possible that this deficit was caused by the necessity to manipulate the original FR. Indeed, in their OCFR condition, participants faced the board from a different point of view (mismatch of encoded and retrieved FRs), which required a mental manipulation. When
asked to relocate the objects in the VCFR condition, participants faced the board from the same orientation as when they memorized the objects’ positions (match of encoded and retrieved FRs).

A study by Pouliot and Gagnon (2005) reinforces the notion that when the encoded FR is congruent with the retrieved FR, then age-related differences are negligible. In their study, drawings were displayed on one of two monitors positioned on participants’ left or right side. At retrieval, the studied drawings were displayed in the center of a monitor placed in front of the participants. Their task was to indicate whether each drawing was initially displayed to their left or to their right. Their results showed that older participants performed with great accuracy on this task. Although their performance was slightly below the performance achieved by their younger counterparts, the authors suggested that the difference was mostly due to the number of items to be remembered. Accordingly, they concluded that VCFR processing was not impaired in older adults. As indicated here, the small but significant difference that they obtained could be interpreted differently, considering that the encoding and retrieval FRs did not perfectly match.

Additional arguments supporting our interpretation are provided by the age-related decline found in the mental imagery literature (Craik & Dirkx, 1992; Fullerton, 1983). Studies on viewer rotation (VCFR rotation) suggest that, when older adults are asked to imagine a perspective that is different from their original viewpoint, significant deficits are observed (Herman & Coyne, 1980; Imagaki et al., 2002). Imagaki and colleagues used a variant of Piaget’s three-mountain tasks and asked participants to imagine what their viewpoint would be if they were standing on the other side of a presentation tray. These researchers found that the number of correct responses decreased significantly with age. Moreover, studies on object rotation (OCFR rotation) demonstrate that older individuals are slower at rotating objects mentally and that their accuracy is inversely related to the angle of rotation (Berg, Hertzog, & Hunt, 1982; Cerella, Poon, & Fozard, 1981; Clarkson-Smith & Halpern, 1983; Dror & Kosslyn, 1994, Gaylord & Marsh, 1975; Hertzog & Rypma, 1991; Jacewicz & Hartley, 1979, 1987; Puglisi & Morrell, 1986). For instance, Dror and Kosslyn presented participants with a pair of shapes that were oriented differently and asked them to determine whether or not the two shapes were identical. Older adults displayed slower decision time and reduced accuracy.

The performance of older adults on spatial memory and imagery tasks seems to be mediated by the necessity to manipulate the spatial FR at retrieval as a result of a mismatch of FRs. Unfortunately, our interpretation is confounded by the nature of the FR used to assess spatial memory. By definition, OCFR memory tasks imply a mental manipulation of the FR at retrieval, whereas VCFR assessment can be studied while keeping the FR unchanged. Consequently, our purpose in this study was to determine whether this interpretation still holds true in a VCFR paradigm under both match and mismatch conditions.

We deemed the VCFR rotation task developed by Farrell and Robertson (1998) to be appropriate because it comprises conditions under which the FR may or may not change between encoding and retrieval. In this task, participants are blindfolded and are submitted to physical or imagined rotations. Spatial memory is assessed through pointing accuracy for seven objects that surround the participants. We predicted that pointing accuracy between older and younger adults would be similar when the condition did not induce a spatial FR shift. In contrast, when a mental manipulation of the FR was induced by a shift of the spatial frame between encoding and retrieval as a result of a physical or imagined rotation, we anticipated that pointing accuracy in older adults would be significantly lower than that in younger adults.

**METHODS**

**Participants**

There were 24 younger adults (12 men and 12 women) between the ages of 18 and 35 years \( (M = 23.0, SD = 3.4) \) and 24 older adults (12 women and 12 men) between the ages of 65 and 78 years \( (M = 72.1, SD = 4.0) \) who participated in this study. We recruited students both in classrooms and on campus. Older adults responded to an ad we placed in a local newspaper. All participants took part in the study on a voluntary basis. We surveyed health history and status through an unstandardized health questionnaire administered over the phone. None of the participants indicated suffering from major health problems (neurological or psychiatric illness) or having antecedents of substance abuse, and they all reported being healthy at the time of testing. Statistical comparisons revealed that older adults had fewer years of education \( (M = 12.88, SD = 4.38) \) than did younger adults \( (M = 15.92, SD = 1.59) \). However, education did not correlate with pointing accuracy and therefore was not statistically considered.

**Neuropsychological Testing**

We administered the Vocabulary subtest of the third edition of the Wechsler Adult Intelligence Scale (Wechsler, 1997) to all participants. This test provides an estimate of the global knowledge of the examinees (Spreen & Strauss, 1998), and we used it to determine that the groups were homogeneous in terms of intelligence. We found no significant differences between older adults \( (M = 50.55, SD = 6.89) \) and younger adults \( (M = 52.74, SD = 4.97) \). Older participants also completed the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). All older participants obtained scores equivalent or superior to 25 on the MMSE (Spreen & Strauss).

**Apparatus and Layout of the Experimental Setup**

We based the apparatus and layout of this experiment on the study designed by Farrell and Robertson (2000). For this experiment, we created a 2-m-diameter circular wall with a curtain and installed it in a 9-m² room. We attached drawings of seven common household objects (book, cup, jar, shoe, plate, brush, and box), which were printed on a 10.5 cm × 9.5 cm white piece of cardboard, to the curtain at shoulder height. In order to define eight possible rotation magnitudes, we had an interval of 51.5° separate each drawing. We placed a fixed-base rotating chair in the center of the circular room (see Figure 1). The participants sat in the chair and used a laser pointer to point to the fixed drawings on the wall. They were free to move their legs; however, a plastic rim was attached to the bottom of the chair, which prevented the participants from using the chair legs as orienting cues.
Figure 1. Schematic representation of testing environment (2 m in diameter). These were the seven common household items used as drawings: shoe, brush, jar, plate, box, book, and cup. To define eight possible rotation magnitudes, we had an interval of 51.5° separate each drawing. We placed a rotating chair in the center of the circular room.

**VCFR Testing Conditions**

Participants were blindfolded and performed the pointing task under the following four conditions as described by Farrell and Robertson (1998). The first condition was the updating condition: The participants’ chair was rotated to a new direction, either in a clockwise or counterclockwise fashion. After they completed the rotation, the participants were asked to point to a target object. The updating condition explores the effect of a mental manipulation on the VCFR when the rotation is induced by a physical rotation congruent with the reached position. The second condition was the imagining condition: The participants had to imagine that they were rotated. They were asked to point to a target object as if they were facing one of the seven surrounding objects. This condition assesses mental manipulation of the VCFR when the participants remain in a static position. The third condition was the ignoring condition: The participants’ chair was rotated to a new direction, but they had to pretend that they were still facing the starting position when they pointed to the indicated target object. This condition investigates the effect of a mental manipulation when the rotation is incompatible with the reached position. The fourth condition is the control condition: The participants’ chair was rotated in one direction and then brought back to its original location. The participants were then asked to point to a target object. This condition does not require mental manipulation, as the retrieval FR is compatible with the starting FR.

Participants completed the four conditions. Half the rotations were executed in a clockwise manner whereas the other half of the rotations were counterclockwise. For each of the four conditions, we used the eight rotation magnitudes twice (once for the clockwise and once for the counterclockwise direction). Thus, 16 trials were performed by the participants for each condition. The starting point remained the same for each participant in every condition. Considering the extremely large combination of starting orientations, rotation magnitudes, and target objects, we used the same set of trials in all four conditions and we counterbalanced the trials within each condition.

This procedure had the advantage of controlling for the amount of rotation executed in all four conditions and ensured that the differences found between the conditions could not be attributed to variations in difficulty between conditions.

**Procedure**

**Neuropsychological testing and familiarization trials.**—To ensure that the participants were healthy, we administered a detailed health questionnaire over the phone. Upon arrival at the laboratory, all of the participants completed the Vocabulary subtest of the third edition of the Wechsler Adult Intelligence Scale. We also administered the MMSE to the older adults. Participants were then walked to the circular room and the familiarization trials began. An experimenter invited the participants to sit on the rotating chair. The experimenter told them to look at the drawings surrounding them, at which time each drawing was identified by its name tag. The experimenter informed them that they had to memorize the eight drawings sequentially. Participants were free to rotate their chair, in both the clockwise and counterclockwise directions, while memorizing. When they felt that they had learned the sequence, the experimenter blindfolded them and asked them to name the objects. In order to proceed with the next step, participants had to recall the sequence twice in a row (in both the clockwise and counterclockwise directions) without any error (either name tag error or sequence error).

Then the participants’ pointing abilities were practiced. The experimenter oriented participants so that they faced a drawing and asked them to point, with their eyes shut, to one of four specified target drawings in proximity to the “confronted” drawing (i.e., the drawing they were facing). As it is impossible for participants to point to targets placed behind them, only four targets could be pointed at while the participants were facing any given drawing: the two closest targets on the left or right of the confronted drawing. Therefore, the four pointing angles were extreme left, middle left, middle right, and extreme right. The confronted drawing—the drawing where the rotation stopped—was never pointed within a given trial. In the pointing practice phase, we administered a total of 12 trials. Before they pointed, the experimenter allowed the participants to look at the target to which they were told to point. The experimenter then blindfolded the participants and pointing was executed. If the laser pointer did not fall within 25.5° on either side of the target (i.e., they had to be closer to this target than any other drawing), the experimenter asked them to point to the same target again. Contrary to the experimental trials, we used several starting orientations in order to eliminate any learning effect. Every younger and older participant successfully completed the practice trials, and we carried out the experimental trials on all participants.

**Experimental trials.**—In the updating condition, the experimenter requested that the participants point to a given target after a physical rotation. The experimenter touched the shoulder of a participant before rotating the chair to inform the participant of the rotation direction (e.g., right shoulder for a clockwise rotation). The rotation speed was low, and no participants reported dizziness during the experiment. When the chair stopped, the participants faced a drawing; the identity of
the confronted drawing was never revealed to them. A laser pointer was mounted under one of the chair arms, and markers were fixed to the curtain for each target object. The experimenter stopped the rotation when the laser and the relevant marker were aligned. The experimenter then asked the participants to point to the drawing that was either to the extreme left, middle left, middle right, or extreme right of the confronted drawing. The experimenter instructed the participants to point once at the target, to perform their pointing as quickly as possible, and to maintain their arm straight until the experimenter could score their pointing accuracy. A small round sticker was placed where the laser light hit the curtain. To ensure scoring accuracy and to reduce the risk of confusion, we had the experimenter write a trial number on the dot; a specific color was associated with each of the four conditions. Participants were not allowed to verify their performance or restart the trials.

In the imagining condition, the experimenter instructed the participants to point to a given target as if they were facing another drawing. The imagining condition also featured a procedure similar to the updating condition; however, in this condition, the experimenter informed the participants (before they rotated) to ignore their rotation and to point to a given target as if they were facing their starting position.

In the control condition, the participants were rotated and then brought back to their original location. To keep the same amount of rotation, we had them rotate only half of the rotation that was requested in the equivalent trials of the other conditions. After this “double” rotation, the experimenter asked the participants to point to a target object. In the experimental session, we grouped trials of the same condition, we counterbalanced the administration of the four conditions between participants, and, in all four conditions, we had the starting orientation remain the same for each participant. We randomly assigned the participants to one of the seven starting positions. Between every condition, we had the experimenter give the participants 2 minutes of rest; to prevent them from becoming light-headed, we had them remain blindfolded and sitting on the chair.

Scoring.—After the 64 experimental trials (16 trials for each of the four conditions), the experimenter measured pointing accuracy (measured in the number of degrees either to the left or right of the target). We computed statistical analyses on the mean absolute angular deviations from the target: lower scores indicated better performance. For all analyses, we averaged the pointing at the four target objects. We selected this scoring method because of its discrimination sensitivity in comparison with a dichotomous scoring method (correct–incorrect) and also because it has been used in previous studies (Farrell & Robertson, 1998, 2000).

RESULTS

We analyzed the magnitude of age group and condition effects on pointing error by using a 2 (group) × 4 (condition) analysis of variance (ANOVA), in which age group was the between-subjects factor and condition was the within-subject factor. The analysis showed a significant age effect, $F(3, 138) = 14.42$, $p < .001$, which indicated that the younger adult group ($15.4^\circ$) was more accurate on average than the older adult group ($26.0^\circ$); a significant condition effect, $F(3, 138) = 16.03$, $p < .0001$; as well as a significant interaction, $F(3, 138) = 4.09$, $p < .01$ (see Figure 2).

We computed simple main effects and post hoc contrasts to decompose the significant interaction and to assess the influence of group on pointing accuracy. Simple main effects revealed that younger adults were more accurate in pointing than were older participants in both the ignoring condition, $F(1, 138) = 4.18$, $p < .05$, $d = 0.59$, and the imagining condition, $F(1, 138) = 10.97$, $p < .002$, $d = 0.96$ (see Figure 3). Age-related differences were not significant in the updating and control conditions.

We used post hoc contrasts to ascertain the impacts of the experimental conditions on pointing error. For the older adults, the three experimental conditions requiring mental manipulation (updating, ignoring, and imagining), taken together, differed significantly from the control condition: $F(1, 138) = 19.94$, $p < .0001$, $d = 1.29$, and the ignoring condition, $F(1, 138) = 20.95$, $p < .0001$, $d = 1.32$. We also computed simple main effects to examine how pointing error varies within the experimental conditions. The results indicate that older adults were more accurate in their pointing performance in the ignoring condition than in both the updating condition, $F(1, 138) = 11.48$, $p < .001$, $d = 0.97$, and the imagining condition, $F(1, 138) = 12.25$, $p < .001$, $d = 1.01$.

For the younger participants, the three experimental conditions, taken together, also differed significantly from the control condition: $F(1, 138) = 9.16$, $p < .0001$, $d = 0.29$. Specifically, the performance of the younger adults was better in the control condition than in the updating condition, with $F(1, 138) = 14.69$, $p < .001$, $d = 1.19$. When we compared the imagining and ignoring conditions independently with the control condi-
tion, we found no significant differences. Furthermore, the younger adults were less accurate in their pointing execution in the updating condition than in both the imagining condition, $F(1, 138) = 14.51, p < .001, d = 1.18$, and the ignoring condition, $F(1, 138) = 23.60, p < .0001, d = 1.51$.

**Trend Analysis of the Rotation Magnitude**

The previous set of analyses disregards the influence of the rotation magnitude on pointing error. In one of their studies, Farrell and Robertson (1998) observed that their participants’ pointing error varied according to the rotation magnitude. Although our framework does not make specific predictions as to how the rotation magnitude would impact on pointing error, we thought that such an analysis could help us to further understand the age-related differences that we detected in the main analysis. We achieved this by conducting one-way analyses of variance (for each group and each condition) on the rotation magnitude (eight levels); when we deemed it significant, we followed these with a trend analysis. Our analyses indicated that, in the updating condition, the pointing error followed an increasing linear trend as a function of the rotation angle in both younger adults, $F(1, 184) = 28.39, p < .001$, and

![Figure 3](image-url)
in older adults, $F(1, 184) = 12.98, p < .001$ (see Figure 3). The pointing error of the older adults was characterized by a quadratic trend in the imagining condition, $F(1, 184) = 13.86, p < .001$, whereas it increased linearly in the control condition, $F(1, 184) = 20.48, p < .0001$. We detected no such pointing pattern in younger participants. Finally, in the ignoring condition, the pointing error in both younger and older adults did not follow any specific trend.

**DISCUSSION**

In the present study we investigated whether the mental manipulation of the studied spatial FR could account for the age-related differences found in the spatial memory and imagery literature. Overall, our results show that the impact of age on memory for spatial positions was quite obvious when a mental manipulation of the VCFR was required. Older participants showed a decrease in pointing accuracy in two conditions that required a mental manipulation of the studied VCFR, namely the imagining and ignoring conditions. Interestingly, age-related differences were not significant in the control condition where the FR remained stable. Somewhat contrary to our hypothesis, both younger and older adults displayed poor pointing accuracy in the updating condition. To ease the interpretation of our findings, we discuss the data pertaining to each condition separately.

We anticipated, on the basis of both the literature on mental imagery (Craik & Dirx, 1992; Fullerton, 1983) and on viewer-rotation tasks (Herman & Coyne, 1980; Imagaki et al., 2002), that the imagining condition would be particularly difficult for older adults. Our findings demonstrate that when older participants need to manipulate their spatial FR, their performance decreases as a function of the rotation magnitude. Specifically, the more rotation older participants need to mentally increment to their FR, the more difficult it is for the older adults to point to the target. This is especially true prior to exceeding 180° of rotation. Indeed, after 180° and until 360°, the participants possibly imagined the rotation in the opposite direction, which explains the observed significant inverted U-shaped curve. In contrast, younger adults showed virtually no difficulty imagining themselves facing a different orientation. Indeed, pointing accuracy in the imagined condition was similar to that in the control condition.

The results obtained in the ignoring condition are also consistent with our mental manipulation hypothesis. In comparison with younger adults, older adults showed increased difficulty when their FR shifted as a result of the physical rotation, which they were told to ignore. Ignoring a physical rotation requires participants to mentally realign their VCFR with the starting orientation. One could argue that some form of inhibition has to take place in this condition because participants are asked to point to target objects as if no rotation occurred. In fact, given the known declines in inhibitory abilities among healthy older adults (Hasher & Zacks, 1988; McDowd, Oseas-Kreger, & Filion, 1995; Radavynsky, Zacks, & Hasher, 2005) and that the inhibition of one’s current representation is a crucial element of the perspective-taking theories (Samson, Apperly, Katirgamanathan, & Humphreys, 2004), it is not surprising that these FR shifts accentuated age-related differences. Interestingly, Farrell and Roberson (2000) found that the ignoring task was one of the most difficult conditions for their young participants. It is likely that the inhibitory effort was further increased in their experiment because participants rotated themselves with their feet, which added a motor input to the rotation movement.

The lack of significant differences between younger and older adults in the updating condition was somewhat surprising. We anticipated that older participants would have more difficulty than their younger counterparts in the updating condition, given that this condition requires mental manipulation of the VCFR even though the physical rotation is congruent with the FR. The errors made by both age groups in our study, as well as in the updating condition of the studies by Farrell and Robertson (1998, 2000), either approached or surpassed 25.5° in magnitude. This indicates that when the participants needed to update their FR, they pointed closer to another target than to the one indicated by the experimenter. It is possible that supplementary processing takes place during a physical rotation when proprioceptive cues are poor or insufficient. This is indirectly suggested by the fact that the pointing error increased linearly in both young and older participants as a function of the rotation magnitude. Conversely, updating the FR could also rely on mental manipulations when the proprioceptive cues are not salient enough to automatically update one’s position in space, as postulated by Farrell and Robertson. This would explain the low performance of both age groups in this condition. Nonetheless, we realize that future studies should examine this issue by manipulating the “inherent features” of physical rotations.

For our hypothesis to be supported, a lack of differences between younger and older adults had to be observed when the spatial FR after rotation was compatible with the starting orientation. We used pointing accuracy in the control condition to assess this prediction. As we expected, younger and older adults performed similarly in this condition. However, a closer look at the data indicates that pointing accuracy fluctuates linearly as a function of the rotation movement for the older participants, regardless of the fact that both groups of participants performed quite well in this condition. Even if in this condition the end state of the FR was identical to the beginning state of the FR, the rotation induced a shift in the FR that perhaps required some updating. Fortunately, all conditions included two trials in which no rotation occurred. Those trials were necessary for us to estimate younger and older adults’ capacity to point to objects when the FR was completely unchanged. Performance on those trials is displayed at the 0° angle of all four conditions in Figure 3. It is quite obvious that the performance of younger adults and that of older adults on these trials overlap, indicating that retrieval of spatial information through pointing is fairly intact in older adults when the FR is not shifted.

At this stage, we deem it important to address the issue of the cognitive mechanisms that sustain mental manipulation and that may decline with age. Given that active processing of the studied FR takes place at retrieval in this task, we consider age-related working memory (WM) deficits as a serious candidate. Even if it is generally accepted that WM declines with age (Bruce & Herman, 1986; Fisk & Sharp, 2004; Myerson, Hale, Rhee, & Jenkins, 1999; Salthouse, 1995), it is important to confront our findings and the cognitive requirements of our task.
with the modular nature of WM. For instance, one could argue that our findings can easily be explained by an age-related decline of the visuospatial sketchpad module of WM. However, our findings, together with an analysis of the cognitive requirements of our VCFR paradigm, seem to reveal otherwise. First, age-related deficits mainly occur when a mental manipulation was required, that is, in the ignoring and imagining conditions. Recall here that no significant differences were observed between young and older adults in the control condition or when no rotation occurred. Second, older adults’ pointing error followed a quadratic trend in the imagining condition. We suggest that such findings are better explained by age-related impairments on the active processes associated with the central executive, such as attention shifting or inhibitory processes. For instance, one could speculate that the imagining condition requires attention shifts in order for the participants to mentally realign themselves (Kosslyn, 1994). We also tentatively concluded that poorer performance by the older adults in the ignoring condition could be attributed to a failure to inhibit a stored salient representation. Even if we argue in favor of WM active processes, our interpretations should be considered only tentative, considering that our study was not designed to establish the link between mental manipulation of a VCFR and older adults’ WM decline.

In conclusion, our results demonstrate that when a VCFR has to be mentally manipulated, age-related differences can be quite striking. Our findings emphasize the importance of considering the presence or absence of a shift between the encoded FR of spatial positions and the recall of those same positions. If such a shift occurs, age differences are to be expected. We propose that mental manipulation deficits associated with old age are likely caused by a decline of WM processes. We advocate for the further validation of this hypothesis by the use of both VCFR and OCFR paradigms.

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References

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