DIS DISTINCTIVE FEATURES OF SPATIAL PERSPECTIVE-TAKING IN THE ELDERLY*

MASAYUKI WATANABE

Shiga University, Japan

ABSTRACT

This study aimed to ascertain the characteristics of spatial perspective-taking ability—assumed to be a form of imaginary body movement in three-dimensional space—in the elderly. A new task was devised to evaluate the development of this function: 20 children, 20 university students, and 20 elderly people (each group comprising 10 men and 10 women) were asked to locate themselves in different vantage points. The relationship between angular deviations from the participants to the points from which perspectives were to be obtained did not differ between the elderly and university students. However, the performance of the elderly and children was inferior to that of the university students with respect to the general response time and percentage of correct responses, which indicates that imaginary body movement can be maintained in normal aging, and an apparent decline in the spatial perspective-taking ability of the elderly may arise from other cognitive information processes.

Spatial perspective-taking refers to the ability of visualizing objects from the vantage point of an imaginary observer who is perceived to have moved from the position of ego to some other point in space (Huttenlocher & Presson,

*This study was partly supported by the Grant-in-Aid for Scientific Research (C), Japan Society for the Promotion of Science, No. 14510136, given to the author.

© 2011, Baywood Publishing Co., Inc.
doi: 10.2190/AG.72.3.d
http://baywood.com
1973). Research on this ability originated with Piaget and Inhelder (1956) and peaked in the 1970s, generating a large volume of data primarily concerning children. A few studies have investigated post-childhood development with respect to spatial perspective-taking to demonstrate that even older children and adults do not always show perfect performance in this regard. Early research assessing the abilities of individuals aged 7, 11, 21, 44, and 76 years, on average, revealed that the performance of 11-year-olds was similar to that of the elderly group and inferior to that of young and middle-aged adults. However, the 11-year-olds performed better than the 7-year-olds (Rubin, Attewell, Tiemey, & Tumslo, 1973). Jacobsen and Waters (1985) reported that some second and fourth graders responded by indicating their own perspectives, resulting in egocentric errors. Inagaki et al. (2002) revealed that in elderly participants (61–86 years), the percentage of correct responses was much lower and the number of egocentric errors much higher than in the two younger age groups (18–29 years and 33–58 years). Hetman and Coyne (1980) reported similar results: they found that young adults performed better than elderly adults on spatial perspective-taking tasks.

However, the reduced performance of elderly people does not necessarily suggest a complete decline in their spatial perspective-taking abilities. Although it is possible that elderly people have weak cognitive-processing abilities for general functions, the more essential ability required for spatial perspective-taking may remain intact. In fact, studies have suggested that spatial perspective-taking entails imaginary body movement to another vantage point in three-dimensional space, in addition to other cognitive information-processing abilities, in order to eventually generate the view from that new point (e.g., Flavell, 1977). In recent years, Hegarty and Wallen (2004) proposed a mental model of spatial perspective-taking in which they separated imaginary body movement from other cognitive information processes. Cognitive information processing—other than that relating to imaginary body movement—could be considered to refer to the recognition of object features (Rosser, Ensing, Mazzeo, & Horan, 1985), object-manipulation spatial ability (Kozhevnikov & Hegarty, 2001), inhibitory functions (Hasher & Zacks, 1988), or simply working memory (Yamadori, Ashina, Fujii, Tsukiura, Okuda, & Osaka, 1999). Even if a person carries out imaginary body movement correctly, his/her responses to a task will contain errors if the subsequent cognitive information processing is inadequate. Newcombe (1989) showed that the peculiarity of each spatial perspective-taking task—a feature closely related to the cognitive-information-processing abilities that each task entails—considerably influences the accuracy of the response. Thus, in spatial perspective-taking, successful imaginary body movement is more important than other cognitive information processes that are relatively inessential to enable one to envisage a view during spatial perspective-taking. With this interpretation, it can be predicted that imaginary body movement might be maintained while other cognitive information-processing abilities might diminish. This study seeks to test this possibility.
In order to achieve this aim, the experimental task would need to satisfy the following three requirements. First, the task performance should bring about the separation of imaginary body movement from other cognitive information processes. This is necessary to accurately judge whether the poor performance of the elderly is caused by imaginary body movement or by other processes. Conventional spatial perspective-taking tasks such as the “three mountains task” (wherein subjects view an arrangement of three model mountains and visualize the scene from other perspectives in the room) are too insensitive to highlight different cognitive-processing abilities. Therefore, some studies that used such tasks, for example Inagaki et al. (2002), where the participants were asked to imagine the view from a different side of the array, were insufficient to reveal the distinctive features of spatial perspective-taking in the elderly.

Second, the task should not solely rely on response accuracy. A correct response is the result of a cascade of appropriate cognitive processes. Even one inappropriate component in this line of processing could render the end-product erroneous. Therefore, it would be difficult to accurately demonstrate the characteristics of imaginary body movement, which is one of the cognitive processes in spatial perspective-taking, merely in terms of the percentage of accurate responses. This is because we cannot specify whether errors occur owing to the inadequate imaginary body movement or due to the lack of one or more cognitive information-processing abilities. The most probable alternative to response accuracy may be response speed, which was used to prove cognitive manipulation in mental rotation (Shepard & Metzler, 1971) and the difference between the cognitive processes of mental rotation and spatial perspective-taking (Zacks, Mires, Tversky, & Hazeltine, 2000). Response speed is effective in two respects. First, although response accuracy as an index requires that the task be moderately difficult to avoid the ceiling or floor effect, response speed can evade such restrictions. This also enables the allocation of the same problem to various age groups. Second, following the logic of the mental rotation study, it is easy to examine the features of cognitive processes because response speed sensitively reflects an inner process. However, a problem occurs at this point. Some previous studies considered the positive slope of the regression line, which predicts the response time from the orientation of the rotated pictures, as a psychological analogy of actual rotation in three-dimensional space. However, there is no consensus regarding the type of regression line that could be observed in spatial perspective-taking. Some researchers argued that response time increased as a function of orientation in the same way as mental rotation (Creem, Hirsch, Wraga, Harrington, Proffitt, & Downs, 2001; May, 2004; Wraga, Creem, & Proffitt, 2000), whereas others suggested that response time was constant irrespective of orientation (Zacks et al., 2000). If we can resolve this issue, it would produce a clear understanding of the cognitive processes involved in spatial perspective-taking.
Finally, the task should be applicable to a broad range of age groups. This point is by no means insignificant. Older children and younger adults would have higher levels of competence than younger children or older adults. Many studies with older children or younger adults as participants have compensated for their superiority by increasing the task difficulty to avoid the ceiling effect. However, increased task complexity could obscure the characteristics of imaginary body movement by diminishing its relative role in the overall cognitive processing during spatial perspective-taking. An ideal task should be simple and sensitive to the developmental changes in spatial perspective.

The tasks used in the early researches did not meet all the above-mentioned requirements. Jacobsen and Waters (1985) used an extremely dull task to clearly separate imaginary body movement from other cognitive information processes; Inagaki et al. (2002) relied on only response accuracy to arrive at conclusions; and Rubin et al. (1973), one of the very few researches that involved both children and the elderly, managed to fulfill the above-mentioned final requirement by introducing four types of tasks with different levels of complexity. Kozhevnikov and Hegarty (2001) also attempted to develop a new spatial perspective-taking task by relying on response accuracy. In the present study, a new task that met all the requirements was devised. In this task, the participants were required to maneuver themselves around a fictional town. Blades (1991) used similar stimulus material to study the abilities of 4–6-year-olds in transferring location information from a sample display onto a rotated equivalent. Although these young children could maintain the relative positions, it was unclear whether they depended on spatial perspective-taking or object mental rotation. In this study, the alignment effect (Levine, 1982), in which maps are mentally coded in the same orientation they are experienced in, was used to ensure that the task required spatial perspective-taking. By creating this effect in the task, it would be possible to make participants understand that they should mentally maneuver the self-holding of the map (physical reference frame), that is, imaginary body movement, rather than the stimulus display (actual space) or just the map. This device meets the first requirement of extracting imaginary body movement.

Additionally, their performances were mainly analyzed in terms of response speed. The difference between the longest response time (almost at the farthest position from the participants) and the shortest response time (almost at the nearest position from the participants) was examined to extract the response time depending only on rotation degrees, namely, the speed of imaginary body movement. This device meets the second requirement of an appropriate index. The time discrepancy enables a comparison between the elderly people and people of other age groups, without an excessive increase in task complexity. This aspect meets the third requirement of wide scope. Thus, the spatial perspective-taking task, which incorporated these unique techniques, satisfied all the above requirements. Using this task, this study investigated the distinctive features of spatial perspective-taking in the elderly.
METHOD

Participants

Twenty children (aged 9–11 years), 20 university students (aged 18–24 years), and 20 elderly people (aged 63–76 years) were involved in the experiment as paid participants. All the groups consisted of 10 women and 10 men. None of the participants suffered from any neurological disabilities that would influence their performance in the experimental task. Further, all the elderly people could perform housework without any difficulty. All the participants were administered the Japanese version of the Wechsler Adult Intelligence Scale-Revised (WAIS-R) or Wechsler Intelligence Scale for Children-III (WISC-III) coding subtest in order to obtain measures of their cognitive-processing speed and motor speed. No significant difference was found when the standard scores were compared, $F(2, 57) = 0.73, n.s.$, and the sample selection was deemed satisfactory. On the other hand, there was a misgiving about the relative decrease in the unadjusted scores of the elderly. Creem et al. (2001) suggested that spatial perspective-taking involved the use of the motor processing areas in the frontal lobe, which were activated using the functional magnetic resonance imaging (fMRI) method; our pilot study, in which fMRI was used, also revealed significant activation in the same region. Therefore, some decline in cognitive spatial information was expected in the elderly because normal aging is accompanied by some inefficiency in the functioning of the frontal lobe (Craik, Morris, Morris, & Loewen, 1990). The elderly were administered the Revised Hasegawa Dementia Scale (HDS-R) to once again obtain measures of their cognitive level, and their scores exceeded the cutoff value (20 points) out of a maximum of 30 points, which confirmed that there was no excessive cognitive impairment.

Materials

An 18-inch LCD monitor and a standing microphone were connected to a personal computer. The monitor was horizontally positioned on a table, and the microphone was placed on the left side of the monitor. The participant, when seated, looked down at the center of the monitor at a 45-degree angle approximately. The microphone was adjusted such that it was close to the participant’s mouth. As shown in Figure 1, a black circle with a diameter of 25 cm was drawn against a white background on the monitor, which had a black outer frame. Around the periphery of the black circle, eight white circles that were 6 cm in diameter were drawn at even intervals, with all the central angles being equal to 45 degrees. These white circles were located at angles of 0 degrees (i.e., the position closest to the participant), 45 degrees, 90 degrees, 135 degrees, 180 degrees, 225 degrees, 270 degrees, and 315 degrees, moving in an anti-clockwise direction. This experiment included two kinds of sessions—the practice session and the following experimental sessions. These sessions differed only in
the figures shown on the monitor. The icons that represented regular facilities (post office, hospital, restaurant, gas station, etc.) in the practice session and the numerals (1–8) in the experimental sessions were randomly pasted onto the circle in each successive trial. A Windows-based program, which was developed for this task, regulated the presentation of the stimuli and the measurement of response time on the basis of voice input from the microphone. The response time was measured every millisecond and recorded in the computer along with information such as stimulus presentation conditions and the responses entered by the experimenter using the keyboard. A beep signaling the presentation of the stimulus was emitted from a speaker on the LCD monitor.

Procedure

The experiment was conducted independently with each participant. First, the position of the LCD monitor and the sensitivity of the voice input from the microphone were adjusted to accommodate each participant. Second, the task instructions were explained, and the practice session was conducted ahead of the experimental sessions to enable the participant to become accustomed to the task. In both the practice as well as experimental sessions, the participant was given the map of a town (Figure 2) in which eight buildings, labeled A to H, surrounded a circular hill. The participants were told that the eight icons in the
Figure 2. The map the participants were given during the experiments, depicted the miniature town on the monitor and is printed in black and white on an A4 sheet. Considering that Japanese children and elderly people participated, the map had Japanese Hiragana characters in place of the alphabets.
circles on the monitor represented a miniature town, the map of which they were holding. To confirm that the correspondence between the map and the miniature town was correctly understood, the participants were asked to verbally state the facilities in the town—on the monitor—that corresponded to the letters on the map (A to H) when the map and town were assumed to be placed in the same orientation. Next, the same task was carried out with the map and the town in different orientations. In this case, the different orientations of the map and the town were specified by verbally stating the letter that corresponded to a particular facility (such as “On the map, which facility would be at C if A were positioned where the post office is located?”).

The task was administered in the following four steps. The experimenter verbally stated one letter from among A to H, which represented a particular position on the map, referred to as the “target location” for a given question. After the participant had verified this position on the map, a one-second long beep—the signal for stimulus presentation—was sounded. Following the 1-second delay, one of the eight white circles turned red, representing the “vantage point” from which the participant had to locate the target location. The participant responded by stating the name of the facility that would correspond to the target location when the vantage point was assumed to coincide with the location of A on the map. The time that elapsed between the white circle turning red—indicating the vantage point—and the verbal response was automatically recorded by a voice-activated switch attached to the microphone.

If the participant could correctly answer three questions in a row, he/she was judged to have understood the task procedure sufficiently, and the experimental sessions were subsequently commenced. In the experimental sessions, the only difference was that the numerals were displayed in the miniature town on the monitor instead of the facilities that had been used in the practice session. Thus, if the target for a particular trial was E (180 degrees) in Figure 2 and the illuminated vantage point was 5 in Figure 1, the answer would be 8. If the target was G and the illuminated vantage point was 1, the answer would again be 8.

**Task Description**

The participants were asked to imagine themselves walking around in the fictional town displayed on the monitor. The goal was to identify particular locations in the town that were marked on the map as facilities A–H. During the experiment, the participants were not allowed to adjust the orientation of the map relative to that of the town (as shown in the monitor). They were required to imagine themselves walking around in the town while holding the map. The mechanisms of the alignment effect ensured that they aligned themselves according to the orientation of the town. Such imagination was possible only if the participants shifted their perspectives to different vantage points within the town because the mental rotation of the map or town increased the complexity of
the task. As a result, we could adequately anticipate that autonomous spatial perspective-taking would occur. After the experiment, most of the participants reported on imaginary body movement around the monitor. Those who reported that they had used strategies other than spatial perspective-taking (e.g., counting up to a target location from a vantage point or mentally rotating the map on the town), were not considered in the results. The number of each group excluded from the experiment was one child, two university students, and no elderly people, and those who corresponded to them were recruited for compensation.

Design

A single experimental session consisted of 64 questions (target locations [eight positions from A to H] × vantage points [eight positions from 1 to 8]). The order of presentation was automatically randomized by the computer program. A total of six trials, except for the practice session, were conducted for each participant over a period of 2–4 days in order to avoid fatigue.

Response Measurement

In the analysis of the experimental results, three types of indices for response time were used. The response time between stimulus presentations and responses in each vantage point for all the trials was the general response time and was named “RT-G,” encompassing the cognitive information processing required for solving the entire task. The discrepancy between the largest RT-G and smallest RT-G was calculated for each participant and named “RT-D,” which depended only on the distance between the vantage points and represented cognitive processing in terms of imaginary body movement. Additionally, if the response time assumes a linear regression with the vantage points, the linear function formula \( y = ax + b \) (x: degrees of vantage points, y: response time) is applicable. The gradient “a” represents the speed per degree for imaginary body movement, and the intercept denoted by “b” represents the time required for other cognitive information processing. The percentage of correct responses in each vantage point for all the six trials was also calculated as part of further analysis. Although a trade-off relation between accuracy and response time reported in the mental rotation research (Kail, 1985) might rule out the double use of the response time and the percentage of correct responses, the problem need not be considered serious in this study because RT-D and the correct answer rate do not influence each other.

Strategies

With the introspection of each participant after the experiment, those who had reportedly used strategies other than spatial perspective-taking were excluded. Still, three kinds of strategies are conceivable to be used implicitly; these are
spatial perspective-taking, object mental rotation, or counting up and can be distinguished by the pattern of response time. If the object mental rotation strategy was used in this task, an object that could be mentally rotated was not the stimulus display—the map was—because the random arrangement of numbers complicated the stimulus display and made mental maneuvering difficult. In this case, the time required to rotate the whole map to the vantage point increased in a linear function of the rotation angles from 0 degrees, while that required to identify the number corresponding to a specific target location was not related to the distance from position A. Consequently, the RT-G graph plotted against the vantage points would be bell-shaped with nearly straight gradients and a peak at around 180 degrees and that of RT-G plotted against target locations would be horizontal. If the counting up strategy were to be used, which implies that the positions between home position (A) and each target location (A-H) would have to be moved to the right or left of the vantage point, the time required for counting up would increase in a linear function of the numbers of the positions, regardless of the vantage point. Consequently, the RT-G graph plotted against vantage points would be horizontal and that of RT-G plotted against target locations would be bell-shaped with nearly straight gradients and a peak at around 180 degrees. On the other hand, if the spatial perspective-taking strategy is used as expected, the time required to move an imaginary body to the vantage point increases in a linear function of the rotation angles from 0 degrees, and that required to identify the number corresponding to a specific target location also increases in a linear function of the distance from the position A. Consequently, each RT-G graph plotted against the vantage points or target locations would be bell-shaped with nearly straight gradients and a peak at around 180 degrees. To ensure that only the spatial perspective-taking strategy was used in this task, the RT-D of each target location was calculated in addition to one of each vantage point.

RESULTS

A two-way repeated measures ANOVA was conducted on RT-G with the three age groups as the independent variables and the vantage point as the repeated measure. The results indicated a significant main effect for both the age groups, $F(2, 57) = 36.08, p < .01$, and the vantage point, $F(2.1, 117.1) = 65.61, p < .01$; Greenhouse-Geisser correction). The interaction between these two variables was not significant, $F(4.1, 117.1) = 0.83, n.s.;$ Greenhouse-Geisser correction). The average response time for children was 1155.5 ms ($SD = 428.0$), which was midway between the average response time of 985.9 ms ($SD = 336.7$) for university students and 1373.2 ms ($SD = 544.4$) for the elderly. Scheffé multiple comparison revealed significant differences at the 1% level between all three pairs of age groups.
When the RT-G was plotted against vantage points, a bell-shaped graph with nearly straight gradients and a peak at around 180 degrees was obtained for each group (Figure 3). Linear regression was expected and a regression analysis was conducted. Locations that were symmetrical to the median line in front of the participant were at equal distances from the participants (e.g., at locations of 90 degrees and 270 degrees). Therefore, the data corresponding to locations greater than 180 degrees were included with the data corresponding to locations of less than 180 degrees, and calculations were conducted considering the five locations between 0–180 degrees as variable X. A significant regression equation was obtained for each group—children: $y = 2.56x + 925$, $F(1, 7679) = 390.71$, $p < .01$; university students: $y = 2.05x + 801$, $F(1, 7679) = 406.04$, $p < .01$; and the elderly: $y = 1.93x + 1200$, $F(1, 7679) = 132.29$, $p < .01$. A test of homogeneity of slopes that was conducted to compare the speed of imaginary body movement across the groups revealed a significant effect of the interaction between group and vantage point, $F(2, 23034) = 6.13$, $p < .01$, suggesting that the regression lines were not parallel. Although a similar analysis between the elderly and children, $F(1, 15356) = 8.97$, $p < .01$, and between children and university students, $F(1, 15356) = 9.54$, $p < .01$, revealed significant interactions, in the analysis between the elderly and university students, the null hypothesis was not rejected, $F(1, 15356) = 0.41$, n.s.). This suggested that although the regression lines between the elderly and university students were parallel, children took more time than adults to adopt perspectives, depending on the rotation degrees. The results of the ANOVA conducted on RT-G showed that there were differences between all pairs of age groups and that the intercept of the elderly was larger than those of children and university students.

Here, a one-way repeated ANOVA test was conducted on RT-G with the target location as the repeated measure in order to identify the strategy being used in the task. Main effect for the target location, $F(2.2, 122.9) = 67.52$, $p < .01$; Greenhouse-Geisser correction, was significant and an M-shaped graph with nearly straight gradients and two peaks at 135 and 225 degrees was obtained when the RT-G was plotted against target locations. The RT-G graphs plotted against the vantage points and target locations suggest the possibility of the use of the spatial perspective-taking strategy.

The average RT-D of each age group was as follows: children, $M = 331.4$ ms, $SD = 133.7$; university students, $M = 249.6$ ms, $SD = 110.3$; and the elderly, $M = 302.2$ ms, $SD = 186.6$. The RT-Ds of university students and children were below 600 ms, while those of the elderly were scattered over a larger range; that is, between 128.6 ms and 760.3 ms. In a Bartlett test for homogeneity of variances, the null hypothesis was not rejected, ($\chi^2 = 5.36$, $df = 2$, n.s.), but $F$-tests conducted to compare the RT-D frequency of the groups revealed a significant difference between university students and the elderly, $F(19, 19) = 2.86$, $p < 0.05$. A one-way ANOVA conducted on RT-D with the three age groups as the independent variables did not show a significant effect, $F(2, 57) = 1.59$, n.s.
Figure 3. Average response time for each vantage point in each group. The means were calculated from 960 values, which are the total of eight target locations × six trials per subject × the number of participant per group.
A two-way repeated measures ANOVA was conducted on the percentage of correct answers with the three age groups as the independent variables and the vantage point as the repeated measure (Figure 4). The results indicated a significant main effect for both the age groups, $F(2, 57) = 79.68, p < .01$, and the vantage point, $F(2.0, 116.8) = 24.68, p < .01$; Greenhouse-Geisser correction. The average percentage of correct answers for university students was 98.1% ($SD = 13.7$), which was higher than the average percentage of correct answers of 94.7% ($SD = 22.3$) for children and 94.4% ($SD = 22.9$) for the elderly. Scheffé’s multiple comparison revealed significant differences at the 1% level between these groups. The interaction between these two variables was also significant, $F(3.9, 117.1) = 6.97, p < 0.01$; Greenhouse-Geisser correction. The pattern of the percentage of correct answers for each vantage point is different in each age group, but owing to the ceiling effect it was inappropriate to further analyze these results.

In order to examine the differences between sexes, a two-way ANOVA was conducted on RT-G and RT-D by using sex and age group as factors. Significant main effects of group were found again; however, there was no significant main effect of sex (RT-G), $F(1, 632) = 3.08, n.s.$; (RT-D), $F(1, 72) = 0.01, n.s.$), and interaction between the variables, (RT-G), $F(3, 632) = 2.03, n.s.$, (RT-D), $F(3, 72) = 0.04, n.s.$

**DISCUSSION**

In this study, a new task was devised to investigate the distinctive features of spatial perspective-taking in the elderly. The performance was measured using mainly response time. The results for RT-G confirmed a curvilinear change, as demonstrated in a number of conventional studies (e.g., Rubin et al., 1973), in which the average response time accelerates from childhood to early adulthood and slows down in late life. However, the results for RT-D and the regression equation revealed other findings; namely, the elderly were not inferior to university students in imaginary body movement ability apart from the point that the elderly are more variable, whereas they fared worse in other cognitive information processes; on the other hand, children were inferior to university students in terms of both imaginary body movement and other cognitive information-processing abilities. Three important points follow from this finding.

First, spatial perspective-taking ability can be divided into imaginary body movement and other cognitive information processing. Thus far, there has been little research on how imaginary body movement develops. This is partly because the separation of imaginary body movement from other cognitive information processing has not been previously addressed. This study placed much importance on this problem and attempted to solve it by considering the speed of imaginary body movement as the gradient of a regression line and that of other cognitive information processes as the intercept of the regression line. This new technique will serve as an effective experimental method in this area.
Figure 4. Percentage of correct answers for each vantage point in each group. The means were calculated from 960 values, which are the total of eight target locations × six trials per subject × the number of participant per group.
The second important point is that in the case of normal aging, imaginary body movement is not impaired as seriously as other cognitive information processes. This was suggested from the fact that the size of the difference in the intercepts among age groups was large and statistically significant, while that in the slopes was smaller and statistically non-significant. The often-reported decline in the spatial perspective-taking ability of elderly people (e.g., Inagaki et al., 2002) might not stem from inadequate imaginary body movement but from a lack of other cognitive information-processing abilities, for example, decreased inhibitory functions (Hasher & Zacks, 1988) or selective attention as well as a decline in working memory (Yamadori et al., 1999). In order to solve a spatial perspective-taking task, one needs to appropriately switch from the real perception of the stimulus display to a view presumed from other perspectives. To achieve this, it is necessary to suppress the cognitive activation of images produced by perception and appropriately use several conflicting frames of references (May, 2004). When inhibitory functions decline with aging, excess information is allowed to enter the working memory, and one tends to rely on information that can be easily gleaned from the situation (Hasher & Zacks, 1988). Furthermore, working memory itself is known to deteriorate with aging (Salthouse, 1991). Along with these changes, selective attention is also reduced in elderly people as compared to the case in young people (Hartley, 1993). One or more of these factors could cause a difficulty in forming accurate images from other perspectives.

Given the known changes in cognitive information processing in the elderly, it is important to consider why little change was observed in the imaginary body movement of the elderly. Although the neural mechanisms pertaining to the current task are unknown, it is possible to speculate that the minimal changes in imaginary body movement among the elderly were due to the functional preservation of their cortical motor areas. It is also important to emphasize that most people in the elderly group (aged 64–75 years) are categorized as “young old” in gerontology and healthcare administration, owing to their comparatively good state of health. In “old” elderly people who exhibit a prominent decline in motor functions, a commensurable decline in imaginary body movements may well be observed.

Third, it is notable that response time linearly increased according to the vantage point. This implies that imaginary body movement is a phenomenon resembling mental rotation. However, as Kosslyn (1980) noted, it is inadequate to conclude that the image has a picture-like character. In fact, some researchers point out that it is appropriate to think of spatial images as steps by which a meaning embedded within a situation is extracted or an understanding is formed thereby (Huttenlocher & Presson, 1973, 1979; Presson, 1982). Nevertheless, this study is valuable because it is one of the few successful attempts to clarify the features of imaginary body movements.
Finally, it is important to briefly provide directions for future research on spatial perspective-taking. Is imaginary body movement in fact the essence of spatial perspective-taking? How developed is spatial perspective-taking in early childhood, and can it be maintained at least until the initial stages of late life? It is necessary to examine the nature and life-span development of spatial perspective-taking in greater detail. Moreover, it is extremely important to elucidate the characteristics of imaginary body movement because such findings would increase our understanding of mental images and, at the same time, open up a new research area pertaining to the link between spatial cognition and neuroscience.

REFERENCES


Direct reprint requests to:

Masayuki Watanabe
Department of Psychology
Shiga University
Hiratsu 2-5-1
Otsu, Shiga 520-0862
Japan
e-mail: watanabe@edu.shiga-u.ac.jp