JVIB

March 2005 • Volume 99 • Number 3

# The Role of Visual Experience in Mental Imagery

*Annick Vanlierde and Marie-Chantal Wanet-Defalque*

***Abstract:*** The mental imagery of participants who became blind early in life (EB participants), participants who became blind later in life (LB participants), and sighted participants was compared in two experiments. In the first experiment, the participants were asked to image common objects and to estimate how far away these objects appeared in their image. In the second experiment, the participants were asked to point to the left and right sides of three objects, imaged at three increasing distances. The LB participants' performance of the tasks in both experiments was similar to that of the sighted participants, whereas the performance of the EB participants differed. The results reflect the close relationship between the development of visual perception and the properties of images.

The authors are indebted to Professor Claude Veraart for his helpful comments and thank the volunteers and the Œuvre Nationale des Aveugles for their essential collaboration in this study. This research was supported by Grant 3.4547.00 from the Belgian Foundation for Medical Scientific Research.

Visual mental imagery plays an important role in daily life and in solving many problems. It is involved in several cognitive activities like memory, spatial reasoning, the acquisition of skills, and the comprehension of language (for a review, see Kosslyn, Behrmann, & Jeannerod, 1995).

A close relationship between visual perception and imagery has been observed in various studies. According to Farah (1988), both visual perception and imagery share some modality-specific internal representation and involve similar functional properties. For example, Kosslyn (1978) found that people apply the laws of perspective to their mental imagery, and Kosslyn, Ball, and Reiser (1978) found that visual mental images preserve metric spatial information. Other researchers have found that the reaction time taken to rotate an object mentally to judge whether two shapes were identical or mirror images increased as a linear function of the angular discrepancy between the stimuli (Cooper & Shepard, 1973, 1975; Shepard & Metzler, 1971).

With regard to imagery in people who are blind, some studies have shown that persons who became blind early in life are able to perform some tasks of mental imagery at the same level of performance and with the same characteristics as do sighted persons, even if they have no visual experience and know their environment only through nonvisual modalities. Indeed, Marmor and Zaback (1976) and Carpenter and Eisenberg (1978) showed that persons who became blind early in life were able mentally to rotate and compare images of objects that they had previously explored tactilely and, like the reaction times of sighted persons, their reaction times increased with the angular discrepancy between shapes. In addition, they seemed to be able to maintain mentally some metric spatial information. Indeed, Kerr (1983) reported a linear relationship between scanning time in the imagination and the distance between two objects in an imaged scene. In contrast, other researchers have concluded that the mental imagery of persons who became blind early in life is different from that of sighted people. In a task similar to the one designed by Kosslyn (1978), Arditi, Holtzman, and Kosslyn (1988) found that the laws of perspective did not appear in the mental imagery of persons who became blind early in life. In their study, some visual aspect of the mental imagery seemed inaccessible to these persons. However, some persons who became blind early in life were able to apply the laws of perspective in raised-line pictures (Kennedy, 1980) but did not spontaneously generate these effects (Heller, Calcaterra, Tyler, & Burson, 1996).

People who lost their vision when they were teenagers or adults adapted to their blindness over several years with various degrees of efficacy using their unaffected sensory modalities. Compared to persons who became blind early in life, those who become blind later in life can rely on their visual experiences of the world. This remaining visual experience proves to be useful in tasks that involve spatial representation, enabling them to perform some tasks at the same level as do sighted persons that some persons who became blind early in life find difficult (see Gaunet & Thinus-Blanc, 1996, for a review).

Do the visual mental images of persons who became blind later in life retain their vividness and precise details, and are they comparable to those of sighted people? On the one hand, one can argue that persons who became blind later in life can efficiently deal with spatial representations, as numerous studies (see, for example, Gaunet & Thinus-Blanc, 1996; Rieser, Guth, & Hill, 1982; Rieser, Lockman, & Pick, 1980; Veraart & Wanet-Defalque, 1987) have shown. On the other hand, compared to sighted people, persons who became blind later in life do not receive any more input to refresh their stored model of the visual world. Even if this lack of input does not excessively affect the general experience of mental imagery, it could be more important in the detailed characteristics of objects, such as shapes and colors, or in transformations of images that are related to the person's own movements.

The study reported here investigated the role of visual experience in the visual mental imagery of sighted persons and persons who became blind at different times in life. It is important to understand the influence of vision on mental imagery because mental imagery is a higher-order cognitive function that is used to resolve many everyday problems.

## Experiment 1

In sighted persons, the distance at which an object is imaged depends on the size of the object (Kosslyn, 1978). According to Arditi et al. (1988), persons who became blind early in life imaged large objects at arm's length, closer to themselves than did sighted persons. Similar data are not available for persons who became blind later in life. Accordingly, this study examined how persons who became blind later in life take advantage of their visual experience in visual mental imagery. Would these persons image large objects farther away than small objects, as sighted persons do, or at a length that is similar to that of persons who became blind early in life?

## Method

### Participants

The participants were 10 persons who became blind early in life (EB) (3 women and 7 men) aged 20–62 (mean age = 40 years, *SD* = 13.01), 9 persons who became blind later in life (LB) (5 women and 4 men) aged 37–61 (mean age = 52 years, *SD* = 8.42), and 27 sighted persons in the control group (SCG) (13 women and 14 men) aged 22–68 (mean age = 43 years, *SD* = 15.07). (Persons who lost sight before age 3 are defined, for the purpose of this study, as EB; and those who lost vision after the complete development of their visual system—that is, at about age 6–10—are defined as LB.) The EB and LB participants were completely blind and had no other disabilities (see Table 1 for a description of the participants). All the participants were unpaid volunteers.

## Materials

The 10 objects of different sizes that were selected as items were familiar to all the participants: an aspirin pill, a coffee cup, a telephone, a 33-rpm vinyl record (with a 6.5-inch radius), a briefcase, a seat, a broom, a horse, a van, and a bus. An independent group of sighted persons ($n = 3$) and persons who became blind early in life ($n = 3$) confirmed the familiarity of all the items in an image-generation task. In addition, each participant's familiarity with the items was assessed before the experiment began.

## Procedure

Before each of the four conditions was presented, the experimenter read the instructions to the participants. The familiarization condition was presented first, followed by three experimental conditions of an increasing level of complexity in a set order: a free condition, a horizontal condition, and an overflow condition.

### *Conditions*

#### *Familiarization.*

After the name of an object was given, the participants were asked to create its image in their minds. In the image, the object and the participant were to be stationary. After the participants achieved a good image of the object, they were to say "OK," and the name of the next object would be given. Only the specified object had to be imaged when it was named. The names of the objects were read in a pseudorandom order: the broom, telephone, bus, horse, aspirin pill, seat, 33-rpm vinyl record, coffee cup, van, and briefcase. The same order was kept for the subsequent experimental conditions.

The aim of the first condition was to familiarize the participants with the task and the items. The participants were also told that from then on, they had to keep the same image of any one of the 10 objects during the entire experiment. To illustrate this point, the experimenter noted that if a participant was asked to create an image of a cat and he or she imaged a Siamese cat, then the participant had to maintain the same image of the cat in all the conditions.

***Free condition.***

In this condition, the participants were asked to try to generate the image of the object exactly as they did in the first condition, with the same size and at the same distance from them. Then they had to estimate how far away they thought the object was from them.

***Horizontal condition.***

In this condition, the participants had to image that the object was oriented so that its largest side would lay horizontally, that is, at an orientation that made the object (such as a broom) the largest on the horizontal plane. Then they again had to estimate the object's distance from them in the image.

***Overflow condition.***

In this condition, the participants were again asked to image the object with its largest side laying horizontally but at a great distance and then to image moving toward it. The participants were told that when they imaged that they were approaching the object, the object would enlarge and would eventually overflow the boundaries of their mental images. When it did, they had to assess the object's distance. For the free, horizontal, and overflow conditions, the participants estimated a distance expressed in either centimeters or meters.

## Results of Experiment 1

### *Sighted participants*

The data obtained with the sighted participants were analyzed to verify whether we replicated the results obtained by Kosslyn (1978) and Arditi et al. (1988). The 10 objects were divided into three groups of different sizes: small objects (the aspirin pill, coffee cup, and telephone), middle-sized objects (the 33-rpm record, briefcase, broom, and seat), and large objects (the horse, van, and bus). A 3 by 3 analysis of variance (ANOVA) on the estimated distance from the subject (the sizes of objects as between-participants variables and the conditions as within-participants variables) revealed significant main effects that were due to the objects' size ($F(1, 7) = 30.281$, $p < .001$) and to the conditions ($F(2,14) = 105.204$, $p < .001$). A significant interaction between the size of objects and the conditions was found ($F(4, 14) = 58.277$, $p < .001$). The means of the estimated distances ranged from 0.38 meters (about 1.2 feet) for the aspirin pill to 15.98 meters (about 52 feet) for the bus in the free condition and from 0.32 meters (about 1 foot) to 12.60 meters (about 41 feet) in the horizontal condition, but only from 0.02 meters (about 0.8 inch) for the aspirin pill to 5.67 meters (about 18 feet) in the overflow condition. The object-size effect was larger in the free and horizontal conditions than in the overflow condition. A Scheffé post hoc analysis showed a significant difference between the large and small objects ($p = .001$) and between the large and middle-size objects ($p = .001$). The SCG (sighted) participants thus imaged the large objects at a greater distance in each condition than they did the small or middle-sized objects. A *t*-test for paired observations, which was performed to compare each condition, showed a significant difference between the overflow condition and the free ($t = 4.367$, $p < .001$) and horizontal ($t = -4.075$, $p < .001$) conditions and between the free and the horizontal condition ($t = 2.143$, $p < .05$). This finding means that estimated distances decreased in the overflow condition compared to the free and horizontal conditions. The SCG participants had to move mentally toward the object for the overflow condition. When no instruction was given, they imaged the objects farther away than when a precise point of view was required.

***The EB participants***

The task proved difficult for some participants in the EB group, particularly in the overflow condition, in which only 3 of the 10 participants were able to perform the task and to give an estimate of distance. Consequently, only the free and the horizontal conditions included enough data for statistical analyses. The 7 participants who were unable to perform the task in the overflow condition reported that the question made no sense to them because the image of an object could never overflow the frame of representation—that the entire imaged object always existed even if the object was touching their bodies. The 3 EB participants who performed the task estimated a distance only for the three large objects and at arm’s length. For the free and horizontal conditions, all the participants were able to perform the task.

A 3 by 2 ANOVA (the sizes of objects as between-participants variables and the conditions as within-participants variables) revealed significant effects that were due to the size of the objects ($F(2, 7) = 10.883$, $p < .05$) and the conditions ($F(2, 7) = 10.628$, $p < .05$). No interaction was found to be significant between the size of the objects and the conditions ($F(2, 7) = 2.675$, $p > .05$). A Scheffé post hoc analysis showed a significant difference between the large and small objects ($p = .009$) and between the large and middle-size objects ($p = .025$). The EB participants imaged the largest objects farther away. A *t*-test for paired observations showed a significant difference between the free and horizontal conditions ($t = 2.642$, $p < .05$). The EB participants imaged the items farther away in the free condition than in the horizontal condition, as did the SCG participants.

### *LB participants*

All the participants in this group could perform the task in the three conditions. A 3 by 3 ANOVA (the sizes of objects as between-participants variables and the conditions as within-participants variables) revealed significant effects that were due to the size of objects ($F(2, 7) = 18.160$, $p < .05$) and to conditions ($F(2, 14) = 38.740$, $p < .001$). A significant interaction was found between the size of objects and the conditions ($F(2, 14) = 19.522$, $p < .001$). The means for distance ranged from 0.30 meters (about 12 inches) for the aspirin pill to 8.63 meters (about 28 feet) for the bus in the free condition and from 0.27 meters (about 11 inches) to 9.67 meters (about 31 feet) in the horizontal condition, but from 0.019 meters (about 0.8 inches) for the aspirin pill to 3.50 meters (about 11 feet) for the bus in the overflow condition. A Scheffé post hoc analysis showed a significant difference between the large and small objects ($p = .002$) and between the large and middle-size objects ($p = .008$). As did the other groups, the LB participants imaged the largest objects farther away. A *t*-test for paired observations revealed a significant difference between the overflow and free conditions ($t = 2.672$, $p < .05$) and the horizontal condition ($t = 2.551$, $p < .05$) but not between the free condition and the horizontal condition. This finding means that the estimated distance decreased in the overflow condition compared to the free and the horizontal conditions. The LB participants had to move mentally toward the object in the overflow condition.

### *Comparison among the groups*

The mean estimated distances for each group in the free, horizontal, and overflow conditions are illustrated in Figure 1. A 3 by 3 by 2 ANOVA (grouped as the between-participants variables and the sizes of objects and the conditions as the within-participants variables) was conducted to compare the performance of the three groups of participants on the three sizes of objects. Only two conditions (the free and the horizontal) were used because there were not enough data for the EB participants in the overflow condition. This analysis revealed a significant main effect of the groups ($F(1, 58) = 4.700$, $p < .05$) and of the size of objects ($F(2,116) = 22.680$, $p < .001$), but no significant effect of the conditions ($F(1, 58) = 1.823$, $p > .05$). A significant interaction was found between the groups and the size of objects ($F(4, 116) = 3.570$, $p < .05$), but no interaction was found to be significant between the groups and the conditions ($F(2, 58) = 0.433$, $p > .05$). A Scheffé post hoc analysis showed that in the free condition, the EB participants imaged the largest objects to be not as far away from them as did the SCG participants ($p = .008$) and that both the EB and LB participants tended to image large objects nearer to them than did the SCG participants, but this finding was not significant ($p = .062$). No significant difference was found between the EB and LB participants ($p = .256$) in this regard.

In the horizontal condition, a Scheffé post hoc analysis showed that for the large objects, the distances estimated by the EB participants were significantly shorter than those estimated by the SCG participants ($p = .007$) and tended to be shorter than those estimated by the LB participants, but the latter finding was not significant ($p = .071$). No significant difference was found between the SCG participants and the LB participants ($p = .322$) in this regard. For the small and middle-size objects, the three groups were not significantly different, since they imaged these items at arm’s length (a distance of 0.50 to 0.70 meters, or about 19 to 28 inches).

In the overflow condition, a 2 by 3 ANOVA (the groups as the between-participants variables and the sizes of objects as the within-participants variables) was conducted to compare the performance of the LB and SCG participants. This analysis revealed a significant main effect of the size of objects ($F(2, 90) = 10.392$, $p < .001$) but no significant effect of the groups ($F(1, 45) = 0.361$, $p > .05$). No significant interaction was found between the groups and the sizes of objects. The mean estimated distance for the LB and SCG participants in the overflow condition is illustrated in Figure 1c. A *t*-test for paired observations showed that the large objects were imaged farther away than were the middle-size objects ($t = –5.295$, $p < .001$) and than the small objects ($t = –5.989$, $p < .001$). Similarly, the middle-size objects were imaged farther away than were the small objects ($t = –7.379$, $p < .001$).

### *Discussion of Experiment 1*

The results indicate that the distance at which the SCG participants freely imaged an object depended on the object's size: larger objects were imaged at greater distances. In addition, the estimated distance decreased in the overflow condition compared to the free and horizontal conditions, since the participants had to move mentally toward the object. When no instruction was given, the participants imaged the objects as being farther away than when an overflowed image that would fill the entire mental image was required.

The EB participants also imaged the large objects at greater distances, but the distances were not as great as those that the SCG participants imaged. This finding was also noted by Arditi et al. (1988), who interpreted it to mean that imagery in the EB participants was mediated tactilely, whereas imagery in the SCG participants was mediated visually. As in Arditi et al.'s study, our study found that many of the EB participants were unable to perform tasks in the overflow condition. This finding suggests that visual experience is necessary for this task.

For the group of LB participants, as for the other two groups, the distance at which an object was imaged depended on its size. Nevertheless, in the free condition, the LB participants tended to image objects at a shorter distance, in between the SCG participants' and the EB participants' estimates. This was not the case in the horizontal condition. A trend for the LB participants to image objects at a shorter distance, compared to the SCG participants, could also indicate the LB participants' tactile mediation of the image. However, this was only a trend, and in the other conditions, the data for the LB participants were generally similar to the data for the SCG participants. Indeed, the LB participants were able to perform the tasks in the overflow condition, and their estimates were not significantly different from those of the SCG participants. Similar to the SCG participants, the visual angle limited the size of the image spread in the LB participants. Thus, early visual experience seems to influence the characteristics of objects that are imaged.

## Experiment 2

Experiment 1 showed that in contrast to the EB participants, the images of the LB participants could overflow the angular extent of their fields of view. To do so, they, like the SCG participants, had to move mentally to a distance at which the entire object filled the image. Thus, they seemed to be able to apply the laws of perspective in their mental imagery.

To study these aspects of mental imagery further, we tested the same three groups of participants in a task that required them to point to the left and right sides of imaged objects at three distances. We expected that objects that were imaged at a greater distance would subtend smaller visual angles.

### Method

### *Participants, materials, and procedure*

All the participants who were involved in Experiment 1 also participated in this experiment, which immediately followed Experiment 1. No feedback was given at the end of Experiment 1.

Only three objects from Experiment 1 were used in this experiment: the briefcase, the broom, and the horse. The participants were asked to image the object at three successive distances: 1 meter (about 39 inches), 3 meters (about 10 feet), and 9 meters (about 30 feet). When they had succeeded in forming the image of the object at the given distance, they were then asked to point on a ruler (attached to the table in front of them) to the left and right sides of the object with their left and right index fingers. The pointing span on the ruler was then measured.

## Results for Experiment 2

The mean pointing spans for the three groups of participants and for the three distances are illustrated in Figure 2. At first, an ANOVA was separately conducted on each group's data.

### *SCG participants*

A 3 by 3 ANOVA (the objects as the between-subjects variables and the imaged distances as the within-subjects variables) revealed a significant effect that was due to the objects ($F(2, 78) = 62.146$, $p < .001$) and to the imaged distance ($F(2, 156) = 27.767$, $p < .001$), as well as a significant interaction between the object and the imaged distance ($F(4, 153) = 6.266$, $p < .001$). A Scheffé post hoc test showed that the pointing span for the horse was larger than was the pointing span for the broom ($p < .001$) and for the briefcase ($p < .001$). A *t*-test for paired observations showed that there was a significant difference between objects that were imaged at 1 meter (about 39 inches) and those that were imaged at 9 meters (about 30 feet) ($t = 5.871$, $p < .001$) and between objects that were imaged at 3 meters (about 10 feet) and those that were imaged at 9 meters (about 30 feet) ($t = 9.171$, $p < .001$), but not between objects that were imaged at 1 meter and 3 meters, as reflected by the significant interaction. Accordingly, larger objects subtended larger visual angles, and the angle decreased with the imaged distance.

### *EB participants*

Only six participants (EB1, EB2, EB3, EB6, EB8, and EB10) performed this task. The four other participants refused to perform this task because they said that the question made no sense to them, since a horse, a broom, or a briefcase is always the same object at all distances. A 3 by 3 ANOVA (the objects as the between-subject variables and the imaged distances as the within-subject variables) revealed a significant effect that was due to the objects ($F(2, 12) = 7.506$, $p < .05$). Neither the effect of the imaged distance nor the interaction between objects and the imaged distance was found to be significant. A Scheffé post hoc analysis showed that the pointing span for the horse was larger than that for the broom ($p = .009$), but no significant difference was found between the horse and the briefcase ($p = .561$) and between the broom and the briefcase ($p = .061$).

### *LB participants*

A 3 by 3 ANOVA (the objects as the between-subject variables and the imaged distances as the within-subject variables) revealed a significant effect that was due to the objects ($F(2, 23) = 7.352$, $p < .05$) and to the imaged distance ($F(2, 46) = 38.858$, $p < .001$). No significant interaction was found between the objects and the imaged distance. A Scheffé post hoc analysis showed that the pointing span for the horse was larger than that for the broom ($p = .023$) and that for the briefcase ($p = .007$). A *t*-test for paired observations showed a significant difference between objects imaged at 1 meter (about 39 inches) and those imaged at 9 meters (about 30 feet) ($t = –5.391$, $p = .001$), between objects imaged at 1 meter (about 39 inches) and those imaged at 3 meters (about 10 feet) ($t = –3.565$, $p < .05$), and between objects imaged at 3 meters (about 10 feet) and those imaged at 9 meters (about 30 feet) ($t = –4.488$, $p < .05$). As was found for the SCG group, larger objects subtended larger visual angles, and the angle decreased with the imaged distance.

### *Comparison among the groups*

A 3 by 3 by 3 ANOVA (the groups as the between-participants variables and the imaged distances and objects as the within-participants variables) was conducted to compare the performance of the three groups for the three objects at the three distances. This analysis showed a significant effect of the groups ($F(1, 38) = 3.951$, $p < .05$), of the imaged distance ($F(2, 76) = 64.129$, $p < .001$), and of the objects ($F(2, 76) = 37.896$, $p < .001$). Significant interactions were found between the groups and the imaged distance ($F(4, 76) = 7.486$, $p < .001$), between the groups and the objects ($F(4, 76) = 2.715$, $p < .05$), and between the objects and the imaged distance ($F(4, 152) = 6.153$, $p < .001$). A Scheffé post hoc analysis showed that at an imaged distance of 9 meters (about 30 feet), the EB participants' pointing spans were larger than the LB participants' ($p = .001$) and the SCG participants' ($p < .001$), whereas at 3 meters (about 10 feet), they were larger than those of the LB participants ($p < .05$) and tended to be larger than those of the SCG participants ($p = .07$) This difference between the three groups did not appear at 1 meter (about 39 inches). For both the horse and the briefcase, the Scheffé post hoc analysis showed that the pointing spans decreased significantly more from 1 meter to 9 meters for the SCG participants than for the EB participants ($p < .05$). Figure 2 shows that the SCG and LB participants decreased their pointing span of objects as the imaged distance increased, but the EB participants did not.

### Discussion of Experiment 2

The results of Experiment 2 show that the EB participants performed differently from the SCG and LB participants. Indeed, the SCG and LB participants decreased the size of the image with the increasing imaged distance, as in typical visual perception. This basic concept of perspective was not grasped by the EB participants, who had no opportunity to learn it.

The lack of difference among the three groups in the case of the broom was unexpected. For this object, all the participants, even the SCG participants, underestimated the angle at each imaged distance. They may have been more used to seeing a broom vertically and hence underestimated it in a horizontal view.

## General discussion

The results of the experiments indicate that the LB participants created images of large objects farther away than they did small ones, were able to experience the overflow effect of an imaged object in their mental representation when they represented it at a closer distance with their field of view totally filled in, and decreased the angular size of an imaged object with increasing distance. Generally, the results for the LB participants were similar to those for the SCG participants, while the results for the EB participants differed. The only difference for the LB participants that could be found was their tendency to place imaged objects at a shorter distance, between the distance chosen by the EB participants and the SCG participants. This finding could be tentatively interpreted as an interference effect of their extensive haptic experience of objects, which the LB participants needed to integrate with their past visual experience. Haptic exploration involves shorter distances between participants and objects to be explored, which could have led the LB participants to image the objects from a closer point of view.

Nevertheless, the results of these experiments emphasize that the imagery of the LB participants had a lot in common with the imagery of sighted people, which has visual as well as spatial aspects. Various studies have shown that visual imagery involves some functional properties that are close to visual perception (Farah, 1988; Ishai & Sagi, 1995; Kosslyn, 1978; Shepard & Metzler, 1971). Visual experience would be necessary to perform visual mental imagery tasks efficiently. The results of these experiments suggest that even limited visual experience is sufficient to allow the application of purely visual rules. The effects of perspective were present in the mental imagery of the SCG participants, as well as that of the LB participants, but were absent in the mental imagery of the EB participants. The laws of perspective are learned through visual experience, are specific to vision, and cannot be accessed by other sensory modalities.

Hollins (1985) studied the mental imagery of persons who were blind who had various amounts of visual experience (0–31 years) before they became blind. Hollins concluded that mental imagery may be modified during life following the sensory experience. Its development depends on the input of information from different perceptual modalities. The results of these experiments are in accordance with this assumption. The EB participants demonstrated a haptic style of imagery, while the LB participants demonstrated a visual imagery that was similar to the visual imagery of the SCG participants. These different styles of imagery depend on the perceptual systems from which information on the shapes of objects and on objects in space was acquired. The sensory systems have different characteristics and constraints. Vision allows people to take global information and information that is from a farther point of view than touch, whereas touch allows a good spatial representation of three-dimensional objects, as long as these objects are small enough to be explored as a whole. Because their visual modality could not develop, the EB participants had to use other sensory modalities, such as touch and hearing, to develop their imagery.

For the LB participants, the results indicate that visual memories played a major role in their mental imagery. Early exposure to visual experiences, with a minimum of nine years in our sample, allowed the LB participants to maintain visual representations, with their specific rules on perception, after they became blind. These participants were still using visual imagery after years of blindness (a maximum of 48 years) and had not replaced it with an imagery that was based on haptic experience. In others words, the LB participants maintained an efficient way to use visual imagery with its specific perceptual organization. This fact could lead to new therapeutic approaches that are based on visual mental imagery. For example, for a number of years, visual devices have been used to help people who are blind locate obstacles and increase their mobility. These displays translate a visual image into sounds (Arno et al., 2001) or into tactile information (Bach-y-Rita, Collins, Saunders, White, & Scadden, 1969). Individuals must be able to translate the information provided by the devices into a mental representation of the image being conveyed. A better understanding of the process by which information is translated into mental representations of images could improve training with these devices and their efficient use.

## References

Arditi, A., Holtzman, J. D., & Kosslyn, S. M. (1988). Mental imagery and sensory experience in congenital blindness. *Neuropsychologia*, *26*, 1–12.

Arno, P., Vanlierde, A., Streel, E., Wanet-Defalque, M.-C., Sanabria-Bohorquez, S., & Veraart, C. (2001). Auditory substitution of vision: Pattern recognition by the blind. *Applied Cognitive Psychology, 15,* 509–519.

Bach-y-Rita, P., Collins, C. C., Saunders, F. A., White, B., & Scadden, L. (1969). Vision substitution by tactile image projection. *Nature, 221*, 963–964.

Carpenter, P. A., & Eisenberg, P. (1978). Mental rotation and the frame of reference in blind and sighted individuals. *Perception & Psychophysics, 23*, 117–124.

Cooper, L. A., & Shepard, R. N. (1973). Chronometric studies of the rotation of mental images. In W. G. Chase (Ed.), *Visual information processing* (pp. 75–76). New York: Academic Press.

Cooper, L. A., & Shepard, R. N. (1975). Mental transformations in the identification of left and right hands. *Journal of Experimental Psychology: Human Perception and Performance, 1*, 48–56.

Farah, M. J. (1988). Is visual imagery really visual? Overlooked evidence from neuropsychology. *Psychological Review, 95*, 307–317.

Gaunet F., & Thinus-Blanc, C. (1996) Early-blind subjects' spatial abilities in the locomotor space: Exploratory strategies and reaction-to-change performance. *Perception, 25*, 967–981.

Heller, M. A., Calcaterra, J. A., Tyler, L. A., & Burson, L. L. (1996). Production and interpretation of perspective drawings by blind and sighted people. *Perception, 25*, 561–566.

Hollins, M. (1985). Styles of mental imagery in blind adults. *Neuropsychologia, 23*, 561–566.

Ishai, A., & Sagi, D. (1995). Common mechanisms of visual imagery and perception. *Science, 28,* 1772–1774.

Kennedy, J. M. (1980). Blind people recognizing and making haptic pictures. In M. A. Hagen (Ed.), *The perception of pictures* (pp. 263–303). New York: Academic Press.

Kerr, N. (1983). The role of vision in "visual imagery" experiments: Evidence from the congenitally blind. *Journal of Experimental Psychology: General*, *112*, 265–277.

Kosslyn, S. M. (1978). Measuring the visual angle of the mind's eye. *Cognitive Psychology, 10,* 356–389.

Kosslyn, S. M., Ball, T. M., & Reiser, B. J. (1978). Visual images preserve metric spatial information: Evidence from studies of image scanning. *Journal of Experimental Psychology: Human Perception and Performance, 4,* 47–60.

Kosslyn, S. M., Behrmann, M., & Jeannerod, M. (1995). The cognitive neuroscience of mental imagery. *Neuropsychologia, 33,* 1335–1344.

Mamor, G. S., & Zaback, L. A. (1976). Mental rotation by the blind: Does mental rotation depend on visual imagery? *Journal of Experimental Psychology: Human Perception, 2*, 515–521.

Rieser, J. J., Lockman, J. J., & Pick, H. L. (1980). The role of visual experience in knowledge of spatial layout. *Perception & Psychophysics, 28,* 185–190.

Rieser, J. J., Guth, D. A., & Hill, E. W. (1982). Mental processes mediating independent travel: Implications for orientation and mobility. *Journal of Visual Impairment & Blindness*, *76*, 213–218.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. *Science*, *171*, 701–703.

Veraart, C., & Wanet-Defalque, M.-C. (1987). Representation of locomotor space by the blind. *Perception & Psychophysics*, *42*, 132–139.

***Annick Vanlierde, Ph.D.,*** *Neural Rehabilitation Engineering Laboratory, Université Catholique de Louvain, Avenue Hippocrate, 54, UCL-54.46, B-1200, Brussels, Belgium; e-mail: <vanlierde@gren.ucl.ac.be>.* ***Marie-Chantal Wanet-Defalque, Ph.D.,*** *Neural Rehabilitation Engineering Laboratory, Université Catholique de Louvain, Avenue Hippocrate, 54, UCL-54.46, B-1200, Brussels, Belgium; e-mail: <mch.wanet.defalque@sympatico.ca>.*

www.afb.org | Change Colors and Text Size | Contact Us | Site Map |

Site Search Go

About AFB | Press Room | Bookstore | Donate | Policy Statement

---

**Please direct your comments and suggestions to afbinfo@afb.net**