KINESTHETIC AND VISUAL-KINESTHETIC PERCEPTION OF INCLINATION: TESTING THE VALIDITY OF THE PADDLE METHOD

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Abstract

Some years ago, Feresin, Agostini & Negrin-Saviolo (1998) tested the validity of the paddle method for measuring: a) the kinesthetic perception of inclination; b) the visual-kinesthetic perception of inclination. In three conditions subjects performed three different tasks: a) rotating a manual paddle to a set of verbally given inclinations (blindfolded subjects), b) rotating a manual paddle to the same set of verbally given inclinations after specific kinesthetic training (blindfolded subjects) and, c) rotating the paddle to a set of fixed visual inclinations after the kinesthetic training. The results showed a high degree of accuracy and precision in the second and third task but not in the first one. When subjects were asked to rotate a manual paddle to a set of verbally given inclinations they used three main anchors (0°, 45°, 90°). Furthermore, the paddle method is biased by a kinesthetic deficiency, namely a rotational problem of the wrist which can be corrected by means of specific training.

In 1998 we tested the validity of a method used for the first time by Gibson, who called it the “method of reproduction” (Gibson, 1950), while other researchers named it the “haptic method”. We preferred to appeal it as the “paddle method”, because a paddle is adjusted by the observer with his/her palm until the kinesthetic impression of inclination of a slope is perceived the same as the visual impression of inclination of the slope itself. Here is a résumé of a paper we published on Behavior Research Methods, Instruments & Computers (Feresin, Agostini & Negrin-Saviolo, 1998).

Since the very beginning of our investigation, we clearly observed that a person while rotating his/her wrist has a main motor deficiency: the wrist cannot rotate completely to achieve the vertical position when the forearm is orthogonal with respect to the arm. To avoid this rotational problem close to the vertical, the person has to lift his forearm up in respect to the arm, and incline the arm and the shoulder by a small amount. We also noticed that if it is so for the range of inclinations around the vertical, it was not the same for the range of inclinations around the horizontal. Close to the horizontal the subject's wrist had an impediment in its rotation due to the inclined position of the forearm with respect to the arm (see Feresin *et al*, 1998; Figures 1, 2, 3).

Because of this possible motor problem around the vertical, it was better for the person to choose a position for the forearm and the wrist, depending on his/her ability to freely rotate the paddle from the vertical to the horizontal. This position resulted in a compromise between the best position for rotating the wrist to the vertical and the best position for rotating the wrist to the horizontal. Because of this compromise we supposed that when a person is asked to kinesthetically set a paddle to the vertical position (0°), he/she will rotate the wrist more than 0° stopping the setting forwards and than overestimating the perceived inclination. On the contrary, when a person was asked to kinesthetically set a paddle to the horizontal (90°) we supposed again he/she will rotate the wrist less than 90° stopping the setting backwards and than underestimating the perceived inclination.

Furthermore we hypothize it was a reasonable strategy for observers to find and use spontaneously some kind of kinesthetic anchor, since we knew from the literature that the vertical and the horizontal are the main visual and haptic orientational anchors or norms (Bouma &

Andriessen, 1967; Cecala & Garner, 1986; Howard, 1982; Howard & Templeton, 1966; Gentaz & Hatwell, 1995; Lechelt, Eliuk & Tanne, 1976; Schone, 1984). When people are asked to judge the visual and the haptic inclination of a surface or a rod they use the horizontal and the vertical plane as a frame of reference: so why should it be different in the kinesthetic domain?

The first aim of our research was to investigate the purely kinesthetic perception of a range of inclined surfaces to test if the paddle method was biased in some way by motor problems or strategies used by the subjects. The second purpose was to measure the perception of the visual inclination of a line by means of the paddle kinesthetic method. If the paddle method was influenced by motor problems, as we supposed, it should be possible to compensate for such motor biases with an appropriate kinesthetic training. When the motor biases were avoided we can use the paddle method to test the perception of the visual inclination of a surface or a line. In this way it is possible to separate the kinesthetic outcome from the visual outcome.

During a preliminary study we observed that, while doing the kinesthetic task of rotating the manual paddle to a set of eleven inclinations going from the vertical (0°) to the horizontal (90°), subjects had a limit in the extent of rotation of the wrist. The subject's wrist could rotate completely to achieve the vertical or horizontal position only by forcing it, but since the subjects were not asked to do it, they stopped their adjustment of the vertical and the horizontal position whenever they started to feel the impediment of rotating the wrist. We also noticed they used three main kinesthetic anchors to refer their paddle adjustment: 0° (gravitational vertical), 45° and 90° (horizontal). It is a reasonable strategy that the subjects use the vertical and the horizontal anchors for the reason explained in the introduction; but we want to point out that also the 45° is used as an anchor. This anchor is derived because it was achieved by the subjects as the middle position between the vertical and the horizontal. For example, when the subjects had to set the paddle to 45°, they first started from the vertical, then they went to the horizontal and finally found the middle position corresponding to 45°. When they were asked to set the paddle to 40° or 50° they first looked for 0° and for 90°, than they reached 45° and went from it to reach finally 40° or 50°. At the end of the pilot study we asked subjects if they had used any anchor as reference point. All of them told us that they were using the three anchors we had observed while watching them doing the kinesthetic task.

Experiment

In two conditions we measured accuracy and precision (Ono, 1993) of adjusting the inclination of a manual paddle to a set of verbally given angles. In a third condition we measured accuracy and precision of adjusting the inclination of the same manual paddle to a set of visually given inclinations. The measure of accuracy was the mean of the Point of Subjective Equality (P.S.E.) compared to the Point of Objective Equality (P.O.E.). The measure of precision was the standard error. The task performed by the subjects in the first and second condition was a "purely kinesthetic task" because the inclination of the manual paddle was not compared with a visual surface and the observer was blindfolded. We also investigated subject's possible strategies in performing the task. The task performed by the subjects in the third condition was a "visual-kinesthetic task" because the inclination of the manual paddle was compared with a set of inclinations of a luminous line.

Method

Observers

Eighteen observers took part in the experiment: six for each condition. They were undergraduate and graduate psychology students of the University of Trieste. All were volunteers and naive to the aim of this work.

Apparatus

A cubic chamber 150 cm long on each side was placed in the middle of the laboratory. A rotatable paddle was connected to the frame of the chamber by means of a small table. The paddle was connected to an electronic protractor (Emaco Angle Star Protractor System, Montrèal, Québec, Canada) with an accuracy of 0.1° and to a visual display (see Figure above here). During the third condition the chamber was illuminated by two projectors placed outside the right and the left side of the chamber itself. A thick luminous line was mounted on a wooden rotatable bar and fixed to the cubic chamber in front of the observer at a viewing distance of 150 cm. The center of the line was at eye level (Figure above here).

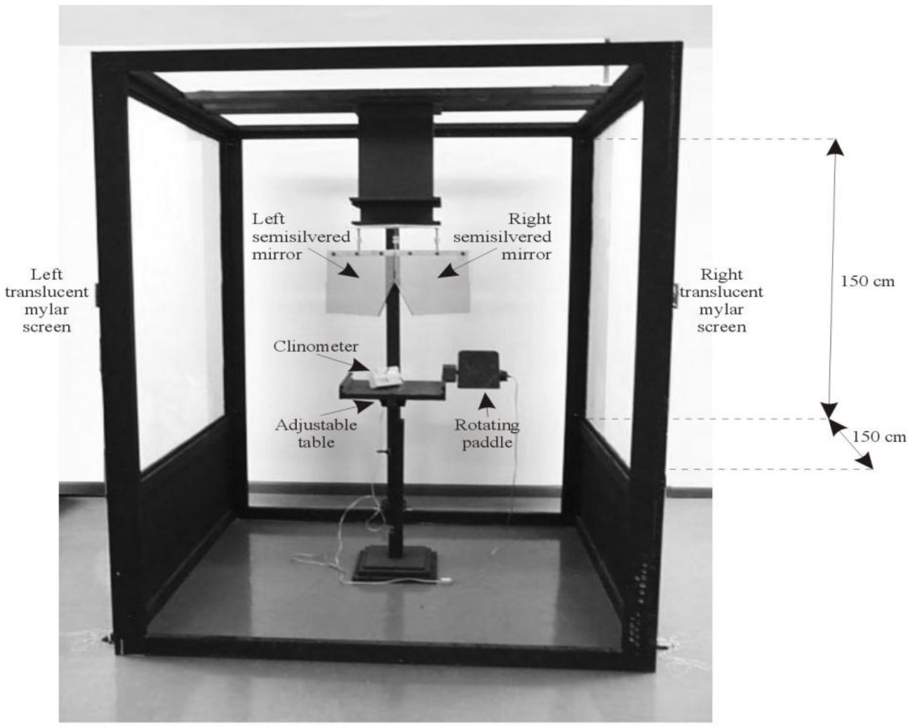

Figure 5

Results

Condition 1. In this condition, we noticed that the six subjects overestimated (forward direction) the kinesthetic inclinations relative to the verbal angle from 0° to 30°; settings were accurate and precise (small standard errors) from 40° to 50° and underestimated (backward direction) the kinesthetic inclinations relative to the verbal angle from 60° to 90°. When the verbal angle was close to the gravitational vertical (from 10° to 30°) subjects started their settings always from the vertical. This means that if they tended to slightly overestimate the vertical itself stopping their setting forwards, they carried this initial overestimation with them and showed this bias also for angles close to the vertical. It is the same for the horizontal: indeed the subjects tended to underestimate the horizontal stopping their setting backwards and carried this underestimation with them showing it also for angles close to 90° (from 60° to 80°). We divided the distribution into two halves: from 0° to 40° and from 50° to 90° excluding the 45° since it is the inversion point between positive and negative PES. Then we subtracted the paddle settings from the verbally defined values and finally analysed the two distributions by using a one group t test. The statistical analysis showed a significant difference for the 0°-40° distribution (t (4)= -2.8; p<.05) and a tendency to significance for the 50°-90° distribution (t (4) = 2.4; p<.07). See Feresin *et al*., 1998; Figure 5.

Condition 2. The six subjects were more precise than in Condition 2 as the small standard errors show. Furthermore there was no over / underestimation of the perceived kinesthetic inclination, indeed the subjects showed a great accuracy from O° to 90°. We analysed the data in the same way as in condition 1. A one group t test showed significant difference neither for the 0°- 40° distribution nor for the 50°- 90° distribution (see Feresin *et al*., 1998; Figure 6).

Condition 3. The six subjects were very accurate and precise when they kinesthetically adjusted the paddle to the 10 different visual inclinations. A one group t test showed significant difference neither for the 0°-40° distribution nor for the 50°-80° distribution (see Feresin *et al*., 1998; Figure 7).

Discussion

Summarizing our results, we found in the first condition, where subjects were not trained to use the paddle, an underestimation of the perceived kinesthetic inclination when the tested angles were close to the horizontal, an overestimation when they were close to the gravitational vertical, and a quite good level of accuracy and precision around 45 degrees.

In the second condition, where subjects were trained to use three anchors (spontaneously used in the pilot study and in the first condition) and had a feed-back to compensate for the wrist rotational problem, we observed a good level of accuracy and precision of the responses without any under-/ overestimation.

In the third condition, the subjects had the same kinesthetic training as in condition 2 before performing a "visual-kinesthetic" task. The results of this final condition showed a great degree of accuracy and precision of the responses.

The main point emerging from our research is that the use of the paddle method presents a wrist rotational bias due to the position of the subjects' forearm while performing a kinesthetic task. The under -/ overestimation found in the first experiment nearly disappears when the rotational bias is compensated by giving the subject a kinesthetic feed-back concerning the veridical inclination of the paddle.

We emphasized that, when subjects were asked to perform a kinesthetic task by rotating a manual paddle, they spontaneously used three anchors, that is, the perceived 0, 45 and 90 degrees. We supposed that training the subjects to consciously use these anchors reduced data variability since it prevents the use of uncontrolled strategies.

Furthermore, we supposed that the kinesthetic outcome could be affected by the use of strategies different from those we found in our first condition, and we hope to investigate them in a future experiment. Moreover, we thought that these kinesthetic variables such as the effect of wrist and forearm position, should be taken into account when the paddle method is used. Our results showed that, in a visual-kinesthetic task, an inclined line is matched correctly when subjects are previously trained in the kinesthetic domain. This suggested that an uncontrolled use of the intersensory method could measure a motor problem and the presence of heterogeneous strategies rather than a visual misperception.

In conclusion, we underlined the intersensory paddle method is a valid one but only when precautions are taken by training the subjects to overcome the rotational problem of the wrist and by verifying their strategies.

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