The interaction of postural systems in visual orientation

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Visual orientation judgments were made during right head tilt, left body tilt, and left trunk tilt, each of 30 deg. In these postures the otolith, neck, and trunk systems are stimulated in pairs. The hypothesis that the visual vertical during trunk tilt is equal to the algebraic sum of those in the same direction of body tilt and the opposite head tilt was tested and accepted. This result demonstrates the interaction of these postural systems in visual orientation, and complements the confirmation of the same hypothesis for the visual aftereffect following prolonged tilt.

Visual orientation is precise and accurate when the body is upright. However, it can be influenced systematically by the inclination of the trunk while keeping the head upright (Fischer, 1927; Schöne & Udo de Haes, 1968; Wade, 1968), or a prior period of head, body, or trunk tilt (Day & Wade, 1966; Wade, 1968). An analysis of the visual effect and aftereffect from these postures has been made in terms of the otolith (o), neck (n), and trunk (t) receptor systems stimulated (Wade, 1968). These systems are stimulated in pairs during head, body, and trunk tilts. When the same degree of tilt is employed for each posture the relative contributions of these systems to visual orientation can be examined. More specifically, left trunk tilt (L TT) involves trunk stimulation as in left body tilt (L BT), and neck stimulation equivalent to that in right head tilt (R HT). Denoting right tilt as "+" and left tilt as "-", these values can be expressed symbolically in the following manner:

$$\begin{aligned} \text{L TT} &= +n_{30} - t_{30} \\ \text{L BT} &= -o_{30} - t_{30} \\ \text{R HT} &= +o_{30} + n_{30} \end{aligned}$$

Assuming that the effects of right and left otolith stimulation are equal and opposite, the neck and trunk stimulation in trunk tilt can be derived by summing the values from head tilt and body tilt:

$$\begin{aligned} \text{R HT} + \text{L BT} &= +o_{30} + n_{30} - o_{30} - t_{30} \\ &= +n_{30} - t_{30} \\ &= \text{L TT} \end{aligned}$$

Therefore, it can be hypothesized that the visual vertical during trunk tilt is equal to the algebraic sum of those in the same direction of body tilt and the opposite head tilt, all of the same degree.

This hypothesis has been accepted for the visual aftereffect following tilt, and was referred to as the "additive hypothesis" (Wade, 1968). However, the otolith system is most probably not involved in the visual aftereffect following tilt (Day & Wade, 1968), but it is involved in visual orientation during tilt (Correia, Hixson, & Niven, 1965; Miller & Graybiel, 1966a, b; Schöne, 1964; Schöne, Parker, & Mortag, 1967). Thus the assumption that right and left head inclination of the same degree stimulates the otolith system equally and oppositely requires supporting evidence. In the cited experiments, and others involving equal degrees of right and left tilt, no consistent differences have been found in visual orientation, strongly suggesting equivalence of function.

The present experiment was designed to test the additive

Table 1
Means (degrees) for visual vertical with 30 deg right head tilt, left body tilt, and left trunk tilt, together with the mean for the relation between them.

Posture			
R HT	L BT	L TT	R HT + L BT - L TT
-3.80	+3.06	-0.71	-0.03

Note: + denotes a CW deviation from gravity; - denotes CCW.

hypothesis for tilt of 30 deg. Visual vertical judgments were obtained for each of the three postures, and it was hypothesized that the visual vertical with right head tilt plus that during left body tilt would equal the visual vertical with left trunk tilt.

METHOD

Apparatus

The apparatus was the same as that used in a previous study (Wade, 1968). It enabled independent tilting of the head and trunk, so that the postures of head, body, and trunk tilts could be achieved.

Subjects

Twenty Ss from an introductory course in psychology participated.

Procedure

The body postures investigated were 30 deg right head tilt, 30 deg left body tilt, and 30 deg left trunk tilt. Two practice trials were given initially with the body upright. Four adjustments to the visual vertical were made during tilt in each posture, from starting positions of 10 deg and 20 deg CW and CCW of the gravitational vertical. The order of presentation was randomized, and the body was returned to the upright following completion of each judgment, and it remained there for 45 sec before the next tilt. The S's eyes were closed at all times other than when making an adjustment.

RESULTS AND DISCUSSION

The visual vertical was averaged over starting positions for each tilt. Table 1 gives the means for the visual vertical for each tilt condition, together with that for the algebraic sum of the visual verticals from right head tilt plus left body tilt minus left trunk tilt. The null hypothesis for the difference of this sum from zero was accepted ($t = 0.04$, $df = 19$, $p > .05$).

For both head and body tilt the E-effect was obtained, i.e., the visual vertical was on the opposite side of the gravitational vertical to tilt. The magnitude of the E-effect from head tilt, however, was greater than that from body tilt, and the algebraic sum of the two was almost exactly equal to the visual vertical with left trunk tilt. That is, the additive hypothesis was confirmed for judgments during tilt. This complements the previous acceptance of the hypothesis for the visual aftereffect following prolonged tilt (Wade, 1968). Furthermore, it has been shown that the aftereffect following 15 deg head tilt plus that from 15 deg body tilt is equal to the aftereffect from the combined head and trunk tilt, i.e., with the head tilted 15 deg to the trunk, which was in turn tilted 15 deg to gravity (Day & Wade, 1969). As noted above, however, the otolith system does

not appear to be involved in the visual aftereffect from prolonged tilt.

Clearly this additive model can be applied and tested for all tilt combinations. For example, the visual vertical may be predicted for postures involving stimulation of all three systems by determining the influence of each and summing algebraically. The hypothesis has been tested initially for the simplest combination of postures involving the otolith, neck, and trunk systems, i.e., when they are stimulated in pairs.

These studies have demonstrated that for tilts within 30 deg of gravity the involvement of the neck system in visual orientation is greater than that for the trunk. Furthermore, they also indicate how predictions concerning the interaction of the different postural systems involved in visual orientation can be made and tested.

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NOTE

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