We have studied the movements of the eyes, head and ears as cats are actively locating sounds with their heads unrotated. Typically, the pedestal we use will move first with a quick, saccadic-like movement toward the target, followed shortly by head and gaze saccades. We have previously described a compensatory counterrotation of the ear on the head that stabilizes the direction of the ear in space as the cat makes active movements during orientation to sounds and lights which we have termed the vestibulo-auricular reflex (VAR). This active VAR has characteristics similar to the well-known vestibulo-ocular reflex (VOR). To test the hypothesis that the VAR is vestibularly evoked and not due to an efference copy from the head movement signal, we studied the effect of passive head movement on the VAR in cats as they actively located sounds while being rotated on a platform. Typically, the VAR was still present despite the passive head movement—the ear-counter-rotated on the head to maintain stable orientation in space (passive VAR). We conclude that the counter-rotation and stabilization of the pinna are the head movements during active orientation and passive movement is not due to an efference copy from the head movement command and is therefore truly vestibular in origin.

**METHODS**

We monitored eye, head and ear position while cats were trained using operant conditioning to indicate the apparent target location. We used a headmounted digital video camera to record eye position (GeneSys Development Corporation, Mount Olive, N.J.) and an electromagnetic digitizer (Polhemus, Colchester, VT) to record head and ear position. For the eye camera, the camera moved with the head on a platform which was positioned at 45° to the right or left after the cat had made a gaze shift and remained stationary during the trial. Trials in which the cat did not show a vestibulo-collic reflex were selected for analysis, i.e. trials we analyzed in which the VAR was absent.

**EXPERIMENTAL SETUP**

Schematic diagram of the behavioral setup. The motor that turns the platform is located to the left of the cat. The inset picture shows the head tube attached to the head holder as the cat works with the head unrestrained.

**Hypothesis: the VAR will persist during passive head movements**

To test whether the VAR could be due to an efference copy signal from the head command signal, we passively rotated the cat on a platform while it located sounds. If the VAR persisted when the head is rotated passively and there is no active head command signal, then the VAR cannot be due to an efference copy signal. A complication with passive whole body rotation is the vestibulo-collic reflex, where the animal will rotate the head to keep it stable in space and compensate for the head rotation. For these experiments we had to select trials where the VOR was absent.

**The vestibulo-auricular reflex (VAR)**

Gaze, head, left pinna, and ear-on-head positions in space as a function of time with respect to the onset of the head movement for an acoustic target along the horizontal plane. The VOR and VAR peaks are often observed in parallel in response to the pincus movement. For leftward targets (left panels), the pincus movement was followed by gaze movements. For rightward targets (right panels), left pinna did not move and generally followed the head movement.

**The vestibulo-collic reflex (VCR)**

Gaze, head, left pinna, and ear-on-head positions in space as a function of time with respect to the onset of the head movement for an acoustic target along the horizontal plane. The VCR and VAR peaks are often observed in parallel in response to the pincus movement. For leftward targets (left panels), the pincus movement was followed by gaze movements. For rightward targets (right panels), left pinna did not move and generally followed the head movement.

**SUMMARY**

1. When the cat is actively locating sounds, the ipsilateral external ear will rotate to the target and counter-rotate on the head to maintain the pinna orientation. The compensatory movements of the ears elicits the vestibulo-auricular reflex (VAR) in analogy to the well-known vestibulo-ocular reflex (VOR).

2. To see whether the VAR is due to the efference copy signal to move the head, we passively rotated the cat on a platform while it was actively locating sounds.

3. We had to choose trials in which the vestibulo-collic reflex was not present, i.e. trials in which the head rotated with the platform.

4. The VAR persisted during passive head rotation. This rules out efference copy as a possible source of the pinna movement and reinforces the hypothesis that the reflex is innervated by activation of the vestibular system by head movement.

**Supported by grants NIDCD DC-00116 and DC-02840**