Behavioral Evidence for Motion Specific Processing in the Auditory System

Objects are frequently in motion, and accurate tracking of these moving targets is critical for safely navigating our environment. For this, humans depend on processing of motion cues in the visual and auditory domains. It is well established that smooth pursuit (SP) eye movements for tracking of a moving visual target depend upon specialized sensory circuits encoding velocity. However, it remains unclear whether the auditory system encodes motion by a similar “motion specific” process. In the present studies, we asked whether SP eye movements could improve our understanding of auditory motion processing. Eye movements (both saccadic and SP) provide a useful method of quantifying motion perception, as accurate SP eye movements are thought to generally require a visual moving target. Previous research in our lab and others has found that subjects can also smoothly pursue moving auditory targets (though with a lower gain than for visual targets), suggesting motion-specific coding within the auditory pathway. We adapted established visual motion paradigms to further investigate SP of auditory targets. We hypothesized that SP of auditory targets is driven by a velocity-dependent signal similar to vision, thereby providing evidence for motion-specific processing within the central auditory system.

We confirmed that SP of auditory linear ramp targets resembles SP of visual targets, but with a lower gain. Auditory SP velocity increases, and auditory SP gain decreases, with increased target velocity, indicating it is more difficult to pursue faster auditory targets. These findings were also confirmed with gaze pursuit (head-unrestrained, eye + head = gaze) demonstrating an involvement of the vestibulo-ocular reflex in the processing of auditory motion as well. Additionally, there was no evidence that SP relies differentially on low or high frequency spectral cues related to specific localization channels, either in the free field or under headphones. Finally, prediction is known to play a prominent role in visual SP, but has been neglected in the study of auditory motion perception. We recorded head-restrained SP and head-unrestrained gaze pursuit following the sudden disappearance/silencing of moving visual and auditory targets, as well as in advance of a predictable return of these targets. These experiments provided some evidence for prediction and anticipation in auditory SP, though the findings do not completely reflect what we know of visual motion processing.

Together these experiments characterize the dynamics of ocular and gaze pursuit of moving auditory targets and help address a critical gap in our understanding of how auditory motion cues are used for navigation. These findings support a possible shared mechanism for sensory motion processing across vision and audition.