Enhancement of Otolith Specific Ocular Responses using Vestibular Stochastic Resonance
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Introduction: Astronauts experience disturbances in sensorimotor function after spaceflight
during the initial introduction to a gravitational environment, especially after long-duration
missions. Our goal is to develop a countermeasure based on vestibular stochastic resonance (SR)
that could improve central interpretation of vestibular input and mitigate these risks. SR is a
mechanism by which noise can assist and enhance the response of neural systems to relevant,
imperceptible sensory signals. We have previously shown that imperceptible electrical
stimulation of the vestibular system enhances balance performance while standing on an unstable
surface. Methods: Eye movement data were collected from 10 subjects during variable radius
centrifugation (VRC). Subjects performed 11 trials of VRC that provided equivalent tilt stimuli
from otolith and other graviceptor input without the normal concordant canal cues. Bipolar
stochastic electrical stimulation, in the range of 0–1500 microamperes, was applied to the
vestibular system using a constant current stimulator through electrodes placed over the mastoid
process behind the ears. In the VRC paradigm, subjects were accelerated to 216 °/s. After the
subjects no longer sensed rotation, the chair oscillated along a track at 0.1 Hz to provide tilt
stimuli of 10°. Eye movements were recorded for 6 cycles while subjects fixated on a target in
darkness. Ocular counter roll (OCR) movement was calculated from the eye movement data
during periods of chair oscillations. Results: Preliminary analysis of the data revealed that 9 of
10 subjects showed an average increase of 28% in the magnitude of OCR responses to the
equivalent tilt stimuli while experiencing vestibular SR. The signal amplitude at which
performance was maximized was in the range of 100–900 microamperes. Discussion: These
results indicate that stochastic electrical stimulation of the vestibular system can improve otolith
specific responses. This will have a significant impact on development of vestibular SR delivery
systems to aid recovery of function in astronauts after long-duration spaceflight or in people with
balance disorders.