The American Otological Society

CLINICIAN SCIENTIST AWARD 2010-2011

"Visual and Vestibular Perceptions of Motion"

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AMOUNT AWARDED BY AOS: $40,000

ONGOING FUNDING: 2010 - 2016 National Institute on Deafness and Other Communication Disorders K23 award (1 K23 DC011298): Visual and Vestibular Perceptions of Motion. PI: Crane BT, Sponsor: NIDCD, Percent effort 75% ($1,545,633 direct costs, $1,669,666 total). Planned duration: 5 years. 2011 - 2015 Triological Career Scientist Award: Visual and Vestibular Perceptions of Motion. PI: Crane BT, Sponsor: Triological Society, Percent effort 25% ($80,000 per year all direct costs for 4 years, total $320,000). 2014 - 2019 National Institute on Deafness and Other Communication Disorders R01 award (1 R01 DC013580) Multi-modal vestibular perception. PI: Crane BT, Sponsor NIDCD, Percent effort 25% years 1-2, 50% years 3-5. ($1,893,650 total over 5 years). No cost extension until 12/31/2019 2020 - 2024 National Institute on Deafness and Other Communication Disorders R01 award (2 R01 DC013580) Multi-modal vestibular perception. PI: Crane BT, Sponsor NIDCD, Percent effort 35%. ($1,925,000 over 5 years).

PUBLICATIONS: *This includes only the publications related to AOS award or that built on that work:*

Roditi RE and Crane BT, Directional Asymmetries and Age Effects in Human Self-Motion Perception. *JARO.* (2012) Jun;13(3):381-401.

Roditi RE and Crane BT, Supra-threshold Asymmetries in Human Motion Perception. *Experimental Brain Research.* (2012) Jun;219(3):369-79.

Crane BT, Fore-aft Translation Aftereffects. *Experimental Brain Research.* (2012) Jun;219(4):477-87.

Crane BT, Direction specific biases in human visual and vestibular heading perception. *PLoS One* (2012) Dec:7(12):e51383.

Crane BT, The influence of head and body tilt on human fore-aft translation perception. *Experimental Brain Research*, (2014) Dec;232(12):3897-905. [PMID 25160866].

Crane BT, Coordinates of human visual and inertial heading perception. *PLoS One*, (2015) Aug 12;10(8):e0135539. [PMID 26267865]

Crane BT and Schubert MC, An adaptive vestibular rehabilitation technique. *The Laryngoscope*, (2018) Mar;128(3):713-18 [PMID 28543062]

Crane BT, Effect of eye position during human visual-vestibular integration of heading perception. *Journal of Neurophysiology*, (2017) Sept 1;118(3):1609-21 [PMID 28615328]

Rodriguez R and Crane BT. Common causation and offset effects in human visual-inertial heading direction integration. *Journal of Neurophysiology*, (2020) Apr 1;123(4)1369-79 [PMID 32130052]

Rodriguez R and Crane BT. Effect of timing delay between visual and vestibular stimuli on heading perception. *Journal of Neurophysiology*, (2021) Jul 1;126(1):304-12 [PMID 34191637]

RESEARCH SUMMARY: The research as focused on several areas:

Vestibular aftereffects. After starting my laboratory at the University of Rochester, I decided to focus on the uncrowded field of suprathreshold vestibular perception. When comparing two suprathreshold stimuli an initially unexpected finding was that the initial stimulus was often perceived larger than an equal second stimulus. Subsequently, it was found that after an initial movement, perception of subsequent motion is biased in the opposite direction. Similar phenomena in other sensory systems have been described as aftereffects, but such effects had not previously been described for the vestibular system. These effects have a frequency dependence and time course not seen with other sensory aftereffects. They likely play a key role in identifying unexpected movements that might indicate risk of an impending fall.

Description of biases in human heading perception. Population vector decoder (PVD) models have proven to be useful for describing how neuronal activity influences behavior. It has previously been shown the majority of neurons have sensitivities to visual and vestibular headings such that they best discriminate left/right of straight ahead. Based on this, a PVD would predicts the later aspect of headings would be overestimated relative to straight ahead. I was able to demonstrate that this actually occurs for both visual and vestibular headings. For recent work has looked at this in the vertical planes which has shown utility in predicting the relative numbers of otolith and saccule units. Current projects in the lab involve using this to look at coordinates of heading perception, further manuscripts in this area are currently in process.

Multisensory motion integration. Traditionally, vestibular perception has been studied in response to simple stimuli in isolation. However, this is not how they are experienced during common daily activities such as ambulation where translation and rotation occur simultaneously, and visual stimuli are also present. In this area I have been able to demonstrate that motion perception takes into account the pattern of movement seen during ambulation. An addition visual stimuli influence motion perception including visual motion illusions and effects of vection. Clinical disorders such as migraine have an influence on the transfer of visual motion to perceived inertial motion

OUTCOMES: Ultimately, we hope this research will lead to better vestibular rehabilitation techniques.

FURTHER FUNDING HAS ENABLED US TO EXPAND OUR RESEARCH TO: Initially the focus was understanding vestibular perception in terms of thresholds, later studies moved to suprathreshold perception, effects of previous experience, and visual-vestibular integration. More recent work has focused on factors like perception after clinically relevant conditions like unilateral vestibular loss and migraine.

LAY SUMMARY OF FINDINGS AND IMPLICATIONS OF THIS RESEARCH: Dizziness is a disorder of pathologic motion perception but surprisingly little is known about how normal motion perception. Motion is perceived in part due to signals from the vestibular organs of the inner ear, but vision also has an important contribution. This work demonstrates that normal perception is not ideal in that the lateral component of both visual and vestibular perception are over estimated. Furthermore, visual stimulus directions are perceived in retina coordinates while vestibular stimuli are perceived in body coordinates. Perception can be manipulated by stimuli that were experienced immediately before, as well as by artificially offsetting the relationship between visual and vestibular motion. This has implications for understanding normal perception as well as for rehabilitating those with common dizziness disorders.