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Striking the Right Balance: It's Not Just a Vestibular Loss: Beyond Vertigo and Dizziness!

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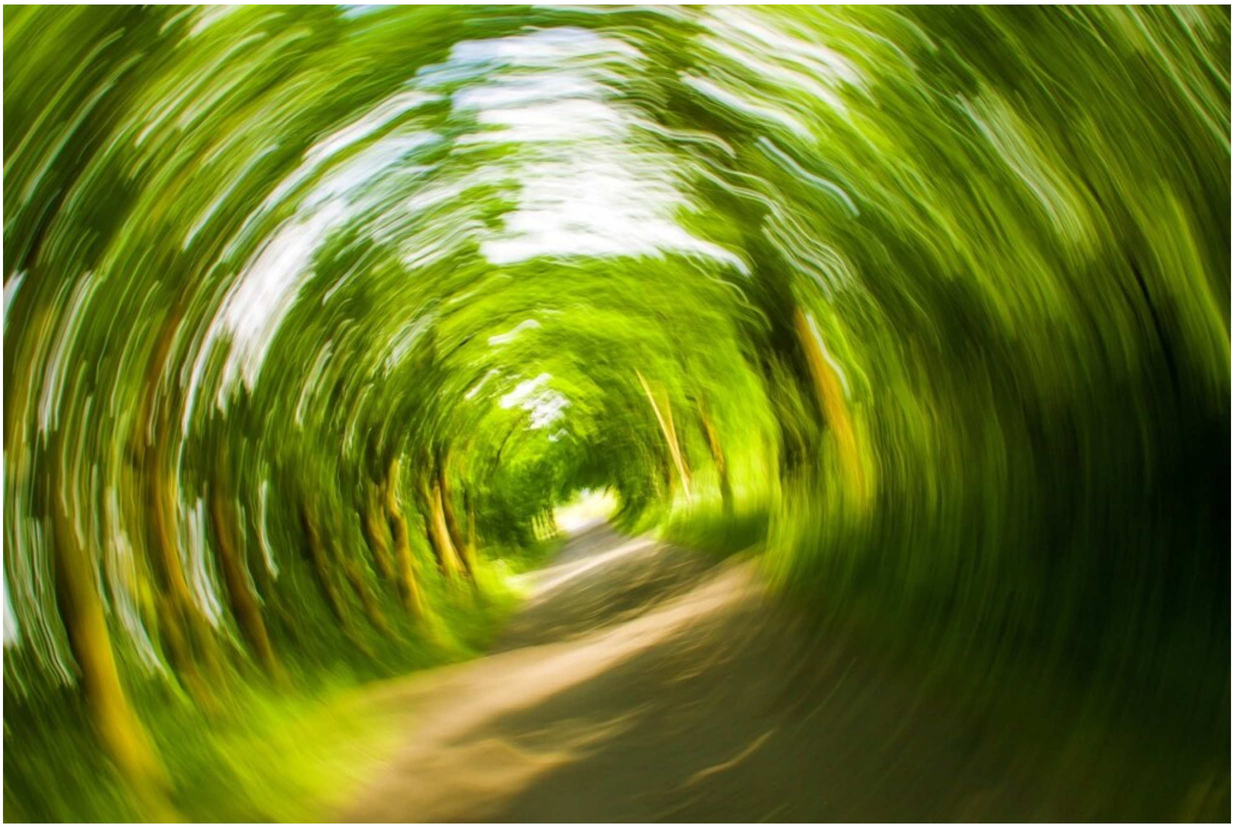
In this edition of "Striking the Right Balance," Assan Mary Cedras, Antonio Sam Pierre, Jonathan Dion, and Clara Orsini, Audiology students at the University of Montreal, and their professor, Maxime Maheu, take a look at vestibular losses beyond the symptoms of vertigo and dizziness.

Michael Vekasi, AuD, R.Aud, Aud(C), FAAA and Erica Zaia, MSc, RAUD are coordinating the "Striking the Right Balance," feature which will cover the latest information on 'all things vestibular.' If you would like to be more involved in all things vestibular, please check out and like our Facebook page by searching for "CAA National Vestibular Special Interest Group" within Facebook. You can also reach us by email at CAAvestibular@gmail.com.



Did you know that in Canada, nearly four out of ten people you encounter everyday will experience a vestibular problem at some point (Statistics - Balance & Dizziness Canada 2015)? Commonly reported symptoms by these patients include episodic or chronic vertigo (i.e., the illusion of rotation) and dizziness (i.e., imbalance, rocking sensation, etc.). They may struggle to maintain balance in various conditions or have difficulties stabilizing their gaze while moving their heads.

Audiologists possess the knowledge and methods to assess vestibular reflexes and identify vestibular lesions. For example, we can use caloric irrigation along with videonystagmography (VNG), video head impulse test (vHIT), or vestibular evoked myogenic potentials (VEMP) to detect vestibular asymmetry. However, some patients report less typical symptoms, such as brain fog, mental confusion, and distorted spatial perception (Guo et al. 2024), complicating their evaluation and management.

During their journey, some patients might hear the dreaded phrase from healthcare professionals: “It’s all in your head.” This phrase reflects a lack of understanding of the broader role of the vestibular system. Recent literature suggests that vestibular impairment has broader consequences, highlighting its crucial role in cognitive functions. As clinical audiologists, understanding and acknowledging the importance of vestibular signals in these processes is essential for improving patient assessment and management. This article aims to introduce audiologists to the impact of the vestibular system and vestibular lesions on cognitive functions and recent advances in this field.

The Role of Vestibular Signals in Body Representation in Space

Have you encountered patients with vestibular loss who mention sensations of “brain fog,” difficulty concentrating, or disorientation? Although these symptoms are less typical of classic vestibular lesions compared to “room spinning” episodes, they may be related to vestibular impairment. A clear representation of our position in space relies on integrating visual, somatosensory, auditory, and vestibular cues. Each sense provides unique information that must be properly integrated to achieve an accurate spatial representation. Precise vestibular information is crucial for integrating multiple sensory cues that contribute to our body's spatial representation (Borel et al. 2008). Data suggest that vestibular signals may act as a reference point (anchor) to integrate and interpret other signals. Specifically, several pieces of evidence support that vestibular cues are vital for identifying the position of somatosensory or auditory cues in space.

Somatosensory and Vestibular Interactions

In the past two decades, many studies have investigated the impact of vestibular perturbations on somatosensory processing, such as detection thresholds. For example, during naturalistic stimulation, researchers measured the ability to detect vibration stimulus onset asynchrony (time difference) on the hands (Figliozzi et al. 2005; Moro and Harris 2018). Following rotational stimulation, Figliozzi et al. (2005) found a temporal advantage towards the hand leading the rotation when participants indicated which hand perceived the vibration first. Similarly, Moro and Harris (2018) found a bias toward the hand contralateral to the tilt position.

To explain this interaction, the two studies proposed different theories: an attentional shift (Figliozzi et al. 2005) and a remapping mechanism at the cortical level (Moro and Harris 2018). However, because both vestibular systems were simultaneously stimulated in these studies, it remains debated whether a shift in covert attention (Figliozzi et al. 2005) or asymmetrical cortical activation (Moro and Harris 2018) best accounts for these results. Our group addressed this question by conducting a study using unilateral vestibular stimulation. We examined tactile temporal processing following selective right and left vestibular system stimulation with bi-thermal caloric vestibular stimulation (CVS). In our study, 24 right-handed healthy participants reported which hand perceived the vibration first during bi-thermal CVS on the left ear (n=12) or right ear (n=12). The results showed that warm CVS in the left or right ear significantly impacted the ability to perceive which hand was stimulated first. However, following cold CVS, a significant impact on tactile temporal processing was observed only when the right ear was stimulated. Given the known cerebral activation patterns following CVS, our results suggest an interaction between the vestibular and somatosensory systems at the cortical level, supporting the hypothesis of asymmetrical cortical activation influencing somatosensory processing after vestibular perturbation.

Auditory and Vestibular Interactions

Despite the proximity of the peripheral vestibular and the peripheral auditory systems, only a few studies have investigated the audio-vestibular interaction. Since these two senses contribute significantly to our body representation in space, it is crucial to understand their dynamics. Recently, two studies from our group support the hypothesis that the vestibular system anchors our perception of spatial auditory scenes.

First, Paromov et al. (2024) showed that a change in body orientation in space, not perceived by the participant, significantly impairs sound localization. In this study, 24 healthy participants were asked to localize sound sources following a disorientation task, the Fukuda stepping task (walking in place with eyes closed). Importantly, even though participants are asked to remain in place during this task, they move relative to the sound source without noticing it. The results are impressive, as subjects made substantial errors in localizing the sound source following the disorientation task. Even though auditory cues were appropriate, they failed to localize the sound source properly. Second, we recently conducted a follow-up study where we modified vestibular cues to create an illusory shift in spatial representation and observed the impact on auditory localization abilities. Galvanic vestibular stimulation (GVS) was used to induce the illusory motion and to create an inadequate representation of body position in space (vestibular cues are incongruent with auditory cues). Consequently, in this study, 17 healthy participants were asked to indicate the perceived position of sound presented through headphones in eleven positions from -90° (left of body midline) to 90° (right of body midline). The results showed that sound localization abilities were significantly impacted when vestibular cues induced a shift in the representation of body position in space. Therefore, even though auditory cues remained unchanged (under headphones), it seems that auditory spatial representation was updated based on the vestibular cues (GVS). These studies support that auditory spatial representation is based on the vestibular representation of our body in space.

Improving Clinical Vestibular Evaluation Methods

When a patient is referred to your clinic for vestibular evaluation, what are the most common tests you perform? Likely, you perform vHIT, caloric testing, or VEMP (cVEMP or oVEMP). These tests measure vestibulo-ocular reflex or vestibular spinal reflex to identify peripheral vestibular system impairment. However, none of these tests measure more cognitive aspects, such as self-motion perception.

Quantifying vestibular perception could deepen our understanding of the vestibular system. Dissociation between VOR response and perceptual response has been observed in various populations. For instance, some elderly patients reported an absence of vertigo following caloric irrigation, even though the VOR response was within normal limits, suggesting normal horizontal semi-circular canal function (Chiarovano et al. 2016; Jacobson et al. 2018; Piker et al. 2020). The lack of perceived self-motion following caloric irrigation has been associated with greater postural instability which could lead to increase falls (Chiarovano et al. 2016; Piker et al. 2020). However, these studies involved elderly patients with imbalance symptoms (non-vestibular). Therefore, it remains unexplored how normal aging affects perception during caloric irrigation. Additionally, vestibular pathologies, such as vestibular migraine, have shown enhanced self-motion perception during rotational chair stimulation compared to controls, despite normal VOR responses between groups (Wurthmann et al. 2021). Transferring this knowledge to clinical settings is challenging as the methods used in these studies are cost-effective and time-consuming. Future efforts are needed to develop measures of self-motion perception that can be easily transferred to clinical settings.

Our laboratory aims to bridge this gap by developing a method to quantify vestibular perception in clinical settings. Using the caloric test, we recently tested a method to compare vestibular reflexes and perception. When the vestibular system functions normally, the caloric test induces a nystagmus recorded using videonystagmography (VNG), typically interpreted to inform the clinician about the horizontal canals' status. However, caloric stimulation also induces an illusion of movement (Shepard and Jacobson 2016). We are hopeful of developing a method easily transferable to clinical practice, allowing measurement of vestibular perception during caloric stimulation in various populations.

Conclusion

In summary, an impaired vestibular system can profoundly impact beyond the traditional reflexes:

the vestibulo-ocular reflex (VOR) and the vestibular spinal reflex (VSR). This article argues that the vestibular system is crucial for integrating and interpreting spatial cues from other sensory systems, such as the auditory and somatosensory systems. Additionally, vestibular perception (self-motion) in clinical settings is lacking and efforts should be made to develop objective methods.

We invite audiologists to view vestibular lesions as a syndrome that impacts patients' everyday lives beyond dizziness/vertigo, gaze, and postural instability. "Strange symptoms" should not automatically be dismissed as non-vestibular, as they could be linked to an inappropriate representation of the body in space, affecting the interpretation of spatial cues from other sensory systems. Almost all current clinical methods (VEMP, vHIT, caloric) assess reflexes but fail to adequately assess the vestibulo-cortical pathway. Therefore, before concluding that reported symptoms are not of vestibular origin, it is crucial to assess all vestibular system functions, which we cannot fully do.

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